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Dissertation

by Justin Dawson

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**An investigation of Usability of E-
Government and E-voting.**

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ABSTRACT

The aim of this project was to compile an e-voting system that addressed usability issues and to implement a system that focused on users that had previously used e-voting to cast votes. Eye gaze analyses would help distinguish where users had visited on the e-voting site which would then decide correct guidelines that could be used in the future to deter poor design.

The literature provides a background on early voting methods to help build an understanding how autonomy via the ballot box had evolved. Poor design and even manipulation of user interfaces had led to votes being spoilt or even the election in its entirety put into question. Later in the literature it is discussed on a voting system that is currently in use in Estonia and how it has dealt with the most common threats from cyber criminals. There are arguments surrounding how secure the system is.

Assistance to the e-voting system would be supported by user's views and opinions of a recent voting system they had used, this would ascertain concerns that would later be reflected in the newly designed e-voting system.

Recommendations are based on implementing the necessary usability guidelines that a project that implements such a system to prevent poor design that could lead to serious consequences.

WHY THE PROJECT WAS CHOSEN

The project was chosen because as we move closer towards making devices and other things some kind of internet capable device there is emphasis on making things better for the greater good. One area that had a particular grey area around this perception was the current voting system and why the UK had not adopted some of the internet etiquette in to a possible alternative? Usability has an important role to play in making these options attractive also, poor usability could impact the result and legitimacy of a vote if a user gets misrepresented or even by simply being confused by the content. It has been heard of that electoral fraud had taken place at some point in the UK or Europe, the law would deliver consequences as a result, but some interesting facts still remained about the systems in place that allowed these kind of things to happen in the first place. Not everybody is familiar with technology and certain groups of people may accidentally be discriminated against because of unfamiliarity with technology. Questions are being asked about e-voting, the subject of e-voting has become somewhat of a hot topic which may have come to the conclusion it's a case of when and not if, that this kind of system will get implemented or not here in the UK. Estonia currently uses an electoral e-voting system, the interesting points is that there are risks associated with internet and big implications financially as to the consequences of failure to adapt some sort of security.

The final aim of this project is to address people's concerns of usability issues with an e-voting system so that usability tests can be carried to find out if a system with a simple interface assist in a viable system. The Aims of this project to help build this system are:

- Analyse the literature on voting, e-voting, security, usability issues in e-government.
- Investigate good and bad design of user interfaces
- Conduct usability tests of the newly created e-voting system
- Produce small questionnaires to specific groups to ascertain requirements of the system.
- Produce heat maps via eye gaze analyses to establish weak points in the system.
- Engage in a focus group for requirements analyses.
- Recommendations on usability requirements for an e-voting system.

CHAPTER 1

1 INVESTIGATION INTO USABILITY ISSUES IN E-GOVERNMENT E-VOTING.

1.1 INTRODUCTION

"The best argument against democracy is a five-minute conversation with the average voter", (Winston Churchill).

The beginning of a British democracy over two hundred years ago laid path to what voting has become today in terms of equality. Integrity of an individual's vote in elections or by elections in the United Kingdom has come under some scrutiny recently, the question has been raised about legitimacy. Legitimacy of a vote is broken down as to what would deem acceptable as a vote that has not been altered, misread or even lost. A possible solution to alleviate the skepticism surrounding legitimacy of a person's vote is discussed arguing a case for electronic voting. It is highlighted that voting electronically has been open to abuse and even fraud. Other countries are used as examples where electronic voting has been implemented and how abuse has led to profound effects on governments. Further to the electronic voting, the machines used have been argued at how affective they are in equality and reliability. The population of the United Kingdom have a possible perception to the effectiveness of electronic voting. Concerns regarding security of electronic voting are argued. Later in this chapter it is also discussed further in to e-government websites that provide a service, research has seemed to suggest usability has succumb to much criticism such as how affective a user can navigate and find essential information. Research in this chapter will cover usability standards as to whether they are adhered to. Factors relating to age and literacy a discussed and whether they are taken in to account whilst building a suitable model to reflect this findings.

CHAPTER 2

2 LITERATURE REVIEW

2.1 Early Voting and Democracy.

Democracy is subject to much scrutiny as to its meaning. Whilst this section highlights democracy and its definition,[1] the unification of people plays an important role and provides proper functioning of the democratic institutions. Voting in the United Kingdom forms part of the British democracy that has reigned success in the determination of who the country is governed by. [2] Since 1708 the United Kingdom saw the union of two parliaments in England and Scotland, these were formerly known as the Whigs (Lord Somers) and Tory (Earl of Godolphin). Before the mid eighteenth century, to have been able to vote in the United Kingdom it did not come without its restrictions or limitations, divisions in classes still existed.

The criteria for voting was based on wealth or status, normally the working classes would have to be a set age with value on assets such as property, and women were exempt until 1916. The electorate would gather in the streets or market squares on the days of an election Votes were counted by counting the hands held up by those gathered. Before 1832 the voting system was in fact corrupt with little integrity, [3] an example of this is highlighted by the fact that residents paying at least forty shillings a year in the UK were eligible to vote. [4] The “rotten borough’s” thrived allowing small populated areas with a few number of residents, were open to bribes practically manipulating the legitimacy of the vote via the electorate.

Divisions made it apparent that equality did not equate to an essential component of a democracy. [5] (Campbell 2008) has argued that political democracy has its different perceptions by various people, these perceptions are influenced by different theoretical definitions. The rotten boroughs were eliminated under the reform act of 1832. Although this reform act showed a positive step towards equality amongst the male electorate, Craik states that: [6] eligibility rules still applied based on the owners property value. the Research has shown that that before the reform act came in to law [7] one year before reform, 150 seats in the House of Commons were elected by less than 100 voters.

By today’s standards 150 seats delivered by an electorate of less than 100 would have serious democratic implications? It has been documented that: [8] in 1867 autonomy via the ballot box was introduced for the electorate, referred to as the ballot box act of 1867. The ballot box act has evolved over the last 150 years with further acts

allowing lesser restrictions thus giving male and female voters equality in a more open and free democracy. Astrom explains that:

“Political decisions are considered legitimate if and only if they are made through certain procedural circumstances” [9].

2.2 THE IMPORTANCE OF DESIGN

In 2004 Birmingham (UK) saw the manipulation of a postal voting ballot, three members of the Labour party deliberately altered the votes for personal gain which as a consequence saw the electoral result being overturned by a judge [10]. The case in Birmingham showed a weakness in the design of the postal vote system and left the door wide open to reform, this arguably would be the alternative as opposed to the possible defection of public voting altogether in that region. The public are entitled as an electorate to have full confidence in the system that is being used, anything that jeopardizes the integrity of this system can ultimately have the confidence of the public affected [11]. If any unfortunate case of fraud is detected no matter how small it is, it has been noted to have an effect, associated encounters with the ballot that are anything less than 100% legitimate risk putting off millions of voters [12]. *DR Wilks-Heeg* states that Voters perception after a number of fraudulent publicized cases have led to the assumption that it is happening everywhere thus impacting confidence of the electorate [11]. The impact of confidence being dealt a blow to the national public has been seen as that of a negative one, voting behavior as documented is one of being cautious as a consequence through deliberate unethical manipulation.

The Electoral registration committee argues that incompetence and human error have attributed to bad design and layout in the ballot paper in recent times [12]. (*Pippa et al*) agrees with this and adds further to the argument that the in excusable poor planning along with the ballot papers flawed design was at fault that led to the rejection of 140000 ballot papers in 2007 in the Bush-AL gore presidential election [13]. The spoilt papers had a second contributory factor to the demise of 142000 ballot votes. Local elections were running concurrent with the 2007 parliamentary election. Presented with over complicated ballot papers led to confusion on how to correctly fill them in accordingly which in turn impacted the overall result [14]. The image below represents the potential confusion added by two similar ballot paper designs.

Figure 1,[15].

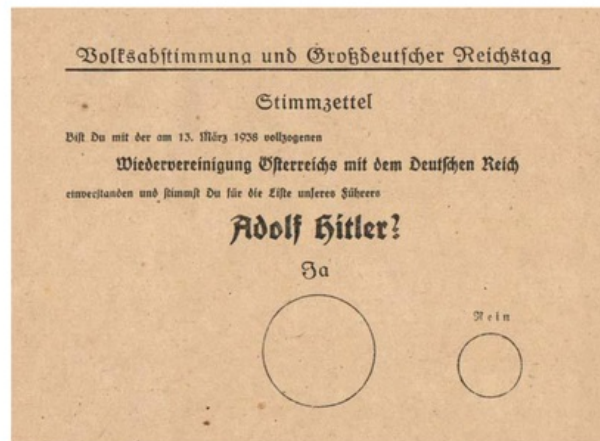
Election of the Scottish Parliament
You have two votes

Any Region Scotland Regional Member	Vote once only (X)	Anytown Central Constituency Member	Vote once only (X)
Scottish Christian Party "Proclaiming Christ's Lordship"	X	Arnold Andrew Solidarity Party	Solidarity
Scottish Conservative and Unionist Party		Bertram Barry	
Scottish Green Party		Clarke Christine	
Scottish Labour Party		Scottish Conservative and Unionist Party	
Scottish Liberal Democrats		Dixon David	X
Scottish National Party (SNP)	X	Edwards Edwin	
Scottish Socialist Party		Scottish Liberal Democrats	
Solidarity Party	Solidarity	Ferguson Francis	
		Independent	

2.3 BALLOT PAPER DISCREPANCY

The Scottish Parliamentary elections in 2007 provided the conditions for accidental misinterpretation via simultaneous elections. On the thirteenth of March 1938 Austria was annexed by Nazi Germany's military, the country was then incorporated into the German-led Reich by Adolf Hitler, who was also Austrian-born [16]. The example given shows a potential manipulation of the ballot paper seeking approval of its electorate's incorporation into German power and to vote for the leader being that of Adolf Hitler.

Figure 2, [17].



The ballot paper reads:

"Do you approve of the reunification of Austria with the German Reich that was enacted on 13 March 1938 and do you vote for the party of our leader, Adolf Hitler? Yes. No." [17].

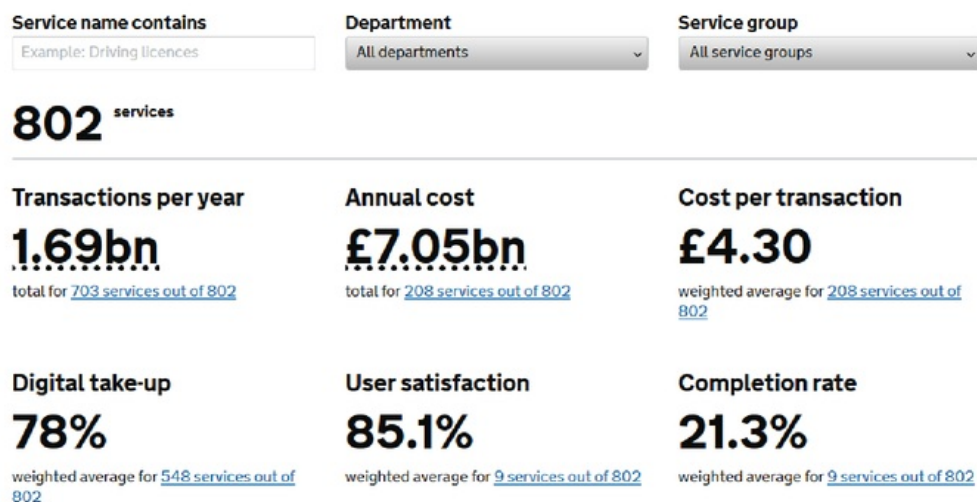
The first discrepancy is the question, it actually asks two questions but only provides one yes or no option. The limitations imposed by the designer of the ballot paper are restricting the electorate by being unable to answer those questions individually. The voter might not necessarily have agreed with one or the other of those questions asked thus compromising the legitimacy and integrity of the vote. Further to the argument of legitimacy is the two circles that represent the answer, being that of yes or no. The large circle represents yes whilst the smaller circle is no. The documentation to support this as a deliberate power of persuasion or outright manipulation is not overly available, the prominence of the large circle representing yes could overpower the smaller circle and have a direct influence in the decision of the voter. The vote was held on April 10 of that year which led to 99.7 % of the voters approving Hitler's union for Germany [18].

