# Voting Machine for People with Disabilities

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## ABSTRACT

In a Maltese election, when a citizen is unable to cast a vote independently through the available methods, the assistance of an electoral representative is provided. This procedure forces the citizens to disclose their vote which compromises the right to a secret vote.

This study has created an accessible interface for a voting machine through an iterative approach. With the involvement of experts in accessibility and users from the target audience, the low-fidelity designs evolved into a high-fidelity prototype through a series of refinements.

All testers were able to cast their intended vote within five minutes when using the high-fidelity prototype. The participants also gave high scores in a questionnaire which measures the user satisfaction.

## 1 Introduction

The main method of casting a vote in a Maltese election is by paper ballot. The alternatives to this are a braille ballot and an audio guide. Less than half of the disabled community are able to cast a vote without assistance using these methods [1]. Casting a secret vote is a fundamental human right [2] which these citizens are being refused. A voting machine with an accessible interface would enable the casting of a secret vote by these citizens.

This project took an iterative and participatory approach to user interface design. To start off this process, three initial designs for a voting interface were created. Experts in accessibility helped identify a number accessibility and usability issues. The designs were developed into higher fidelity and tested by users. The testers were chosen from the target audience in order to ensure that the interface is truly accessible. The feedback provided by the testers and the measures of usability guided the development of the final high-fidelity prototype.

## 2 Background

Single Transferrable Vote is the voting system currently being adopted in Maltese elections. Voters must rank the candidates in their preferred order. When the votes are being counted, the vote is transferred from the candidate with the first preference to the candidate with the second preference and so on. There are a set of rules which determine whether or not the vote is passed on but that is outside of the scope of this project.[1]

The paper ballot is the principal method of casting a vote in Maltese elections. The voter is given a ballot containing the candidates which are up for election. These are grouped by party and sorted in alphabetical order by surname. Voters must put a number in the empty box next to the candidate's details. This number represents the preference they would like to give that candidate. There are many ways a vote may be disregarded because it is invalid. For instance, repeating or skipping a number in the sequence [3].

More than half of the disabled community cannot cast a vote independently in a Maltese election [1]. In a study conducted by the Commission for the Rights of Persons with Disabilities, 60% of people who need assistance to vote would prefer to use technology if this enabled them to vote independently. Furthermore, 64% of people who can vote independently would also prefer to cast a vote using technological means. The participants of this study stressed the importance of having an intuitive interface if such a system would ever become a reality.

[1] Refer to https://www.electoral-reform.org.uk/voting-systems/types-of-voting-system/single-transferable-vote/ for more information

There are voting technologies beyond the paper ballot being used around the world such as punch cards or lever machines. Electronic voting machines were first introduced in the United States of America in 1976 [4]. Since then, more countries are using electronic means to cast a vote such as Japan and The Netherlands [5]. Direct Recording Electronic (DRE) voting machines are touchscreen machines which record a vote by tracking what is being pressed by the user and storing it [6]. Research found that DREs have many advantages over traditional voting technologies. For instance, [7] reported that DREs are comfortable, make text more readable and error correction is easier. Participants in this study were confident that their intended vote was recorded. This is crucial as it may affect future voter turnout and the endorsement of the election's outcome [6], [8]. DREs have a higher average usability rating when compared to other voting technologies [6].

The Diebold AccuVote-TS is one of the most used DRE voting machines. Of the 47 participants in [8], all but one managed to cast their intended vote using AccuVote-TS. Furthermore, in the same study, the system's comfort averaged 7.7 out of 9. Studies which compare different DREs found that an automatic advancing system make the users feel unsure of who they voted for [5].

Zoomable is a voting prototype developed at the University of Maryland. This system is similar to AccuVote-TS but it has a more flexible navigation structure. To change a vote on Zoomable, the voter only has to tap on the intended candidate. Whereas on AccuVote-TS, the voter must first tap on the currently chosen candidate to deselect it and then tap on the new candidate. The participants of [9] found this unintuitive. However, [5] reported better accuracy rates when changing the vote using AccuVote-TS.

