Electronic Voting for All: Co-creating an Accessible Interface

Daan van Eijk(✉), Johan Molenbroek, Lilian Henze, and Geert Niermeijer

Delft University of Technology, Landbergstraat 15, 2628CE Delft, Netherlands
d.j.vaneijk@tudelft.nl

Abstract. The study investigated the extent to which electronic voting is accessible to Dutch voters, especially the visually impaired, those with low literacy, and the elderly. Together with the different user groups, a series of electronic interfaces were developed and simulations of a vote-printer were built to run tests on large numbers of participants. The interface consisted of a card reader, a touchscreen and a printer; audio support was available via a headset. For participants with disabilities, the independent variables were visual impairment and low literacy. For elderly participants, the independent variable was age. All participants were asked to make specific choices on the screen and to check the printed result for their choice. As reference, they were asked to vote using the current Dutch ballot paper/red pencil system. The criteria used to determine the accessibility of both systems was: does the printed ballot match the intended vote? The vote-printer significantly increased independent voting by the visually impaired, however this was not seen for the low-literacy group. For the elderly, the use of a vote-printer with electronic interface is equally as accessible as the current paper ballot. All three groups reported using a vote-printer with electronic interface to be easier than the current paper ballot. The study confirmed that co-creating with intended users in the early conceptualization phase is key.

Keywords: Accessibility · Electronic voting · Design for all

1 Introduction

This study investigates the extent to which an electronic voting system is accessible to all voters in the Netherlands; specifically the visually impaired, those with low literacy, and the elderly.

The Dutch government aims to stimulate independent voting by as many citizens as possible. Voting using an electronic interface including images and audio support could enhance accessibility to those with disabilities, specifically the visually impaired (±1.3% of Dutch population) and those with low-literacy levels (±7.6% of Dutch population). On the other hand, introducing an electronic interface should not reduce accessibility for other voters, specifically the elderly.

In order to investigate the accessibility of an electronic voting system, the Ministry of the Interior and Kingdom Relations (BZK) commissioned Delft University of

S. Bagnara et al. (Eds.): IEA 2018, AISC 824, pp. 800–809, 2019.
https://doi.org/10.1007/978-3-319-96071-5_84

Technology (TUD) to study and design possible interactions and to develop a test set-up. In co-creation sessions with representative users a ‘vote-printer’ simulation was developed, to be used in a first test. The results were analyzed by TUD and reported [1].

Based on this initial research, the simulation was adjusted and a second test was developed and analyzed by the ‘Expert group electronic voting and counting at the polling station’. Van Eijk (principal author) was member of this expert group. The results of this second study were reported by the expert group [2]. This paper is based on both studies and presenting the main results of the second test.

2 Goal and Research Questions

The aim of the studies was to assess whether use of a vote-printer would make voting more accessible. By accessibility we mean the extent to which a voter can cast a correct vote. In particular, the studies focused on voters with a disability and on older voters. On the basis of this objective, we formulated three research questions, namely:

1. Will the introduction of a vote-printer still ensure that voting remains accessible to the current voter? Will the elderly, in particular, remain able to vote independently, as with the current ballot paper?
2. Will the introduction of the vote-printer make voting more accessible to people with lower literacy? Will more people in this group be able to vote independently?
3. Will the introduction of the vote-printer make voting more accessible to the visually impaired? Will more visually impaired people be able to vote independently?

In this report when we use the term ‘correct’ we mean that the subject has correctly executed the given test to make a choice for an election. By ‘independent voting’ we mean that a voter in the can make his/her choice without the help of another person.

3 Method

3.1 Simulation of Vote-Printer

Working together in an iterative co-creating process with members and representatives of the different user groups (Elderly, Low Literacy and Visually impaired), a series of electronic interfaces were developed. During the development of the simulation of the vote printer we consulted the following interest groups:

- Ieder(in), (Everyone in) umbrella organization for people with a physical disability, mental disability or chronic illness.
- Eye Association Netherlands (Oogvereniging) interest group for blind and partly sighted, people with an eye condition or deaf blindness.
- The Reading & Writing Foundation (Stichting Lezen & Schrijven).