2.4 USABILITY OF E-GOVERNMENT

As with voting, e-government services should be usable and easily accessible to users who require that service, fortunately in comparison to websites online they have become more usable over time [19]. An experiment was conducted on E-government website resources to ascertain satisfaction amongst particular services in the EU and discovered that only 47% met user requirements [20]. Since usability has its guidelines and standards which is part of the requirements for user satisfaction, some e-government websites are not as compliant in relation to standards as they are designed in [19]. Although there is insufficient evidence to suggest there is an abundance of dissatisfied users regarding using government web resources. These comparisons of usability standards could be a factor on a percentage of how people perceive e-government services or resources. The image below from the official.gov website represents user satisfaction of all services and combining it with an average for the overall score.

Figure.1

Services data



The user satisfaction rate out of one hundred stands at 85% and there is no alternative information to the further understanding of these percentages and costs.

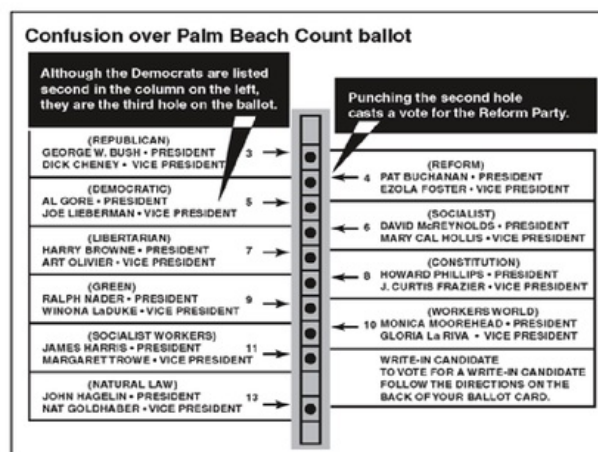
2.5 THE ALTERNATIVE, E-VOTING

E-voting (electronic voting) in the United Kingdom via an official system does not exist, voting is still done via the ballot box and by people who have registered to vote. The prospect of an electronic voting system could be an attractive option to government to reduce low voting turnouts, especially amongst the younger population. According to Areeq Chowdhury the implementation of an online voting option in a general election could see an increase voters by 9 million, an increased turnout to 79% which has not been achieved since 1959, an increase by 1.8 million young voters are included in the figures given also up 26 percent from 2010 [21].

Some other countries use the electronic voting System as a method of voting although it is not clear on the legitimacy of such a system. [22] (Ryan, Schoenmakers 2009) argues that such a system in place may create a fair election and enhance the legitimacy of elected members, the argument is valid but without knowing the legitimacy of the application by an approved developer it could still warrant extended research.

The democratic process is a foundation that could satisfy the voting criteria prompting the legitimacy of the system (Dimitris. Gritzalis 2012) [23]. The prompting of a legitimate system may ensure the integrity of the vote. In Brazil where voting electronically and not via a web application has proved to be the normal standard in the way at which people vote after there had been accusations of fraud that forced the adoption of electronic systems. E-government usability has an important role to play, the engagement of users who experience e-government resources face the task of finding information that is needed to get to the point of interest as intended. Usability standards that have been sub-par in e-government voting have led to big problems and had unintended consequences as a result. An example of poor usability highlighting elected members being mistaken for other candidates using an online voting system in the year 2000 United States Presidential election is shown in figure 1:

Figure 1, [24].



Voting is usually done by selecting a candidate of the voter's choice, votes that are made by mistake or voting for more than one candidate can impact the result with a chosen candidate that the majority did not intentionally choose [24]. Although the voting process is democratic the result has come in to serious question by the poor usability applied.

2.6 IMPORTANCE OF USABILITY

Usability has associated theories such as human factors and visual perception that implement guidelines to assist the user in achieving the desired end result without hindrance. Easy understanding is normally the objective of the user to achieve what they set out to do. As with e-voting the machines used in other countries they require an interface that is easy to use and understand. Too much unnecessary aesthetical features may distort a user's ability to distinguish relevant information. Jakob Nielson argues that:

"design dialogues should not contain irrelevant information and that every extra unit of information in a dialogue competes with relevant units of information and reduces their relative visibility" [25].

Confusion over the design of an interface was seen in the 2000 Presidential (Bush-Gore) elections, this case was so severe it had set off legal action and was resolved by the Supreme Court. This may have been brought upon by the way the user interface was implemented, and the way the confusion escalated. The design of the Bush-Gore ballot paper was based on punch card system that had an outline of a circle hole in the middle ready to be punched out, the names of the candidates were organised on either side [26]. This type of ballot paper was called a butterfly ballot. According to Veit and Huntgeburth voters had major problems in understanding the actual system being used, this led to over votes, spoilt votes and even non votes [23]. This case demonstrates that the usability applied did not favour the voters. The interface had confused voters and shown that information could lead the voter away from the intended candidate they were supposed to choose. The visual perception of the voter is of high importance if the intention is to result without hesitance and confusion. Two studies found that ensuring visual consistency resulted in task times reduced, less error prone and end user satisfaction [27]. The studies show that the implementation of set guidelines could have helped prevent the failure of the ballot in the Bush-Gore presidential election.

2.7 ESTONIA EVOLVES ONLINE

Internet parliamentary elections were unheard of before 2007. Estonia had become the first country in the European Union and the rest of the world to employ the first parliamentary elections online [28]. Internet activity has grown with popularity in countries all over the world that have access, although not all countries benefit from the same democratic model or technological advances that Europe and the west employ.

In the USA a survey was conducted for a project by the Pew Research Center, the survey produced results showing that 54% of the public had used online services that were politically relevant [29]. The increase in internet activity has steered people in to the direction of suggesting online voting is a viable way of casting a vote. The advantages of online voting present an array of possibilities, disabled voters can vote

in the comfort of their own home, this can potentially increase the percentage of the turnout. Some votes are abandoned or not cast due to circumstances that can hinder them to get to a polling station or post box. Estonia has been recognised as being the most technologically advanced part of Eastern Europe with commitment for strong technological advancement and readiness [30].

Estonia has relied heavily on the internet for its banks, security and power stations. Over 95% Bank transactions are done online using the internet [31]. The robustness of Estonia's online infrastructure that its country so heavily relies on has been regarded as the back bone of the economy, a collapse or an attack could financially inflict dire consequences or even a life threatening situation. A cyber-attack on April 2007 tested Estonia's integrity of security when a DDoS crippled the countries access to websites that required user login in, the attack was aimed at the financial sector [32]. This kind of cyber-attack has not caused the country to abandon its online voting system. Estonians see themselves as a recognised democracy and have insisted that the system used to vote online gives the country a bench mark in terms of achievement and standards.

The implemented system requires that the user logs on and registers online. The app is downloaded to a device, the user then inputs a personal number allocated with the card in to the app to gain access to the service. Estonia introduced identification cards in 2002 that allow digital access to all of Estonia's secure e-services [33]. Once presented with the presidential candidates, the user selects their choice, upon completing the select process it is requested a further pin number is inputted to confirm selection, to avoid mixing up pin numbers the second one has slightly more digits than the initial standard pin [34], [35].

The success of the Estonian voting system could be accepted as a system with integrity that fulfills requirements, the system in place has not escaped scrutiny nor criticism. The arguments over the safety of personal data and usability issues require further research analysis in order to ascertain the feasibility and risks.

2.8 SECURITY AND INTEGRITY OF E-VOTING

An important aspect of any internet service that employs data entry methodologies is security. There are four considerations that need to be taken into account when threats pose risks to the integrity of personal data. These considerations are information that's sensitive, operational aspects of the site, availability and the compromise of one's identity [36]. Although these aspects give a foundation to what should be a guide line in terms of security, there are cyber-attacks that have penetrated the core of these standardised guidelines. An example of this was a high profile attack on the online auction site EBay in 2008,

the cyber criminals managed to steal data both sensitive and critical of over 230 million records, the compromise consisted of passwords with usernames and associated user data [37]. EBay has a big presence online with the capitol for large marketing campaigns both online and the television. The case of EBay and its attack represents serious implications not just for the company but to other entities with less capitol or accessible expertise trying to pursue a democratic system that could be implemented as an online voting environment. As technological milestones have been reached so has the ambitions of the cyber-attack. Frunza argues that:

"Traditionally cyber-crime consisted of credit card scams and account theft, now cyber threats over the last decade have targeted nuclear power plants and payment systems which all have gained momentum"[38].

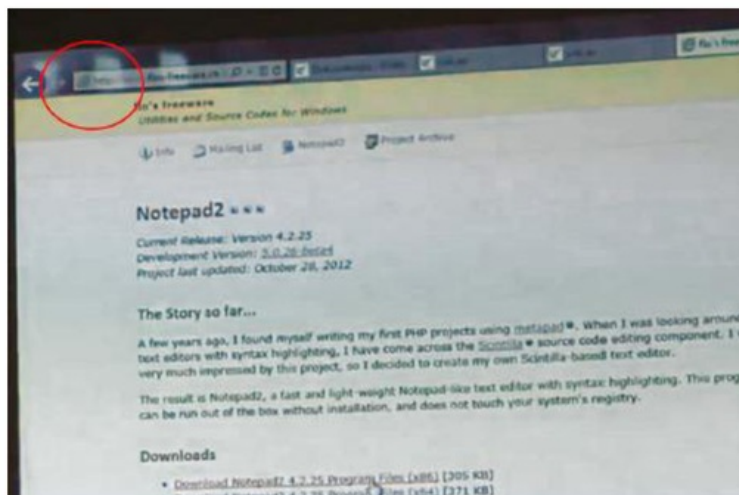
Frunzas argument shows that high profile entities and especially one of a voting system are at higher risk from attack as opposed to smaller attacks with little relishment by the attacker. According to the telegraph cyber security assistance from experts called in to multi-million pound industries has grown four times, since 2014 to 2015 saw high profile attacks on big companies such as Talk Talk, JD Wetherspoon, Sony and Ashley Madison [39] which involved data theft. These cases were reported in the media and news channels and gained significant attention around the world. The case for an e-voting system could also face the same sort of challenges in protecting the integrity of a vote that has been cast online.

Experts in the IT industry have conducted their own analysis on e-voting systems and expressed their findings with evidence to suggest online voting with improper rigorous testing could lead to badly designed systems thus reducing integrity of votes cast. An Independent report investigated a current system in use in Estonia and prompted its withdrawal. [40]. The results of the report discovered that:

"security was lax, the software designed was highly vulnerable to attacks from overseas and insufficient measures in place to prove an honest count"[41].