It is of utmost importance that any voting technology captures the user's intended vote as it has the potential of swaying close elections. When comparing accuracy, AccuVote-TS performed best out of all competitors [9]. This system was tested by blind voters in [10]. The study found that 8 of 13 participants required assistance when trying to cast their vote. Furthermore, AccuVote-TS offers only a few accessibility features, including magnification, audio and a keypad for navigation [11]. A more recent voting machine which is also developed by Diebold, AccuVote-TSX, has added features such as colour contrast voice prompts [11].

# 3 Aims and Objectives

The main aim of this study is to design an interface for a voting machine which will enable the casting of a secret vote by those who are not able to do so using the methods provided at present. This includes people with visual, motor and cognitive impairments. To achieve this, the following objectives have been established:

- O1: Create designs for an accessible voting interface based on previous research and accessibility guidelines
- O2: Determine which evaluation techniques will be used to identify issues in the interface
- O3: Identify the measurements which will be used to assess the usability and accessibility of the prototypes
- O4: Attempt to create and evaluate a usable interface for a designated voting machine which disabled persons can use to vote independently

# 4 Design

This section will discuss the thought behind the initial designs. All three designs were meant for touchscreens. These designs were depicted as wireframes with arrows and textual annotations to convey the system's behaviour.

## 4.1 Design 1

The main inspiration for this design is the paper ballot used in Maltese elections. The information displayed and the structure of the candidate list will mirror that of the paper ballot as seen in Figure 1.

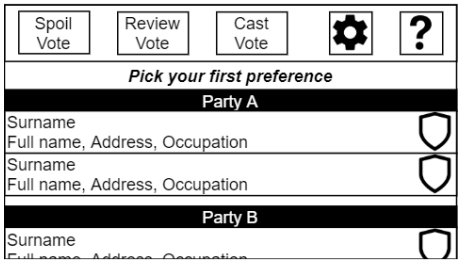


*Figure 1 - Ballot design for Design 1*

The system will ask the user to choose a candidate to assign a preference to. First, the user will be asked for the first preference, then the second preference and so. Once a candidate is assigned a preference, they will no longer be visible on the ballot. This procedure is a precaution taken to keep the vote valid such that no candidate is given more than one preference and no preference is skipped in the sequence from 1 to the highest preference assigned. Each time a candidate is selected, the user is asked to confirm the candidate-to-preference allocation. This helps the voters feel more certain that their intended vote was cast.

A navigation bar is located at the top of the screen. The first button will cast a spoilt vote. The second button will redirect the user to a page where the candidate-preference pairs are displayed in ascending order of preference. The primary purpose of this page is for the user to check the vote before it is cast. The user can also unassign a preference assignment or delete all candidate-preference pairs in this page. When the user returns back to the ballot screen, the user will be asked to assign a candidate to the deleted preference. The next button in the navigation bar will cast the vote containing the candidates which have been given a preference up to that point. Once the vote is cast, the user cannot make changes to his vote. The last two buttons redirect the user to the settings page and the help page.

## 4.2 Design 2

This design is modelled on the paper ballot used in Cambridge, Massachusetts for city council elections. Each horizontal line of this ballot has a candidate's name and a list of circled numbers from 1 to the number of candidates up for election. To assign a preference to a candidate, the voter must find choose the circled preference number in line with the candidate's name and fill it in. To adapt this to a touchscreen, the voter will tap the circled preference rather than fill it in. This action will turn the circle's background black and the text within it white so that the user can easily identify the preferences which have been assigned. Circled preferences symbolize that the preference is assigned to another candidate. This is visualised in Figure 2

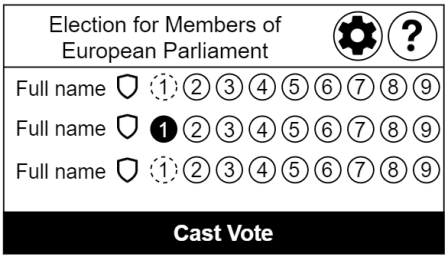


*Figure 2 - Ballot design for Design 2*

A button is statically placed at the bottom of the screen which will be used to proceed with casting the vote. When this button is clicked, the user will be shown the candidate-preference pairs that have been assigned so far. If the user has missed some preferences, these will be highlighted in red. Figure 3 is an example where the user has only assigned the first and fifth preference.