Moreover we consulted representatives of the different user groups with disabilities. By discussing and testing preliminary concepts of the simulation of the vote printer with them we co-created adaptations of the interfaces.

An important starting point for the design of interactions is the 'Design for all' [3] principle, which states: the design has to fulfill as many of the needs of all the user groups as possible.

One way of supporting different groups of voters is by allowing them to use a touch-sensitive screen during voting. A touch-sensitive screen makes it possible to display only those buttons that are important or necessary at a certain moment. The size of the button and the description on the button can be adjusted to specific user needs. As a result, the likelihood of confusion about which description belongs to which (physical) button can be limited. The flexibility offered by a touch-sensitive screen is a practical necessity for achieving the screen interaction required for the complex Dutch voting context, with its many parties (up to 40) and candidates (up to 80 per party). For voters with limitations in understanding and vision, auditory support is desirable. This results in the following two interactions:

Interaction 1: Graphic Touch Screen
Users enter their choices via the touch screen. The user is offered a number of selection screens and can print a ballot paper. We expect that the majority of voters, even those with minor disabilities, will be able to use this interaction.

Interaction 2: Auditory Support
The auditory support interaction has the same graphical touch screen as described in interaction 1, with the addition of a headset. After pressing an on-screen button, the voter will hear the information selected. Users will therefore be more certain about their choices. The auditory support interaction is designed for those who either have difficulty with visual information or understanding the process. These include people with low-literacy levels, those with a mild form of intellectual disability, and some of the visually impaired.

Voters with a physical disability who are unable to operate the touch-sensitive screen will require an interaction with tactile buttons. For those voters with a serious level of visual impairment, a fully auditory interaction is necessary. These two groups were not included in this study.

We chose a 24-in., horizontal screen for the interaction as this allows a better reach/touch area for users than a vertically-placed screen. In our first evaluations, we noted that users had less overview when a 24-in. screen was positioned vertically. We selected the 'Glober' font, which is characterized by good legibility on both screen and paper; it is suitable for both headlines and running text.

Following the current Dutch voting context, presenting all the political parties and candidates in a single overview would lead to unreadable (small) texts or, for many voters, a complex operation like scrolling through the screen. For this reason, we opted for a screen allowing a choice of party, followed by the appropriate list of candidates. Voters first choose a party-list and then select a candidate.

The starting point for the party screen interaction is 40 different political parties. The screen is divided into a grid of 4 columns with 10 buttons in each column (Fig. 1). This form of division gives voters an easily viewed and well-organized overview. The proportions also work well with the content of each button, as many party names fit on one line. More buttons below each other would result in smaller text and a smaller area to press.

Fig. 1. Example of party screen

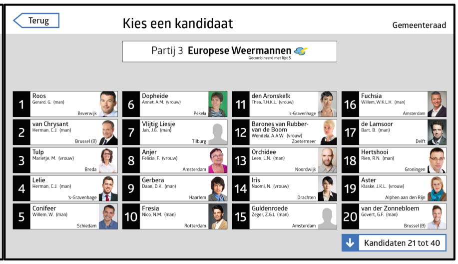

Fig. 2. Example of candidate screen

In the Dutch system, each political party has a number. This is presented in a black square in front of the party name. These black squares ensure that the columns and rows can be clearly distinguished from each other. Large font-sizes are used to ease use for the visually impaired and the low-literate. By using these numbers, all voters make an on-screen choice of party. This is followed by a confirmation screen where the selected names of the party and candidate are displayed in a larger font-size.

An important aspect of the candidate overview is the number of candidates visible on-screen at the same time. When developing the interaction, we took the following aspects into account:

- The number of rows and columns and the ease with which the buttons can be counted.
- The option to view passport photos and the size of the passport photos.
- The ratio of the dimensions of the buttons.
- The size of the texts and their classification.