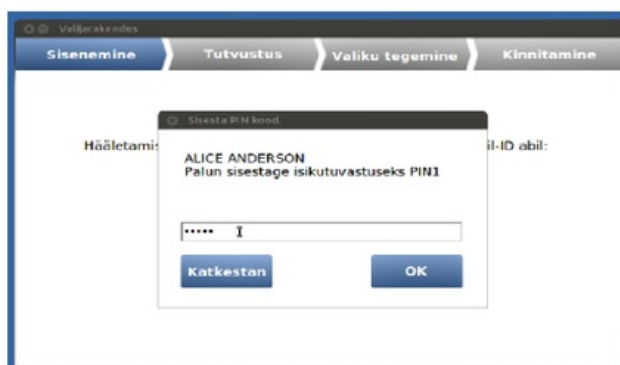
The Images below represent some simple vulnerabilities with the execution of the Estonian software. The Security Analysis of the Estonian Internet Voting System report demonstrates some of their findings with experimental malware to show the potential off attacks by hackers.

Figure 1.



According to Springall *et al*, Users downloaded software over connection that were not secure, cyber criminals that inject the download software with malware could compromise the setup [41].

Figure 2.



Users would use national ID credentials to login and also cast their votes via the online voting system. Springall *et al* demos an execution of malware on the client pc with malware that was able to secretly record the user's personal pin and change the user's vote [41].

E-voting security raises numerous questions on the highest level, it is questionable to whether it is a viable means to entice unenthusiastic voter's with-out assessing the benefits, but also bringing e-democracy into the digital era with security aspects unrecognised by governments and developers.

2.9 SUMMARY

The internet has grown in size since its first implementation in the early 90's, the government of the United Kingdom has taken advantage of this technology by utilising e-government resources in the form of web services. Results of public spending cuts may have resulted in less face to face communication with in physical government locations, the internet service is almost portrayed as an alternative solution, In addition to usability issues that may be deemed as problematic for users, the interaction between teams and business's may need to be an area of improvement to get the desired outcome that effects positive change. It may be agreed that a false premise has been built around spending cuts that prompted the idea of the internet being the other solution. A cause for concern is that if the impact of usability issues affect the members of the public in a way that hinders the prime objective of the user. A case reported about the delays in finding a page relevant that supply's contact information, the lack of email addresses to certain departments all provided a form of frustration for the user [42]. The Inland Revenue e-government has had wide spread issues that have been addressed by the user bearing the same issues as the previous case [43]. Numerous tests have been carried out regarding the usability of government websites, according to (Filipe, Cordeiro, 2012, p134):

"Current research has not given enough attention to the evaluation of usability in e-government websites" [44].

(Leist and Smith) [45] Contradicts this and states usability testing has been experimented through a variety of tests in to these issues rose. The uncertainty generated by a lack of research in to specifics may have stem through the evidence that is scarcely available. It has been mentioned that e-government services don't fully provide the user with an experience of satisfactory navigation, fundamentally in a development environment usability may form part of a model that is already a standard.

This research has established further analysis into usability issues surrounding e-government. The issues discussed and argued in this literature review concerning usability are ones that hinder the user's experience, aesthetics and voting behaviour towards poorly implemented user interfaces. The case for e-voting in the UK was researched and compared with risks associated with security and its feasibility.

CHAPTER 3

3 RESEARCH METHODOLOGY

3.1 INDUCTIVE APPROACH

The Inductive approach collected data from users that had used e-voting systems that provided a foundation on creating similar models found in usability standards that were used in the project. Although there is no official model for usability standards this research was aimed at defining some sort of standard to apply. The advantages of this approach was is that it gives the opportunity to use real life experiences of users of an e-voting system to collect data and help us use it for evaluation.

3.1.1 Phenomenology

A phenomenological approach was chosen to focuses on people's behaviour when poor usability is applied. It was decided there needs to be more research in to peoples experience, this can be experiences in the form of using e-voting systems or ballot papers but also the

proposal of an e-voting system in the UK. Phenomenology is an important approach as it allows us to understand and address people's concerns with this philosophy and collect data based on feelings that contribute to a better evaluation. The implementation of Phenomenology in this report will be aimed at focusing on the aims and objectives that determine the usability of an electronic system in the United Kingdom. The literature provided in this report had attempted to ascertain data relating to a successfully employed e-voting technology in Estonia, the security considerations have taken place with actual software tests. These test results were used to determine people's attitudes towards the implications.

3.1.2 Quantitative

Quantitative research is the approach taken in this project, this approach obtained user analysis and statistics gathered in the form of hard data. The reasons for choosing Quantitative research methodologies is because research outcomes can produce the data with a higher validity rate as opposed to qualitative, this is essential as accurate data analysis will provide more reliable results from questionnaires or focus groups.

3.2 EVALUATION

3.2.1 Questionnaires

The subject of usability is related to the research on e-voting, information for the questionnaires results were collected through interviews or focus, although the implementation of e-voting in the UK is yet to be part of e- government resources, the possibility of it happening has been discussed in articles. Questions were asked to users such as: Would you consider using an online e-government resource to vote on elections or by elections in the future? As part of security evaluation, would you trust the system in place to guarantee your vote would not be compromised? Asking people face to face puts the first part of the focus group at an ethical advantage, the results rely on users having a good experience when answering questions. This method is appropriate because the only way to collect current data statistically is engaging with the public. The Methodology for this research was inductive using the paradigm of Positivism.

CHAPTER 4

4 DEVELOPMENT METHODOLOGY

4.1 THE PROTOTYPE

The application prototype developed is an e-voting system that takes in votes from the user for their selected candidate. The case study is based on a university voting system for a president of the students union as a portrayal of a real system but as a prototype. The user inputs their credentials and casts their vote for their chosen candidate. The application has been built employing usability guidelines whilst incorporating accessibility recommendations. The prototype had been tested by checking that the usability guidelines have been followed through accordingly and testing the integrity of those guidelines that have been applied.

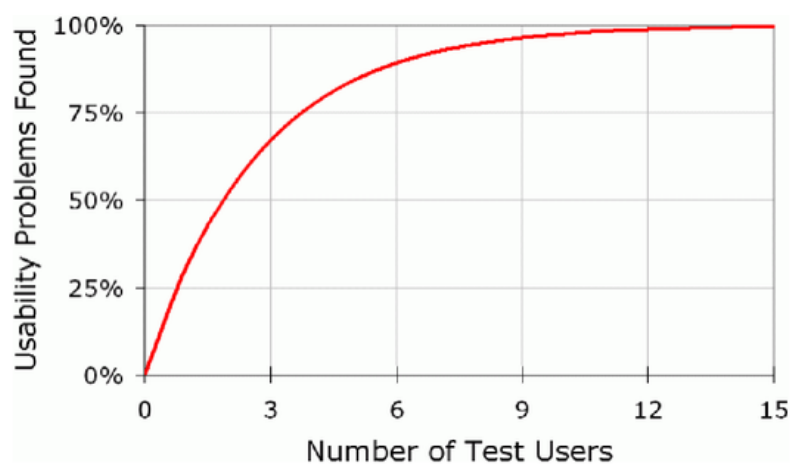


Figure 1 [46].

4.2 USER TESTING

The testing approach is influenced by Jakob Neilson of the Nielson Norman group[46]. In the article Jakob Neilson discusses that the need to test only 5 users should be seen as the maximum number to find usability problems discovered by the user [46]. The graph below represents test users and the percentage of problems found. Observations from the graph show that only minor usability problems were found as the number of users increased, after the third user had learned from the usability issues from the first, the problems decreased the biggest changes were from the first to fifth user after this the problems had been discovered [46]. On the basis of Neilson's findings it had been decided that 5 users were appropriate enough for testing the application.

4.3 USABILITY TESTING

The prototyped was surveyed by 5 users, these users were to evaluate and go through the required tasks in order to achieve what is set out to do. The questions were put to the user in order to build up part of the conclusion and justify the techniques employed. From the literature it was realised and identified that certain areas of websites in e-government were not addressed and did not assist the user in fulfilling the goals in achieving the fundamental navigational aspects. Upon developing the prototyped application the literature has assisted in attainment of functional and navigational requirements, for example contact information in the relevant places as of when and needed. Incorrect user output of user in particular circumstances may cause hindrance or be the causation of undesired consequences in the database connection that queries data.

The survey carried out was designed to focus on whether or not usability standards and guidelines really do have an overall impact on the design of the graphical user interface, the results of the questionnaires have also assisted in the evidence found that interaction with a properly designed interface can give a clearer understanding of the process and help the user achieve tasks that they are suppose too. The application has followed the most essential usability and accessibility guidelines, the use of metaphors and human factors such as visual perception may help define a more efficient usability model that could be referenced to in the future as an acceptable model.

4.4 DEVELOPMENT METHODS

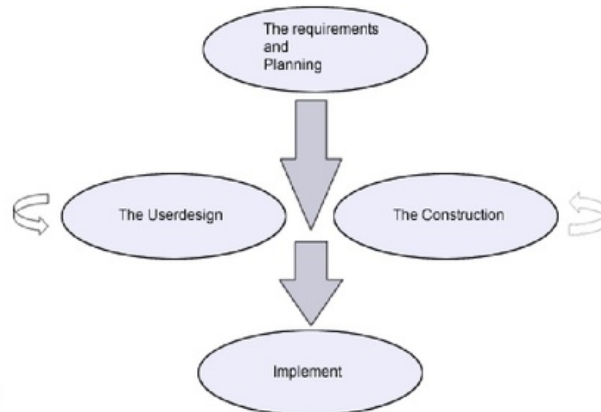
The Author has chosen the RAD (Rapid Application Development) as the most appropriate software development framework. The application has been recognised as having the ability to be broken down in to iterations. The model allows the faster implementation of the voting system requirements whilst maintaining use. The design of RAD has all the most prominent and important design aspects of a system prototyping method, this provides a product that is simple and employs a method for end user feedback [47]. The stages are represented below on how the iteration will work upon creating the e-voting prototype web application. The RAD methodology has been customised to fit to the specifications needed in order to have a more tailored application.

The stages:

1. The requirements analysis has formed part of the planning of the system, inferences made from the literature have been made in order to ascertain the usability issues with current e-voting systems in e-government.
2. The construction or element of the site follows after prototyping with metaphors and human factors, this is to establish the weak areas that would need improving upon.
3. Implementation of the site has been set up in a testing environment, observations are made in the testing of the site. Testing of all the requirements are crucial in this stage as to not cause inconsistencies.
4. The User design is deployed to a server after following a small iteration in the first stages, from here we can see that how functions and consistency of the requirements work.

The diagram below represents how the development cycle is followed.

Figure 1.



The e-voting
when a partic
been address

: scale
ations have
m that will

impact the usability of the system. The RAD framework uses a type of incremental model which bares similarities to an iterative process used in an agile development environment which requires collaboration with team members and the client. The collaboration of user and developer in the stages of development has allowed the user requirements open to change in the event that requirements have needed further enhancements.

The use of RAD has its advantages over traditional methods such as the waterfall model. RAD has enabled this project to define the structure and plan around the information for development. The short stages of RAD help to eliminate small problems that may occur during the development process or catch them early before further development has taken place. The traditional methods of the waterfall models follows a sequence of stages, the only problem with this that stopped the author using this model was that testing or implementation is done at the very end of the design sequence. The implications of deployment and testing at these late stages were that errors, requirements could have potentially caused a knock on effect and force the correction of other design stages thus adding on un needed time for redevelopment. The author has chosen to use the RAD model without the need for collaboration with users for requirements as these have been ascertained via the arguments in the literature. The advantages of RAD have been acknowledged and advanced via the possible disadvantages of traditional models. The advantages of RAD to the e-voting application are as follows:

- Less time on planning, more time is spent on development.
- Completion times more achievable.
- Identification of Errors and problems early.
- Better quality.