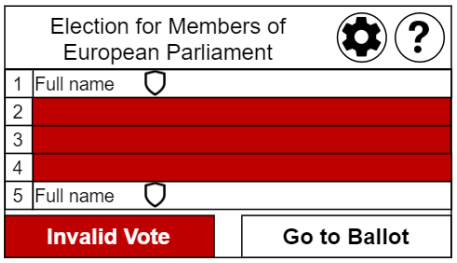


*Figure 3 - Display of an invalid vote*

## 4.3 Design 3

Unlike the previous designs, this design is based on previous voting research rather than existing ballots. The research in [12] found that 70% of respondents have casted a straight party vote at least once. This means that the voter gives his vote to all members of one party and none to candidates of other parties. Therefore, this design included the option to filter candidates by party.

The preference assignment procedure contrasts that of the Design 1. The user will

pick a candidate and then pick a preference to assign to that candidate. This method is identical to the one used in [13]. Naturally, this is a more flexible navigation sequence. Zoomable, a voting prototype for the American voting system, gives a similar overview of candidates and allows the user to navigate through them freely rather than in a predefined sequence.

In order to eliminate the possibility of having multiple candidates with the same preference, the preferences which have already been assigned will be greyed out and not selectable as seen in Figure 4. Contrary to Design 1, candidates assigned a preference will still be visible on the ballot along with the preference assigned to them. To change the preference assigned to a candidate, the user must select the candidate and choose a different preference from those available. This reflects the vote changing process of Zoomable.

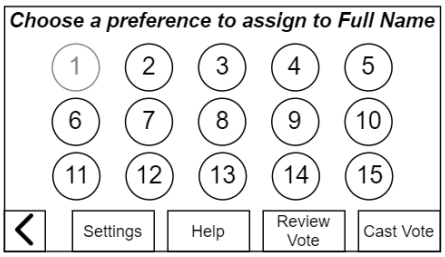


*Figure 4 - Preference selection screen for Design 3*

The navigation bar is placed at the bottom of the screen. It includes a back button and buttons that redirect the user to the settings page, the help page, review page and a button to cast the vote. The review page will hold a list of candidate-preference pairs in ascending order of preference. When the user taps the cast vote button, the screen will ask for confirmation before casting the vote. However, if the vote is invalid, a detailed message will be displayed guiding the user to validate the vote.

# 5 Evaluation and Results

## 5.1 Expert Reviews

The initial designs were evaluated by five experts in accessibility using the expert review technique. The experts were shown the wireframes one by one and a detailed description was given on each. The participants, during or after the explanation, pointed out some pain points in the design. They sometimes offered possible fixes to these issues.

### 5.1.1 Results of Design 1

The main issue identified was the repetitive confirmations for preference assignment. This was found to be tedious by all experts. It was suggested that these confirmations are removed and replaced with an on-screen button in order to maintain the manual advancement mechanism. One expert suggested that an undo button should be included to cancel the last preference assignment.

The experts noted that a candidate portrait will be helpful for persons with intellectual disabilities to recognize which candidates they want to vote for. Another common comment was the unethicality of the spoil vote button. Some experts noted that this function should be included in the system but more discretely. Sometimes the experts had contradicting comments. Two experts debated whether having the candidate be hidden from the ballot is counterproductive. It was decided that this element would remain unchanged so that the users can have their say about it.

### 5.1.2 Results of Design 2

This design was the least accessible according to the experts. Multiple reasons were given for this. This design was deemed too complex for persons with intellectual disabilities. In addition to this, it will be difficult to portray a clear mental image to persons using the screen reader. Furthermore, it was pointed out that, by electoral law, the voter must be given the chance to assign a preference to each candidate. This means that if 20 candidates are running in an election, the numbers 1 to 20 must be displayed on the screen. This would undoubtedly result in an extremely cluttered screen. For these reasons, this design was disregarded from the rest of the study.