A candidate screen with 20 candidates in a grid of 4 by 5 (Fig. 2) provides an optimum between the number of buttons that can be displayed, the clarity of the candidates (columns of 5), the size of the texts, and the size of the passport photo. In the case of long candidate lists, the voter can press a button after the last candidate presented on screen to view the next candidate screen. Voters can also return in this way to the initial screen or move on to the next candidate screen.

To run tests on large numbers of participants, four simulations of a vote-printer were built (Fig. 3). The interface consisted of a card reader to activate the system, a touchscreen and a printer. Audio support was available via a headset.

3.2 Participants

Three user groups participated in the test. Group A consisted of older people who believed themselves able to vote independently with the paper ballot currently used in elections. Group B consisted of people with low literacy. Group C consisted of people with a visual impairment and who, with the current ballot system, are either unable to vote or unable to vote independently.

Fig. 3. Simulation of vote-printer hardware configuration; card reader, touch screen, printer

For elderly participants, the independent variable was age. We aimed for a proportional gender distribution (50% male-50% female) with a maximum of 75% of the same gender. The following numbers of subjects per age category were aimed for:

- at least 50 older voters in the age group 65–69
- at least 50 older voters in the age group 70–74
- at least 50 older voters in the age group 75–79
- at least 50 older voters in the 80+ age category

Educational level:

- at least 30% of the subjects have primary education as their highest level.
- at least 30% of the subjects have higher education as their highest level.
- The remaining 40% of the subjects have a primary, secondary or higher level of education.

For participants with disabilities, the independent variables were visual impairment and low literacy.

3.3 Test Procedure

We simulated a twofold test election simulation. The subjects activated the vote-printer simulation (hereinafter referred to as simulation) by entering a smart card for each election. They then made choices for a typical party candidate-list election and for a referendum. For the party list-election, we made use of fictitious candidate lists or blanks. For the referendum, a fictitious question was asked which could be answered by choosing: for, against or blank. All participants were asked to independently make specific choices on the screen and to check the printed result for their choice. As a reference, they were asked to vote using the current Dutch ballot paper/red pencil system. The criteria used to determine the accessibility of both systems was: Does the printed ballot match the intended vote correctly?

3.4 Test Conditions Group A (Elderly)

Group A took part in two sessions, namely:

- Session 1: perform 2 tests using the current paper ballots.
  - 1 test for the list election, a so-called city council election;
  - 1 test for the referendum.
- Session 2: perform 2 tests with the simulation:
  - 1 test for the list election, the so-called city council election;
  - 1 test for the referendum.

The order of the two sessions changed. Half of the subjects started with the current paper ballots, the other half with the simulation. The subjects themselves determined the order of the test within the session by entering a relevant smart card.

For executing tests on the simulation, two variants were constructed in which each variant was tested by a part of group A. This was to prevent unexpected test effects due to having only 1 screen position, strange name, height of the number, etc.

To ensure an even spread of the variants across the Group A sample, we selected age as an independent variable from the selection criteria (age/gender/education level). The Group A subjects first did the simulation with only the touch screen and without auditory support. If the subject did not manage to correctly print the ballots within the time limit, a new session was started with the same assignment and auditory support was offered. If the subject could not print the ballots correctly, the simulation stopped. The testers conducting the test recorded comments from test subjects as they were made. If the testers noticed anything special regarding the test or subjects, this was also recorded.

3.5 Test Conditions Groups B and C (Low Literacy and Visually Impaired)

Group B took part in three sessions, namely:

- Session 1: perform 2 tests using the current paper ballots.
  - test for the list election, a so-called city council election;
  - 1 test for the referendum.
- Session 2: perform 2 tests with the simulation:
  - 1 test for the list election, a so-called city council election;
  - 1 test for the referendum.
- Session 3: perform 2 tests with the simulation with auditory support.
  - 1 test for the list election, a so-called city council election;
  - 1 test for the referendum.