- Feedback for requirements in each iteration.

Certain disadvantages of RAD development methods could affect the overall design of the application. It has been important to establish this area in the iteration stages. A disadvantage in RAD is that Particular areas of the design may suffer if emphasis is placed too much on an element in the development cycle of the iteration. An approach of delivering equal balance to all elements as to not sacrifice important aspects of the e-voting application. Scalability of the system could be over looked on a commercial level, load levels and user traffic could hinder performance if an inadequate database cannot handle queries. The e-voting system is aimed at a large number of people, there for the system would have to be reliable. These disadvantages are considered fundamental to the overall design, each stage of the iteration has incorporated the following to oversee that they would not be compromised in a real world scenario.

- Create applications ability to adhere to scalability recommendations.
- User interface guidelines employed
- The Correct database application.

Utilising best practices and placing emphasis on learning from the disadvantages of prototyping will ensure that essential components are neither left out that could cause system time consuming errors.

4.5 SOFTWARE

4.5.1 Bootstrap, Foundation 5

According to Ofcom in 2014 61% of adults were the owner of a smartphone, this has slightly risen to 66% later in 2015[48]. The high percentage of adults that have smartphones which are web enabled justifies the importance of creating a responsive web application to be compatible with most devices. The importance of using a web app on different devices is also crucial to the success at the way in which usability is applied to the system.

Pinch to zoom is available on a lot of devices to compensate for non-responsive websites. Different viewports (screen size) display content in a different way unless the web app has been designed to adapt to different viewports. Using open source bootstrap software enables adaptable custom viewports to be created which can be spread across multiple devices. The most common resolutions or viewport sizes are notably desktop, tablet and smart phone. Modern and current mobile devices and desktops have advanced and requiring more pixels per inch [49]. Jakob Neilson recommends optimising for resolutions of 1024 x 768 [50].

The chosen source of the bootstrap responsive framework is Foundation 5 [51]. Foundation supports the most popular browsers, internet explorer 7 and 8 are no longer supported.

Browser/OS	The Grid	Layout/UI	JS
Chrome	✓	✓	✓
Firefox	✓	✓	✓
Safari	✓	✓	✓
IE10	✓	✓	✓
IE11	✓	✓	✓

Foundation 5 contains numerous cascading style sheets that can be referenced in an html page for example, `<link rel="stylesheet" href="css/foundation.css" />` will give access to the framework from the appropriate folders.

4.5.2 Visual studio

The preferred IDE for the development of this project application environment has been Microsoft Visual Studio [52], although this software could not assist in PHP development, C#, HTML and CSS styling could be tested at compile time and checked for thrown errors by the integrated debugging facility within visual studio. Overall this software maintains integrity of code and allowed the application to maintain optimum functionality. Visual studio is an industry standard piece of software. Other alternatives had been considered, some IDEs did not support the integrating ability of other computer programming languages, and separate components would have required their own individual IDE. The separation of different software could have developed missed errors in the code thus adding more time to create the application.

4.5.3 XAMPP

An all in one solution for the database integration (XAMPP) [53] to the website application had been the best option, this has been considered appropriate for the project because that each component is linked together and helped assisting in keeping the workspace decluttered but also version control of each component is kept in sync. There is other portable software servers available of the same caliber and the same all in one solution. The author has decided to use XAMPP on the grounds of familiarity and previous experience with the software.

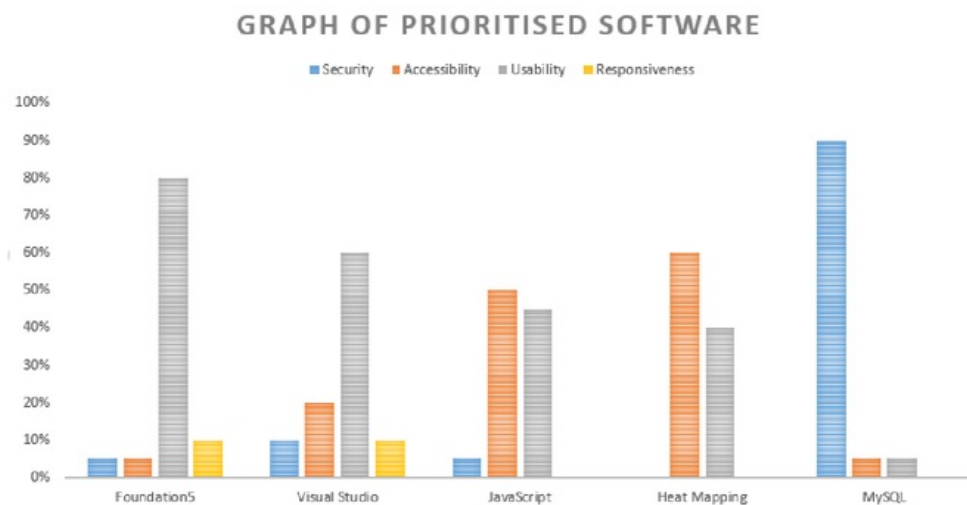
4.5.4 Software Framework

The table below shows different aspects of the implemented software, currently shows the importance of each component.

Table 1- Software priority ratings.

Software	Security	Accessibility	Usability	Responsiveness
Foundation5	5%	5%	80%	10%
Visual Studio	10%	20%	60%	10%
JavaScript	5%	50%	45%	0%
Heat Mapping	0%	60%	40%	0%
MySQL	90%	5%	5%	0%

Table 2- Graph representing percentage of priority.



Each component shows the percentage and importance of the each aspect. The application was built around these percentages to justify its

emphasis. Security had been considered as a low percentage in this case as industrial level expertise would be required to create a safe environment, financial costs also played a part in the implementation. Accessibility scored second in being in a priority, disabled users needed to be able to complete tasks that set out to do, consideration of visual impairment and related disabilities face usability issues if not prioritised. My SQL and PHP my admin run through Apache (XAMPP) scored a high percentage of priority secure the exchange of data inputted and data stored. MD5 hashing was essential to add to pass word encoding as this improved and to some extent prevented passwords from being decoded by a potential hacker.

4.5.5 Screen Sizes and Testing Mobile

The application has been designed to be on the most common versions of screen resolutions these being Desktop, Tablet and mobile. Screen resolutions are as follows:

- 1366 x 768, optimum and most current screen size as of Oct to Dec, 2015 for desktop pcs [49].
- 1024 x 768, tablets/ iPad [54].
- 1920 x 1080, iPhone 6 [55].

The developer's tools in browsers allow sufficient testing for different display resolutions and viewports. For the mobile versions of the e-voting app a testing server enabled the best method of checking the app adheres to usability and accessibility standards.

4.5.6 Additional Hardware

One piece of hardware was decided to be used for the project, the hardware is an eye tracking heat mapping device that shows where a user has observed on a webpage, screen shots etc. This hardware is a fundamental piece of equipment that is essential to providing a usability analysis. The Eye-tribe eye tracker is a part of the package with the heat mapping software, both of these worked together and provided the author with results from the eye gaze analysis.

4.5.7 Programming Languages Used In Development

- HTML: Builds the web page that is compliant with WC3 standards supporting cross browser compatibility.
- CSS: Assisted in styling certain elements of the webpage particularly Media Queries that help coordinate certain elements in a responsive environment dependent on viewport sizes

- PHP: for inputting and outputting database queries, also used for promoting security aspects of database attributes.
- JavaScript: Used for the dynamic aspect of elements that make them distinctive as opposed to static components.
- C#: Used for robust programming and more versatility within the e-voting system.

The programming languages have been chosen on the grounds they provide the best functionality for the prototype application. The author has familiarity with the chosen languages, other programming languages can be over complex and could create other problems such as compatibility and integration. The programming languages implemented are tried and tested open source software.

4.5.8 Heat Mapping Software

The application uses a software package that works in association with the heat mapping hardware. This software is highly appropriate as it allowed the heat mapping observation technique to track a user's eye movements and to see how well the usability standards applied have functioned in accordance to the requirements. Also used as part of the evaluation of the questionnaires and conclusion. The heat mapping software was advantageous to the project as it demonstrated how fast the learnability of the application was and by recording what the user looks at, viable inferences had been made from the observations of the user.

The eye gaze analysis shows a tracking heat map. As seen from the picture the focus has been primarily in the top middle section of the site.

- Grey or purple areas: Slightly noticed.
- Yellow: Acknowledgement.
- Red/ Orange: Highest part of attention.

Eye gaze analysis:

The heat map helped to determine what people see, this formed part of the analyses that had shown what the users can see or what they cannot see. From the findings the results had shown a heat map similar to that of Jakob Nielson's [56] .

Figure.1



CHAPTER 5

5 REQUIREMENTS

5.1 THE STUDENTS UNION

The student Union at Trinity saint David's University holds elections, once every year. These elections are to nominate a candidate and then elect who becomes president of the student union. Elections take place at the University at different locations.

- Swansea.
- Carmarthen.
- Lampeter.
- London.

During a couple of months before the student's elections, students are notified via email to place their nominations. The students cast their votes to their nominee in the relevant campus and the results are added up. Students are notified of the winner in due course.

The student's union voting system was chosen to implement improved usability, accessibility and some basic extra security precautions that could be beneficial for students. The student's union voting system had been discussed between the author and a student who actually used the system and displayed concern at the poor navigational aspects of the voting system and the legitimacy of the votes cast via a student number and date of birth. Anybody who was knowledgeable to another student's credentials could have chosen a candidate without the knowledge of another student. Later in this chapter as part of the user task analysis and user requirements, two sets of questions are given to various people. The first interviews are conducted around people's views and perception on e-voting, the interviewees had no experience of voting online except that of general elections. The second interview was set around a current voting system with students union, these questions that were asked revolved around students experience with the current e-voting system. The reasons for this was to conduct a comparative analysis of respondent's answers from each group. The results helped ascertain the reasons for people's views. These views were then finally categorised in to appropriate requirements for the system.

The arguments from the literature review had highlighted particular aspects of usability that had not been applied.

Examples of these are:

- **Poor interface design.**
Consequences: Confusion, navigation problems.
- **Poor Usability.**
Consequences: Tasks taking longer to achieve.
- **Poor affordance** (Human factors theory).
Consequences: Poor recognition of usable tasks.
- **Metaphors.** (Human factors theory).
Consequences: Failure to use metaphorical images or functions that the user could relate to a particular real life object or scenario to the user and form better functionality. Can also scale down text heavy and information.
- **Visual perception.** (Human factors theory).
Improper use of colours and inadequate layout.

5.2 USER TASK ANALYSIS

This part of the report consists of the requirements or the needs of the user in order to meet their expectations when using the new e-voting system.

This section also aims to establish what the users wanted from the system. Part of the user task analysis has been on the basis of interviewing potential users of a system in stages to ascertain an in depth knowledge of how the system worked best and that the user achieved the tasks they set out to do. The purpose of the interviews was to understand how people felt about the voting process and the ethical aspects of e-voting, by using this method of interviewing, more knowledge was able to be built about people's views and opinions in comparison to a simple yes or no which only defines for and against.

1. Aim of the short interviews: To draw a conclusion that would help determine appropriate user guidelines.
2. How many participants: 4.
3. How many questions 5.
4. Participant's Female age: 35, Male age: 36, Male 56, Female 24.

Focus group

Question1: Do you have a smart phone and how often do you use it?

First person said it is never out their hand, another replied only at breaks or after work, one said yes but only uses Facebook and the last person said yes to own a smartphone but didn't use the internet service and only used free Wi-Fi. The interviewees had no prior knowledge of an e-voting system in use but had voted in general elections.