### 5.1.3 Results of Design 3

The filtering functionality in this design received mixed opinions. Some predicted it would be helpful to have shorter lists of

candidates while others thought it would be better to have the full list of candidates always available. One expert pointed out that the preference assignment process may be too repetitive. These elements were kept for users testing to get the users' opinion.

Some issues were raised by multiple experts. The text used in this design was considered long and complex. Moreover, the chosen preferences should be hidden rather than greyed out to make it clearer to intellectually impaired voters that the preference cannot be chosen.

## 5.2 First iteration of user testing

After the expert reviews, the designs were refined and developed into web applications for user testing. Design 1 and Design 3 were developed into Prototype A and Prototype B, respectively.

The evaluator met with the five participants of this evaluation for one-on-one sessions. Each tester was given the same three tasks: cast the specified vote, make changes to a vote and cast a protest vote. The candidates and the preferences to be assigned were predefined to replicate a real-life scenario. The tasks were carried out on both prototypes by all testers. The evaluator verified whether the task was finished successfully and measured the time taken to compete each task. These are the effectiveness and efficiency measures, respectively. The System Usability Scale (SUS) was used to extract the user's satisfaction with the system.

### 5.2.1 Results

All testers but one managed to complete all tasks successfully. One of the physically impaired testers failed to make his intended changes to the vote on Prototype B.

The mean time taken in seconds of each task on each prototype is shown in Table 1. There was not any statistical significance between these, but the mean times show some discrepancy between the prototypes, especially in task 2.

| | Mean time taken on Prototype A | Mean time taken on Prototype B |
|---|---|---|
| Task 1 | 195.4 seconds | 197.4 seconds |
| Task 2 | 102.5 seconds | 153.75 seconds |
| Task 3 | 18.6 seconds | 25.2 seconds |

*Table 1 - Mean time taken per task per prototype*

Both prototypes were given very high scores for user satisfaction. Prototype A obtained 92.5 out of 100 while Prototype B achieved 91.5 out of 100.

There were no great discrepancies between the usability measures of the prototypes. Given the tester's feedback, it was decided to take the more favoured aspects of each prototype and join it into one final high-fidelity prototype.

## 5.3 Second iteration of user testing

This round of user testing was planned to be identical to the first. However, due to restrictions brought about by the Covid-19 pandemic, the testers were given another two options to evaluate the interface. Ideally, the testers would use a tablet and carry out the same procedure at home. The session would have to be recorded and sent to the evaluator to extract the necessary measures. Another possibility was remote testing on a laptop or desktop. Since the device is different, efficiency and effectiveness were not gathered for this option. The original testing plan and the remote tablet testing had two participants each. Three participants took part in the laptop tests.

### 5.3.1 Results

The four testers that were assigned the tasks completed them successfully. The mean time taken for each task is equal to 191.25 seconds, 84.5 seconds and 51.25 seconds, respectively. When compared to the previous prototypes, task 1 and task 2 had a lower mean time. However, task 3 took longer to complete on average when compared to the other prototypes. This was because the users were given the ability to add a comment to a protest vote. The user satisfaction was measured across all seven participants. The average

score for this prototype is 95.4 out of 100 which is a slight improvement over the previous prototypes.

# 6 Future work

The main drawbacks of this research are the small number of testers and the unideal circumstances in the second round of user testing. Future research should attempt to test the final artefact with a larger testing group in ideal conditions. Furthermore, the participants should have different levels of IT literacy and a wider range of disabilities.

# 7 Conclusion

This project encapsulated the user interface design process for creating an accessible interface for a voting machine. Three initial designs were created and, with the help of experts in accessibility and the target audience, they were iteratively evaluated and refined to create one final high-fidelity prototype.

All the objectives have been reached. The final prototype enabled the participants of this study to cast their intended vote independently. Furthermore, they were all able to do so in less than five minutes. The average time taken to cast the predefined vote using this prototype is 3 minutes and 19 seconds. The scores obtained by System Usability Scale show that the users are satisfied with the interface.

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