The order of the three sessions did not change. The current paper ballots were always started first. Half of the subjects continued with the simulation without auditory support, and finally they used the simulation with auditory support. The subject determined the order of the tests within the session themselves. Two variants were made for conducting the simulation tests, each of which was done by a part of groups B and C. These were the same as for group A. In combination with the required sample size of at least 30 people per group, this resulted in a distribution of test subjects in groups B and C across the test conditions. To get more information about the execution of the tests, we checked whether the right choices were made and asked the subjects questions on how they experienced the interactions.

4 Results

4.1 Test Results Group A (Elderly)

Remarks Table 1:

Table 1. Results group A current Dutch ballot system/vote-printer simulation

Category	Number of ballots	Result	Number of subjects	Per sub group	%
1	2	Both ballots correct	233/234	233/234	82/82%
2	2	Only list election correct	8/6	46/39	16/14%
3		Only referendum correct	27/24		
4		Both incorrect	11/9		
5	1	List election correct	0/1	0/1	0/0%
6		Referendum incorrect	0/0		
7	0	Both ballots incorrect	6/11	6/11	2/4%
			285	285	100%

- In the group of 285 subjects aged above 65, an equal percentage (82%) voted correctly with the current Dutch ballot system and the simulation vote-printer. When using auditory support, this increased slightly to 84%.
- There were hardly any problems with entering the smart card. 95% of the elderly rated this action as easy, the others as neutral or did not answer.
- 61% of the elderly thought making the choices and printing the ballots with the vote printer easier than with the current ballot paper, 4% found it more difficult, and 33% thought it was the same as (2% did not answer).
- 12 elderly subjects who did not print two correct ballots with the simulation used the auditory support. 7 then correctly executes the test. 1 person consciously chose something else. 3 people chose a wrong candidate. 1 person performed both tests incorrectly.
- The number of test subjects (285) distributed over the different age groups and educational level met the set criteria.

Table 2 shows the results when comparing current and simulation. Noteworthy are the considerable differences that occur, as the subjects are older. These differences, however, are practically the same for the current ballots and for the vote printer simulation.

Table 2. Results current/simulation per age group

Age	2 correct ballots	
	Current list ballot	simulation
65–69	96%	95%
70–74	90%	90%
75–79	76%	78%
80+	59%	59%
Total	82%	82%

4.2 Test Results Group B (Low Literacy)

Remarks Table 3:

– Hardly any differences were seen between the current ballot results and the simulation. The subjects who encountered problems with the simulation were the same people who made mistakes with the paper ballot. Note: 1 had problems entering the smart card during the simulation.
– 24 subjects found the simulation easier. Only 1 subject indicated that the simulation was more difficult (but did both paper and printer without problems), 5 subjects saw no difference, of whom 1 actually had problems with the simulation. A number of the subjects said the current ballot paper was more clear, these all had the assignment with candidate 25 (on the second candidate screen).
– Audio: of the 5 test subjects who did not complete the assignments with the simulation at first, 4 did much better with the audio: 3 test subjects performed the tests correctly, 1 test subject consciously chose something else, 1 subject did not understand the simulation: "how to select a candidate".

Table 3. Results group B current Dutch ballot system/vote-printer simulation

Category	Number of ballots	Result	Number of subjects	Per subgroup
1	2	All voting ballots correct	25/24	25/24
2	2	Only list ballot correct	0/1	3/5
3		Only referendum correct	1/3	
4		Both incorrect/invalid	2/1	
5	1	List election correct	1/0	2/0
6		Referendum correct	0/0	
6.5		Incorrect/invalid	1/0	
7	0	None	0/1	0
			30	30

– 14 test subjects found it easier with audio than without. 13 subjects saw no difference (2 of whom experienced problems with both the current ballot and the simulation) and 3 indicated that it was more difficult than without audio (but had no problems).
– The number of test subjects (30) and distribution (11 male and 19 female) met the set criteria.