Question 2. The motive for was to clearly understand if another viable option to vote was available would they be inclined to use it? When this was put to them the answer to this was yes by all three except for the older male who preferred traditional methods but could be swayed by learning more about the system.

Question 3: What do think you think of online voting compared to using a polling station?

The answer to this question was mixed, one person thought it was an easier option as opposed to voting at polling station, one person preferred using a polling station as it was a personal belief that it was more trustworthy, one person thought it saved a lot of time as opposed to traditional methods whilst another person was worried if they picked a candidate by mistake it could not be undone, this was a causation of concern that would be addressed in the user interface of the application.

Question 4: Would you trust your vote be handled properly by an online e-voting system?

One person said yes as it made life easier, another person said not unless there was some safety precautions in place, another person said yes they would on the basis it was advertised as being safe and legitimate the last person was worried they would not understand how to use it.

Question 5: Do you suffer with any visual impairments or any other disability that may cause an unpleasant experience when visiting websites online?

One user said that were colour blind and could not see reds or blues properly and another user said that too much text had caused them to navigate away from the page, one person said sometimes the websites they had visited did not display images correctly and not displayed alternative content the last person said only sites that are badly designed had caused them to go elsewhere.

5.3 CONCLUSION

The last question raised some important points about visual perception, hindrance to view or recognize particular aspects of a website or view accordingly could potentially see a fundamental aspect of accessibility and usability not fit for purpose. Accidental selections of candidates is an important factor that if it is not correctly displayed on the user interface then the integrity of the whole system could be compromised. Making the web application available to smart phone users could be seen a way of encouraging those who do not vote to have it more accessible to devices thus expanding reach to phone users. The aim of the e-voting system interview questions was to address any potential usability issues before designing had taken place. Valuable answers to these question will contribute to which usability guidelines will be applied based on the answers. Guidelines from Jakob Nielsen's website (NNGroup.com)[46] were looked at to which matched those concerns of the users interviewed. Visual perception forms part of the human factors theory that uses metaphors to assist users in relating metaphorical images to real life items or situations. Further analysis of the results from the questions have helped choosing the appropriate guidelines.

5.4 ANALYSIS OF INTERVIEWS

The series of questions established the following concerns:

- Safety

- Appropriate content
- Relevant content
- Accessible help
- Colour blindness
- Security
- Device compatibility
- Trust
- Learnability
- Alternative content
- Integrity

The next step in analysing the results was to understand each of the concerns and put in to relevant usability categories that address concerns. If certain aspects of the list did not fall in line with usability guidelines or accessibility requirements the remainders were incorporated in to the functionality to remedy the concerns found. Each concern has been looked at carefully to see which guidelines that would be appropriately suited to. This helped to ascertain the part of the requirements for users who have had no experience of such an online voting system that would make the system easy to use upon first interaction thus creating a suitable learnability environment.

Table.1

System Requirements	Usability Guidelines	Accessibility
Device compatibility	Learnability	Colour blindness
Integrity	Alternative content	Accessible help
Trust	Appropriate content	
Security	Relevant content	
Safety		

The percentages represent the most concerned issues amongst the people interviewed.

- System Requirements = 46%
- Usability Guidelines = 36 %
- Accessibility = 18 %

5.5 USABILITY ENGINEERING

5.5.1 Task Analysis

The Student election voting system is dedicated towards members of the University of Trinity saint David who wish to vote for the presidential candidate for the students union. The current system allows students or members to input there details to register and essentially cast their vote.

The current e-voting system by the Trinity Saint David students union [57] had been evaluated by a short questionnaire given to 5 of those who had actually used the system to cast their votes, some of the concerns raised were about integrity of the votes cast. Some of the answers are simple yes or no and others have more of a desire to give an explanation.

1. Aim of the questionnaire: To evaluate existing system that addressed users concerns.
2. Participants: 5.
3. How many questions: 5.
4. Male and female aged 33, 23, 19, 21, and 25.
5. Members of what organisation: Students.

Question 1: Was the user interface easy to understand?

- User 1. Yes but the process from A to B required to think twice.
- User 2. Yes with-out any problems.
- User 3. Confusion of credentials to be entered.
- User 4. Confusion about email addresses to input.
- User 5. Simple straight forward.

Question 2: Did you feel the security was up to standard? If not explain why.

- User 1. Only a valid email address to input required was a bit worrying as anybody could find out your credentials
- User 2. Concerns that email password is date of birth.
- User 3. Worries over how simple it is to enter credentials if you know that person or of them.
- User 4. Integrity questionable.
- User 5. Yes it is only a small election.

Question 3: Was the process of voting for your candidate a simple experience? If not explain why.

User 1. Navigation to the page problematic at times.

User 2. Once vote had been cast, redirection to an unfamiliar part of the system became confusing

User 3. No problems.

User 4. Ending the session to a different location became confusing.

User 5. Not really anything serious.

Question 4: Were there any problems with navigation to a page intended?

User 1. Only upon finishing casts of votes.

User 2. Straight forward to an extent.

User 3. Simple but could be improved.

User 4. Became confusing selecting candidate.

User 5. Straight forward enough.

Question 5: Please state any functions of the site that were lacking or not appropriate?

User 1. Login system could be an area of improvement, better validation techniques could have helped legitimacy.

User 2. Selection process should have been more detailed.

User 3. Viewing votes in a clearer way.

User 4. Poor candidate selection process, more info on the candidate was needed.

User 5. Proper email verification or pin number would be a good idea.

5.5.2 Evaluation of questions

After viewing the questions and analysing the results, some clear points were made by users that were important to them but also to the integrity of the vote. In the literature earlier in this report it was discovered that integrity could hinder legitimacy. A considerable concern is the login process that requires only simple credentials relating to the students identification. It was implied that users of the voting system would not have a hard time in finding out such basic information. The task of getting from A to B has been unsupportive by a navigation system that shows lack of proper affordance. The system goes against certain usability requirements for the user to get to the desired place with minimal effort.

The goals of the users of the users were defined by the following:

- Login to the site.
- Use Credentials that were only known to users.
- Simple navigation.
- Assistance if needed.
- A to B without unnecessary content.

- Redirection to appropriate place on website after finishing vote.

5.5.3 New tasks needed

To make complicated tasks of the current e-voting system more effective and simple to use, the current tasks have been designed to make the system more efficient in assisting user's desired goals.

The new tasks defined:

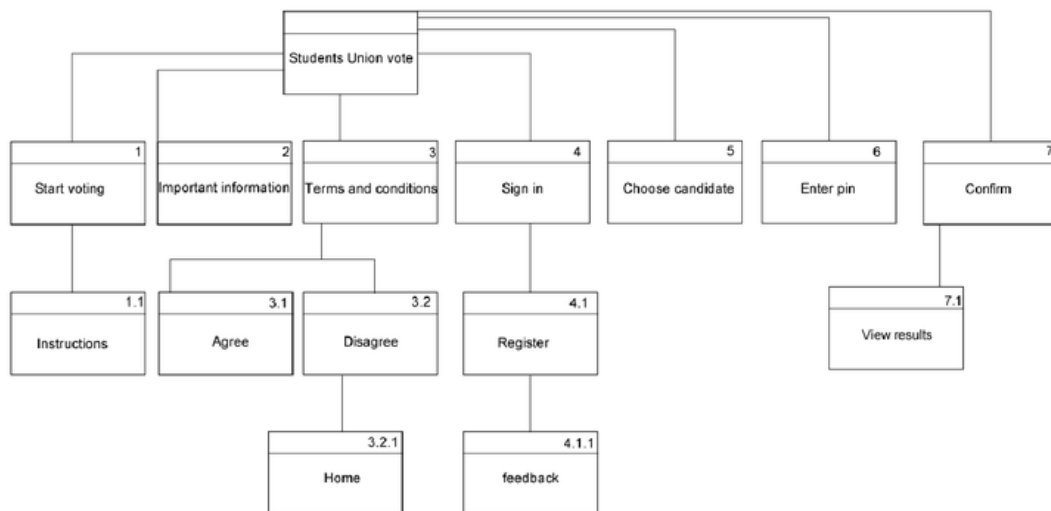
- Establish candidate's profile.
- Understand instructions.
- Agree to terms and conditions.
- Sign in/ Enter email address and password.
- Register if applicable/ enter email address and student number password.
- Choose candidate to vote for.
- Enter unique pin.
- Assess vote again.
- Finalise vote.
- Redirected to results.
- Auto logout
- Redirection to home page.

The concerns of users of the current system on the student union election website was security, by enabling students or members to register their details that match the database details. The added step of extra security was a pin number, the pin number would be sent in theory to the address of the user via post. The use of the pin makes it unique to that user and only the current student or member of the university assumingly would know it but not guaranteed. Although the pin number is not 100% proof it allows the concern to be addressed in a way that eliminates people from guessing other users credentials. If things go wrong with the pin or the website, there are contact numbers and instructions as part of the new tasks in the system, these will be demonstrated in a hierarchical user task diagram.

5.5.4 New Tasks of the System

The diagram shows the new system of tasks and its subtasks, all concerns discovered by users of the previous system had been implemented in to a more simple operation of tasks.

Figure.1- User task diagram.



From this diagram each task can be listed as:

- Start voting process.
- Read important information.
- View terms and conditions, Agree or disagree.
- Sign in.
- Register if applicable.
- Option to leave feedback for improving service.
- Choose candidate.
- Enter pin. Confirm choice, Cast vote, View results.

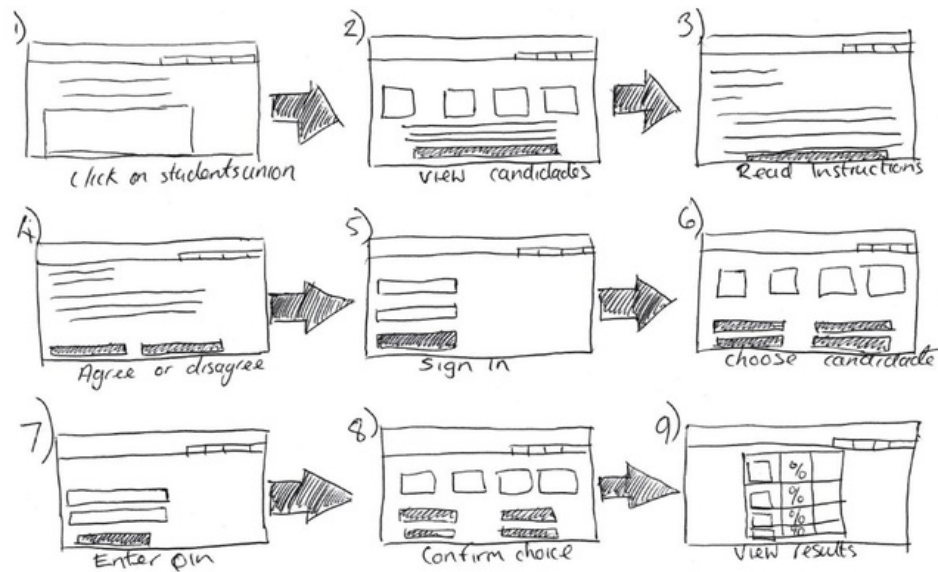
CHAPTER 6

6 DESIGN & IMPLEMENTATION

6.1 STORYBOARD

The challenge of designing the e-voting system had become apparent at the storyboarding stage. Storyboarding presented a realistic simulation of how the e-voting system would work. This initial first stage was important because without it the outcome would have been quite difficult to determine. The illustration below shows the final storyboard design after numerous attempts at applying a simple interface with the goals and tasks as set out in the task analysis.

Figure.1



The challenge this design presented was making the sequence of stages of each page as straight forward as possible. The design had followed usability requirements of allowing users to perform tasks without irrelevant information but help in the places available when needed [58]. The design had been viewed in the prospective of the user to make way for more a more optimal design [58] [59].

6.2 VISUAL PERCEPTION

At a sporting event in the USA a small test was done by reducing the strength of lighting and with the aim of aiding the faster recognition of objects, this proved to be successful by improving the visual experience and the senses of the participants. The influence of that test prompted to use the correct form of colours and not to impose them to strong in features or the background colour [60]. This process also helped with a better learnability of recognisable objects and features with in the web site, examples of these are buttons to navigate which are only one colour throughout the website. On hovering over the button it turns a blue.

6.3 FEATURES OF THE WEBSITE

6.3.1 Login

It was crucial for the website to have a login feature to give users a privacy in voting for their chosen candidate and a register feature to

sign up. It was decided to make members aware of the terms and conditions of the site and order its use in a legitimate way, this was important to emphasize credentials and liability of those credentials to deter others from using people's details even if they were ok about it, later the members would have to confirm by agreeing with these conditions.

6.3.2 Pin number

One of the most interesting features is the pin number, the pin number was designed to address legitimacy of cast votes. Whenever a user would choose their chosen candidate this would have to be confirmed via a pin number. The pin number was looked as being important, the pin number would have to be sent out via post so it is addressed to them specifically, only the member or student of the university should know that number to cast a vote.

6.3.3 Redirection and results

The last task of the website is to cast the vote and once this has been done the user is greeted with a thank you and automatically after five seconds redirected to the results page, the results page features a redirection to the homepage once the results have been viewed. The automatic redirections were to solve a problem of users having to locate the results manually. The results were put to the last section of the site to not influence tactful voting behavior.

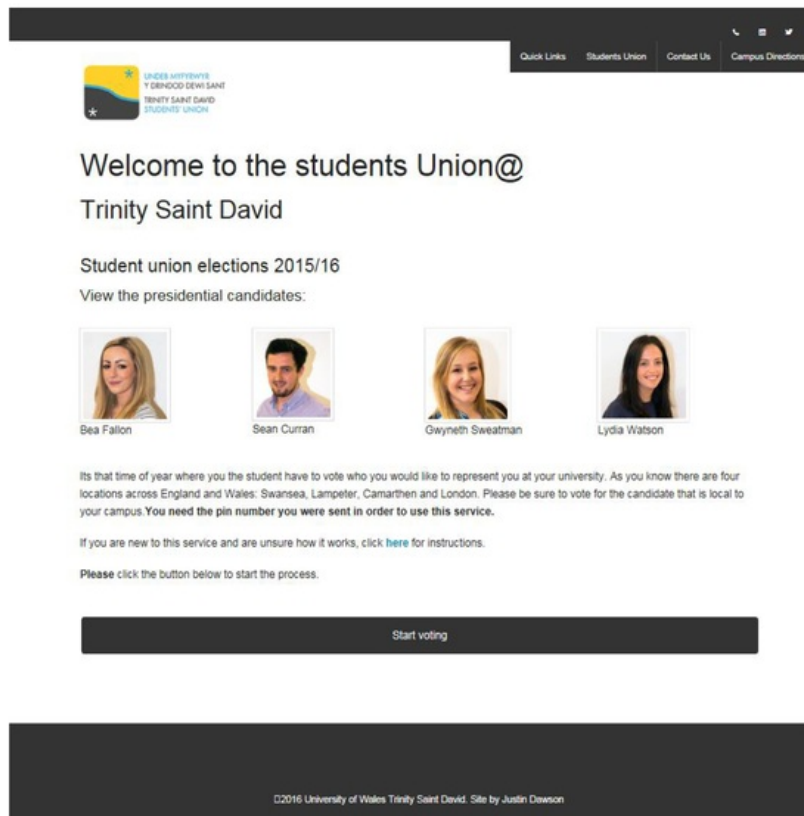
6.4 ITERATIONS

6.4.1 Iteration 1-Responsive framework implementation

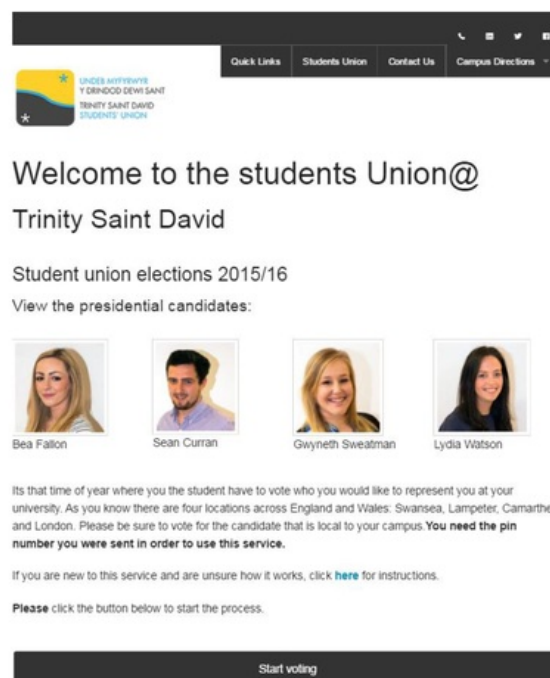
The website uses a responsive framework to make the site accessible from different devices with various screen sizes. To make the site adaptable to the different sized screens the basic headers and footers with links had to be tested. The sizes were tested with the developer's tool available by Google chrome [61]. This had to be the template that the rest of the information would fit in to.

The first size represents the largest resolution at 1366x768.

Figure.1



The second
1024x768
tested. This
commonly
Figure.2



screen size was
that had to be
size fits
the iPad.

The third screen was then checked for its responsiveness at a resolution of 360x640.

Figure.3



Home

UNDEB ARFFWRFFR
Y DRINDOD DEWI SAINT
TRINITY SAINT DAVID
STUDENTS' UNION

Welcome to the
students Union@
Trinity Saint David

Student union elections 2015/16

Please use this form to sign in:

Username or E mail ID

Your Password

SIGN IN

6.4.2 Iteration 2-Login and Register

The next iteration was the login and register section, a simple object orientated login feature was inserted in to the design, the functionality of this was in place to try and emulate a real life scenario where users would have to register in order to use the service with sessions. The integrity of the vote needed to use prepared statements in PHP for the prevention of SQL injections, this was an important piece because security had been a fundamental issue in an e-voting system as a whole. Although the security had been acknowledged it was difficult to get to a point where it was industry standard as that would have

required a team and a bit more experience in that field. The login register system was tested and proved to work [62] [63].

6.4.3 Iteration 3-Using pin to verify

The next stage was to create the voting buttons with the candidates name associated with them. This section of the system would then require a pin number in order to be able to complete the process. Once the pin number was entered correctly against the student number the process of voting would be finished. The pin was designed on the same basis as a login script. The form would execute the following code on button click:

1.

```
<form method = "post" action="studentverifyindex.php">
    <input type="submit" name="submit" value="Confirm pin"></input>
</form>
```
2.

```
<? php
    if (isset ($_POST ['submit'])) {
        $_name = $_POST ['user'];
        $_pass = $_POST ['pass'];
        $class = new Userpin();
        $class->login($_name, $_pass)
    }
?>
```
3. Query executed:

```
$stmt = $this->db->prepare("select * from users WHERE name=? and
pass=?");[64].
```

6.4.4 Iteration 4-Inputting data in table

In the final iteration of the system the user would be directed to the results page this was essential to show the user that there was data in those results and to show percentages. This was achieved by creating a separate PHP file and using the echo method to echo out an HTML table.

Shows connection and SQL query for table [65]:

```

$con = mysqli_connect("localhost","root","","testelection");

$startvote = "SELECT * FROM candidates WHERE name = 'bea'
or name= 'sean' or name='gwyneth' or name='lydia'";

$bea = $row['bea']; //Bea
$lydia = $row['lydia']; //Lydia
$sean = $row['sean']; //Sean
$gwyneth = $row['gwyneth']; //Gwyneth

    echo " <td><img src ='images/bea.png'></td>
    <td>Bea Fallon</td>
    <td>$bea ($bea_v)</td>
    <td>Camarthan</td>
</tr>";

```

6.5 CHALLENGES OVERCOME

One of the challenges overcome was the creation of the actual voting system and allowing a numeric integer to be stored in the SQL database in php my admin and be updated to a different value each time a user would vote. Each button had to represent a candidate and update a candidate's vote count.

Figure. 1

Click any one of the buttons below to select your candidate.

Please make sure you have your pin ready, otherwise you will not be able to vote.

If you are having problems please click [here](#)



An approach to this problem was the creation of conditional statements for each candidate button, below shows how the challenge was overcome.

```

if(isset($_POST['bea']))
{
    $sql = "UPDATE candidates SET bea = bea + 1 ";
    $conn->exec($sql);

    echo "<center><h2>Thank-you</h2><h1>You have voted for Bea
    Fallon<h1>

    <img src=images/bea.png><p>Your Vote Has been Submitted

```

```

    , Thank you. If you are not redirected automatically,
    Click the <a href='index.php'>link</a></p></center></p>";
}

```

Upon button click the following happens:

If the button *name*='bea' is pressed the condition *if(isset(\$_POST['bea']))* is called then the database connection *\$conn* executes *\$sql = "UPDATE candidates SET bea = bea + 1 ";* which adds a value of one in to the database table of candidates.

Figure.2

id	lydia	bea	sean	gwyneth
2	1	4	5	6

Careful programming techniques for button functions in php give way to conditional statements if there is more than one condition, this approach was a possible solution to the buttons being dedicated to individual candidates.

Another challenge became prominent was the prompting of a pin number to be entered when the user makes a choice on their candidate selection. The system is designed so that the pin number will allow the vote to be cast otherwise the user will not be allowed any further. This challenge was overcome by prompting the user to make their choice again after the pin number had been entered. The sequence below shows how this was accomplished.

User chooses candidate.

Figure.3

Bea Fallon	Sean Curran
Gwyneth Sweatman	Lydia Watson

Upon button click, form action posts to direction.php

```

<form action="direction.php" method="post">
<ul class="button-group even-2">
<p>Click any one of the buttons below to select your candidate.</p>
<p>Please make sure you have your pin ready, otherwise you will not be
able to vote.</p>
<p>If you are having problems please click<a href="#.php"> here</a></p>
<li><input type="submit" class="Radius Button" name="bea" value="Bea
Fallon" autocomplete="off"></li>

```

This section provides an automatic redirection with an animated gif loading image until the page finally goes to *studentverifyindex.php*.

```
if(isset($_POST['bea'])){\n    echo'<HTML>\n\n<HEAD\n\n<link rel="stylesheet" href="css/foundation.css" /\n\n    <link rel="stylesheet" href="mycss/style.css" /\n\n<META HTTP-EQUIV="REFRESH"\nCONTENT="2;URL=studentverifyindex.php">
```

The pin number and student id that has to be entered acts like a standard login box that compares the information to the database.

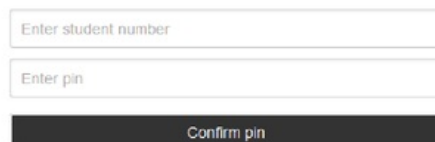
```
prepare("SELECT * FROM users WHERE name=? and pass=?");
```

The student number and pin are separated in another database. If in a realistic life situation the pin would be sent out and stored against the user's student number, this way the data is kept a little more secure.