4.3 Test Results Group C (Visually Impaired)

Remarks Table 4:

Table 4. Results group C current Dutch list ballot/vote-printer simulation

Category	Number of ballots	Result	Number of subjects	Per subgroup
1	2	All voting ballots correct	14/21	14/21
2	2	Only list ballot correct	0/0	1/3
3		Only referendum correct	1/1	
4		Both incorrect/invalid	0/2	
5	1	List election correct	0/1	8/2
6		Referendum correct	8/1	
7	0	Incorrect/invalid	9/6	9/6
			32	32

– A clear difference was noted between the simulation and the current ballot paper; 14 of the 32 subjects were able to perform both tests correctly with the current ballot. This rose to 21 when using the simulation.
– With auditory support, even more subjects were able to conduct the tests correctly.
– 13 subjects indicated that they had great difficulty reading the on-screen texts (some could only read the figures), 4 subjects were unable to read the screen.
– 17 subjects found the simulation easier to use; 5 were neutral. This question did not apply for the others, as they could not read (one of) the two voting methods.
– Of the 23 people who stated that use of audio was easier than without, 2 still had problems making audio choices.
– Audio is not viewed as an improvement by everyone. Of the 11 subjects who performed the tests incorrectly with the simulation without audio support, 4 people did better with audio, but 7 still had problems.
– 28 of the 32 subjects rated the card entry as easy; the remaining 4 as neutral.
– The number of test subjects (32) and distribution (15 male and 17 female) met the set criteria.

5 Conclusions

Based on the test results, we present our conclusions:

1. **Equally accessible to the elderly**
   Of the total group of 285 subjects aged above 65, the same percentage (82%) were able to correctly fill in the current ballot papers and to correctly enter results in the vote-printer simulation. When using auditory support, this percentage rose to 84%. As people age, it became more difficult to vote using both the current ballot paper and the vote-printer. The need to enter a smart card to activate a voting printer did not appear to be an obstacle to accessibility. A majority of the older subjects found making the choices and printing of the ballots with the vote-printer easier than the current ballot. The others considered both systems to be equally applicable.
2. **Not more accessible for low-literate people**
   In the low-literacy group of 30 subjects, equal numbers were able to correctly fill in both the current ballots and the vote-printer simulation. Auditory support slightly improved the result for the correct execution of both tests with the vote-printer simulation. The majority of the subjects found it easier to make choices and print the ballots with the vote-printer.
3. **Vote-printer more accessible for the visually impaired**
   In this group, 14 of the 32 subjects were able to fill in both current ballot tasks correctly. This number rose to 21 when using the vote-printer; when using audio this rose to 24. This is a significant improvement. Auditory support is not viewed as an improvement by everyone. The subjects in this group who were unable to perform both assignments correctly may be able to benefit from using a fully auditory-interactive system, such as are available to the blind.

To answer the research questions by (quantitative) testing, a prototype serving as stimulus in the test, had to be developed. Our co-creation approach proved to work well. By involving people representing the different user groups during development of the prototype, we were better able to take advantages of electronic voting compared with current voting systems into account.

References

1. Van Eijk DJ, Niermeijer G (2015) Ontwerp en toetsing van een simulatie van een stemprinter (Design and evaluation of a simulation of a vote-printer), TU-Delft, Delft
2. Expert Group Electronic voting and counting in the polling station: Nieuwe test met een simulatie stemprinter (New test with a simulation of a vote-printer), letter to Lower Chamber of parliament 28–04–2016, Appendix 4
3. Molenbroek JFM, Groothuizen TJJ, De Bruin R (2011) Design for all; not excluded by design. In: A friendly rest room: developing toilets of the future for disabled and elderly people, pp. 7–18. IOS Press, Amsterdam