Figure.4

Please enter your student number and pin.

Your pin was sent to you via post. If you did not receive your pin please click [here](#).



Enter student number

Enter pin

Confirm pin

Once the user enters the data and then it is compared to the database, user is directed back to make confirm their choice, successful voting then thanks the user for their vote.

Figure.5

Thank-you You have voted for Bea Fallon



Your Vote Has been Submitted , Thank you. If you are not redirected automatically, Click the [link](#)

CHAPTER 7

7 EVALUATION

To evaluate the e-voting system it was essential that the users of the system could use it accordingly to the usability guidelines documented later in this chapter. As discussed earlier in the development methodology eye gaze analysis was a testing foundation that could give results on user's behaviour, this data was recorded by the method of heat mapping.

This evaluation technique involved establishing the reasons for using eye gaze analysis. The motive for this technique is to establish the following [66]:

- See where the users are looking.
- For what length of time are users looking.
- Establish what areas of the application are missed.
- How the full length of the page is navigated.
- How much attention is distracted from items by others in terms of size?

An example of Jakob Neilson's eye gaze analysis shows where users have concentrated the most in that area [66].

Figure 1.



The picture represents the eye gaze analysis of the top of the page. This example shows how the tests to the eye gaze site will be conducted in a similar fashion.

Criteria for this test consists of qualitative data, the tests are subject to five users for this usability test. Quantitative data would require more users in order for the analysis to be benchmarked. Jakob Neilson states that:

"because the data is not consistent in quantitative research methods more users are required, if the problem is the same then 5 users are sufficient as the problems are usually discovered in the first 3 "[46] [66].

From the illustration by Jakob Neilson the image heat maps will vary slightly due to different software and hardware.

Each user has no knowledge of the site except a rough idea of the system, each person gets 30 seconds on the page as some of the pages require input of data.

Each page shown shows where the 5 users had observed.

Figure.1

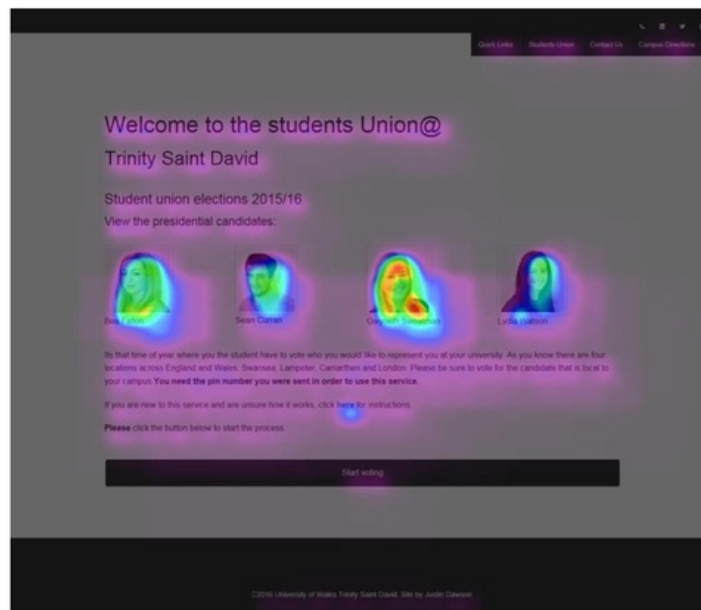


Figure.2

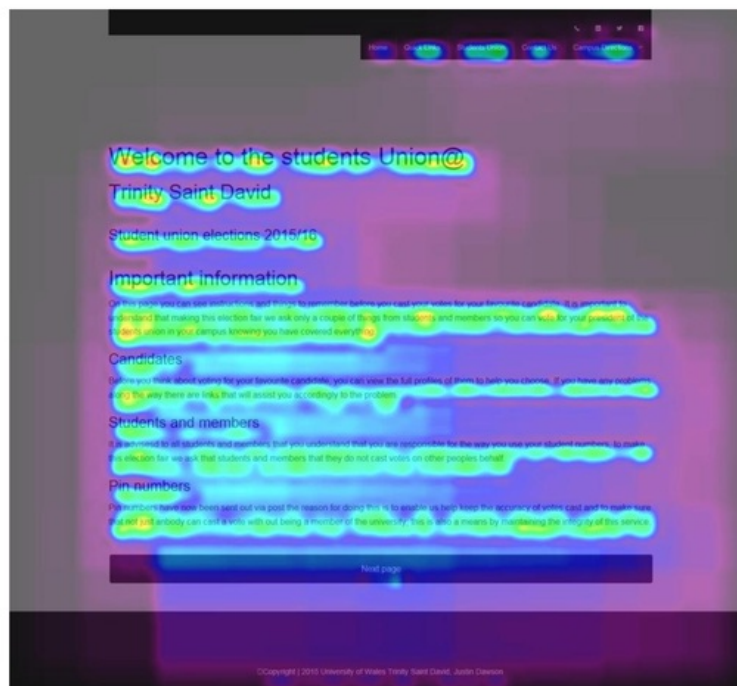


Figure.3

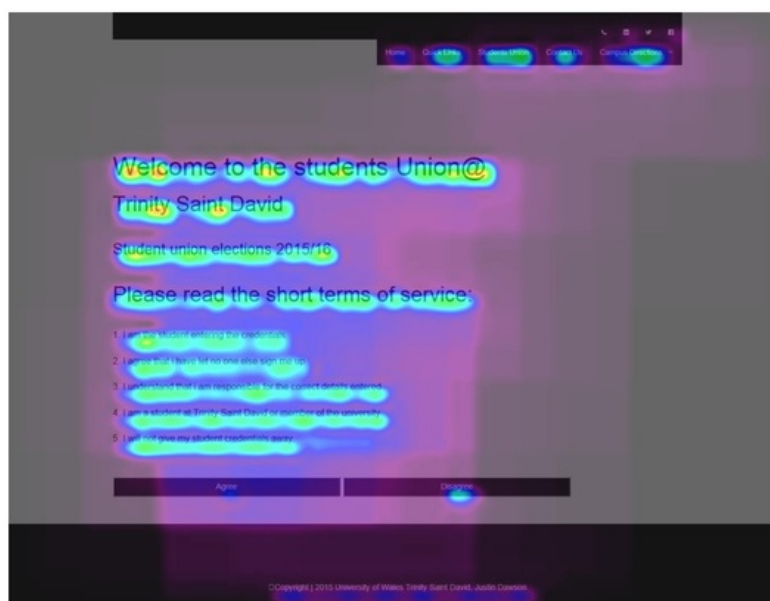


Figure.4

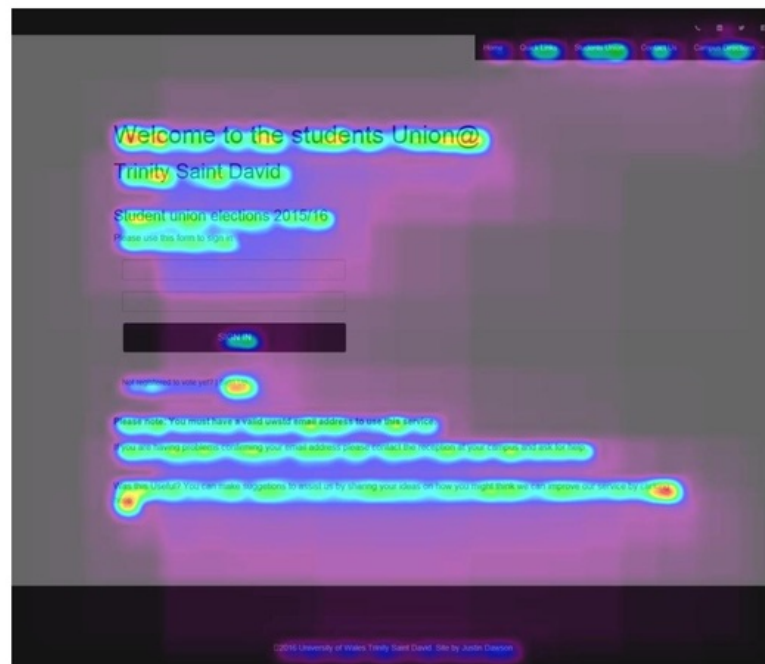


Figure.5

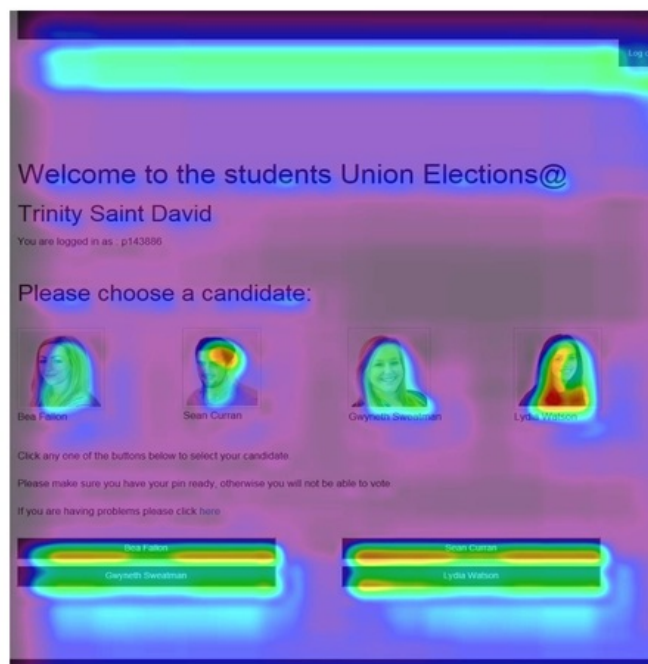


Figure.6

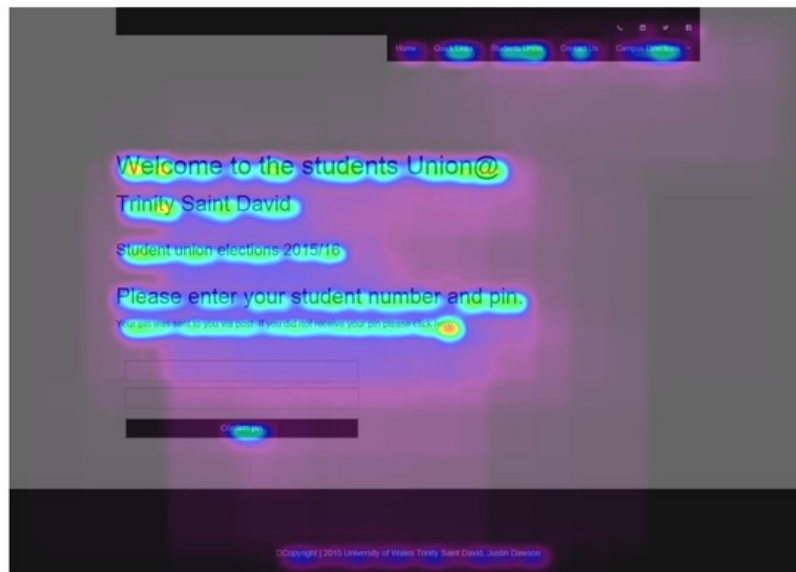


Figure. 7



7.1 FINDINGS FROM DATA

Figure 1-Start page.

The first impressions from data is that users had mainly focused on the images of the candidates, this could possibly be down to who they were thinking of choosing. Other areas such as links at the top of the page and main headers were briefly looked at. Noticeable is the option of the click here link for instructions, it was looked at with no obvious confusion and almost the first choice for help if needed.

Figure 2-Important information page.

The users view had become more intense over this next step of the site due to the green showing areas of interest quite prominently. Emphasis on the large font is shown as being red and orange and certain places highlighting some kind of importance. Other links at the top of the page have been studied but only briefly.

Figure 3-Terms and conditions.

The importance of the terms and conditions is shown by the users reading the majority of the text with some action over the buttons where the user can agree or disagree. Eyes have been very focused on just text only content without showing any drift towards any whitespace.

Figure 4-Login.

Shows prominence again on welcome to the university, it would be the only thing on this page that is getting more attention than the rest of the page.

Figure 5-Choose candidate.

Shows lack of interest and random eye movements as a whole, it is difficult to say here what the user's interest could accurately be. There is an observation closely tied in the pin number header of the page where by at the bottom this raises some interest.

Figure 6-Enter pin.

As the eye gaze analysis goes further in to the process of voting, there are similar patterns at the way in which users look at particular areas on the page. The header of the page gains lots of attention which could show that more important content could go here in a large font as opposed to the repeated welcome message.

Figure 7- Results.

The last area is the results of the system, this shows a lot of emphasis at the header again whilst all users have seemed to have been engaged in all the content and around the photos.

7.2 USABILITY GUIDELINES WALKTHROUGH

The website had used eye gaze analysis to view where users had been through there visit, the large fonts that had been used had a lot of attention paid to them. These guidelines offer a mixture of Jakob Neilson and ben Schneidermans recommendations that have been checked for during this project [67].

7.2.1 Learnability

The e-voting system had followed the rules of learnability, this guideline had been implemented in the design of each page. Each page was built to be predictable and to eliminate surprising factors that could have contributed to inconsistency with task goals. Learnability provides the user with expectant results of the system.

7.2.2 User Control

This concept was thought of with back buttons and logout features at particular stages in the voting process if the user had made a mistake during the process there were options in which the user could rectify.

7.2.3 Error prevention

This particular area was limited to one part of the system, the pin number functioned as a verification to the vote cast but also prevented the error of voting for the wrong person. Error prevention were thought of in login in, registration and pin verification. Instructions and important information pages were assistance in error prevention.

7.2.4 Recognition rather than recall

Buttons had been designed to be larger than average, the purpose was for the user to know that the colour and size represented a click event. Instructions were simple balder text within that offered assistance.

7.2.5 Aesthetic and minimalist design

Applying this guideline was essential to the overall layout of the system, an objective was to eliminate irrelevant information and only use what was needed. Banners and ads are all possible distractions for the user. Unnecessary information could have been a distraction, highlighting the argument in the literature about legitimacy.

7.3 CONCLUSIONS FROM DATA

The data from the heat maps had helped draw some positive conclusions about usability and how it is applied. The heat mapping concept helped discover the learnability of users when usability guidelines are applied. The heat mapping was designed as a usability testing tool to see also how human factors that had been implemented impacted the user's navigational movements. The information in the header with the largest font was not essential but users had taken notice from it. In the future those headers could be replaced with other information if the developer had to get a point across or use to another advantage.

The design of the website addressed issues with current e-voting systems that were discussed in the literature review. The author had learnt that a simple user interface that did not follow guidelines such as the Al Gore and Bush elections ballot would lead to consequences with possibly wrong votes being cast or similar related problems. The concept of simplicity, minimalistic and easy to understand design was confirmed in the heat mapping. The results demonstrated that the only information on the page is content that relates to what tasks of the user should be, the navigation was a simple walk through. One of the arguments of security could not be demonstrated in a heat map but the results had shown emphasis in that area where the user had to think.

The results had shown that users of the system were less likely to make a mistake of choosing the wrong candidate if buttons were prominent and sufficiently spaced. The literature had made the author acknowledge how confusion over irrelevant information could make the casting of a vote become problematic. The results show that adhering to guidelines to ones that match the system and real world make information appear more natural and in a logical order [25].

The data from the eye gaze analysis had shown that when the usability guidelines were followed and implemented that the research in the literature review backed up and confirmed the results. This means that problems people had with websites and ballot papers were collected as data, this helped form the basis of the correct model of usability to apply.

One of the objectives was to analyse current and previous e-voting systems, the analyses had shown that systems had major flaws in its design. Lack of knowledge in a key area such as guidelines for usability, it was a surprise to find that such guidelines that had existed for the prevention of bad design (Jakob Nielson's 10 heuristics [25]) were not implemented. It almost seemed that the internet era and shown the incompetence of developers who had either not caught up with advances, or clients that were oblivious to their own needs.

7.4 WERE OBJECTIVES MET

The objectives were met with greater expectation than first thought, the main objective was to discover the arguments that would be decided of the overall design of the system could address these. The arguments presented by the challenges people had faced when using websites, voting via the ballot or just general issues of usability. Some forms of usability problems were a confusing navigational sequence, poor design that led to wrong votes being cast and help that was not there when needed.

7.5 WERE THE AIMS MET

One of the aims was unfortunately not met, this was involved by conducting a survey to find more about voting behaviour. The reason this was not achieved was on the grounds that later in the project it was replaced by a questionnaire that could bare similar results by understanding user behaviour of a system. However there is a positive outcome to one of the aims not being accomplished, the questionnaire yielded valuable data that aimed at users which had used a current e-voting system in the student elections.

7.6 THINGS TO BE DONE DIFFERENT IF DONE AGAIN

The data and results have provided valuable and essential conclusions as to whether usability can have a real impact on the lives of users when using some form of web service or voting system. If things were to be done differently it would be implementing actual downloadable software that could be tested on a Windows platform or even a smart phone such as Android. The motive for this would be to test the security aspect as software could be more robust and would be compared to using web based apps. Hackers have proved they can hack big companies such as eBay and amazon as discussed in the literature. Those companies are web based but also have software built for different platforms.

Another addition to doing things differently would be a survey to find out if users have used a voting system and what their thoughts are of those systems in place as far as security is concerned. The results would determine how security could be improved by implementing advances in the C# development language with a 256bit encryption technique.

CHAPTER 8

8 CONCLUSION & RECOMMENDATIONS

8.1 CONCLUSION

The aims and objectives were met by the e-voting system, the system used recommendations similar to that of Jakob Neilson and the results had yielded viable data that could be used in a similar area of study.

This research in this project agrees with other researchers that the importance of design plays a big role in the way that the design influences users, this research cannot agree that the online voting system in Estonia should be scrapped as the tests did not involve and government officials that could analyse the data from those tests.

This report had was designed to analyse e-voting and the usability of e-government. To address the problems associated with usability issues the literature review would be key in providing arguments that were backed up by other authors and also relevant cases. At the very beginning of the literature it describes how democracy had fought for autonomy via the ballot box. Autonomy had eliminated corrupt politicians by preventing illegitimate votes and giving the wrong people the undeserved power in government. The evolution of voting had proved that it had to keep up with different means and modern techniques to achieve a successful election, whether big or small scale.

Even today after the reform act of 1832 legitimacy is still called in to question whenever a different system is used or experimented with that still has to provide the same outcome. The interfaces of ballot papers helped achieve an objective in this report, upon recognition of failures in design and what could be learnt from them in order to provide an interface that does what it is supposed to. An objective achieved with this was implementing Jakob Neilson's approach to a minimalistic and a less aesthetical user interface to provide an appropriate functioning system.

In order for the e-voting system to work lessons had to be learned from the consequences of poor planning as discussed in the literature, this was about confusion over the layout in the Scottish referendum where by candidates didn't make the correct choice. Poor planning had also contributed to the thousands of spoilt votes. Jakob Neilson had described usability as:

"a quality attribute that assess how easy user interfaces are to use"
[67].

This guideline observed and implemented allowed usability to be applied in different ways that would help users start and finish tasks successfully. Learnability seemed an obvious core objective of the design of the e-voting system. Without users feeling confident to execute tasks accordingly and achieving those tasks in little time as possible, then certainly the objectives would have not been completed.

The questionnaire which was carried out on two different levels, it organised what parts of the system would be given priority over others. The results of the questions ascertained requirements through relevant questions, those questions were related to the current functioning of the student union elections at Trinity Saint David's University. The questions had helped to apply usability in terms of efficiency and prioritise on the requirements where they scored strongest.

Successful analysing of the questionnaire included accessibility for users that had disabilities. Users that had difficulties with colours and other relevant visual impairments presented further challenges to the design of the student election system. Fonts, colours and font sizes challenged further the usability of the site. Without the implementation of these considerations the student union voting application would have failed a major objective.

8.2 RECOMMENDATIONS

The main recommendation given would be to extend research further to a group research project if e-voting was to be introduced as part of government elections. The study would benefit from a larger number of users on an e-voting system that was based on a general election, the reasons for this is that it would take into account the age ranges, people with certain requirements and accessibility. Further recommendations would be to have a student conduct a feasibility study as part of a major project to see if the cost of such a system would be viable at replacing paper ballots at voting stations.

The recommendations that could benefit this further would address topics in more detail that was not done so by the author. Usability is not an official standard that must be implemented by law nor compulsory, but it helps a great deal when trying to save valuable time or assist developers who want to get it right almost first time.

The recommendations for more up to date usability guidelines that should be applied when contemplating building a website or web app for a client.

If considering usability for users:

- Learnability: Consider learnability factors that help a user complete tasks in the shortest time possible, mistakes in this area could deter users from using your site or app again.
- Assistance and errors: If a user runs in to difficulties from an error, can they recover from it, is there assistance to help the user recover quicker in the event of big mistake through no fault of their own.
- Memorable: Applying popular metaphors could assist users and help them recognise familiar buttons as with other technologies, if a user uses a recycle bin to delete are there other metaphors that can help a user find their way around your site.

Further recommendations would be to investigate further if prototyping a website could supersede storyboarding, the purpose of this is to define guidelines that should be applied and to rid guidelines that are not needed to generate a more official and efficient model.

CHAPTER 9

9 REFLECTION

This project helped my personal development, it taught me to not be bias and to remain neutral until what would deem to be facts are established first. This approach has help me to implement this in to my judgement when sometimes I could just be outright stuck on one thought. Being neutral is a powerful tool that could help make a person's decisions more satisfactory with a thorough thought out analysis.

Researching literature has shown that arguments with in can help in a way that could determine a better outcome for a design, survey or questionnaire. If the arguments are structured correctly a case for your cause can be justified more effectively.

I had also learnt how difficult it was to design a product and to rectify somebody else's product. After completing the design there are areas I know that could have been improved such as security features. It was difficult to sacrifice parts of a system to make a working prototype that functioned without them, I think this was partially down to me personally having high expectations of myself.

Before I had started university I could never of prepared myself for how much professionalism assignments like this would require, I am overwhelmed by how much as person I have grown through learning about literature, studying long hours, investigating issues around the related subject.

This major project has gave me a boost in the things I really believe in, writing about a political issue such as voting and then implementing a product to justify the problems in current e-voting systems gave me huge amount of knowledge that I would sincerely like to share with those of a similar interest. I faced problems with the e-voting system in terms of building and creating the end product, these were overcome by learning more about databases and object orientated php. Some of my decisions had changed through the project enabling me to accomplish my goals that I set out for myself. Usability engineering has been fascinating on how simple concepts can make such a huge differences to an application, the implications of this could be large financial savings and also avoiding accidental discrimination in certain circumstances. The project for me is a big achievement that has taught me how to be professional but also to prepare me to use these skills in my new chosen career.

CHAPTER 10

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CHAPTER 11

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