Electronic voting for all: the experience of the Brazilian computerized voting system

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ABSTRACT:
This paper presents two studies that focus on usability problems (especially for technologically excluded people) of the Brazilian Electronic Voting Machine (BEVM) and an analysis of its evolution from 1996, when this device began to spread throughout the country, to 2002, when the BEVM was put into use in all electoral locations across Brazil.

INTRODUCTION

In the beginning of the 1980's the first publications demystifying computerisation surfaced. Until then, computerisation was seen as an inexorable process leading towards automation and the increase of labour productivity. Several publications presented many examples of the dangers and high costs caused by disturbances in the organisation of work due to computerisation. Since that period, interfaces began to be utilised by everyone, everywhere. For professional applications, because of marketing demands and product competition, computer designers frequently considered, or even had an obligation to consider, the ergonomics of the human-computer interface. But is the same true for other types of applications, particularly applications for a large variety of people and cultures?

The response is not clear, particularly for voting machines that have appeared in many countries around the world. The problems that occurred in North-America during the presidential elections in 2000 suggested generalizing technology as a way to improve electoral process. In fact, a lot of countries in the world are trying to develop their own voting systems. In Europe (United Kingdom, Switzerland, Belgium, the Netherlands, France, Spain and Norway), in Asia (India, Japan) and in America (USA, Brazil, Venezuela) – countries have begun to support initiatives to convert all or part of their paper-based election process into a fully direct recording electronic voting system. Although laws and election procedures may be quite different, some discussions about voting technologies, their vulnerabilities and advantages are universal. Indeed, by focusing on the Brazilian electronic voting process, some issues discussed in this article may be useful in other contexts.

Voting in Brazil is mandatory for all literate citizens between 18 and 60 years old. It is optional for Brazilian citizens between 16 and 18 years old, for those over 60 years old, and for illiterates, as long as they are registered at the Federal Electoral Department (TSE). For all registered electors, absence on election day may imply a penalty. Elections in Brazil usually involve millions of people, of different cultures, different languages, ages, level of education, technological skills and disabilities in all remote corners of the country.

In this paper we present an overview of BEVM (Brazilian election voting machine) usability and its evolution in the past years. It is organized as follows: first we present the Brazilian electoral system; then the main aspects pointed out by a earlier usability evaluation accomplished in 1997 focusing on the BEVM used in the 1996 elections; after, the results obtained by a heuristic evaluation focusing on usability of the BEVM used in the 2002 elections; and finally some conclusions.

METHODS

For these different studies we used different methods like questionnaires, user testing, statistical studies and heuristic evaluation.

MAIN BODY

Fig. 1. The BEVM and the micro terminal used by poll clerk to control voting sessions.

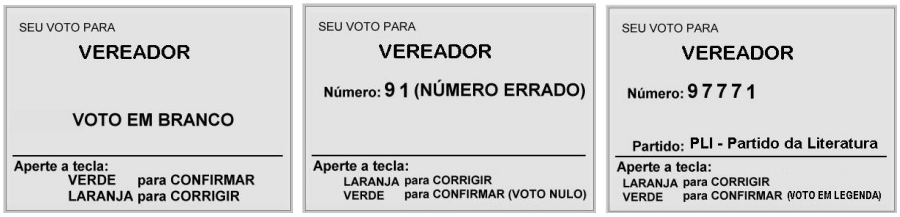
1. Brazilian Electronic Voting Machine: technical features

The Brazilian electronic voting machine BEVM which started to be introduced to voters in 1996, is the only technology currently available to vote in Brazil (Fig. 1 left). A 9.4" LCD monochromatic display shares the device's front panel (at an angle of 45°) with a mechanical keyboard that features 10 numeric keys, arranged in a telephone-like layout and 3 function keys horizontally positioned. This keys are labeled "BRANCO" [BLANK vote], "CORRIGE" [CORRECT the vote] and "CONFIRMA" [CONFIRM the vote]. Associated Braille code inscriptions are currently placed over the numeric as well as the function keys, the last ones corresponding to the abbreviated codes: "BRAN", "CORR" and "CONF". In the first 1996 BEVM, the keyboard was membrane type and the Braille inscriptions were placed just below the keys.

2. BEVM's voter interface in 1996

Fig. 2 – Initial Councilman (a), Councilman Confirmation (b), Initial Mayor (c) Mayor Confirmation (d) and Final (e) screens featured by BEVM supporting 1996 election.

In 1996, the elector interface supported a municipal election. It was organized so that electors first chosen their candidates for city councilmen and afterwards for mayor. Candidates for mayor were identified by two-digit numbers, and those for city council by a five-digit number. To vote, the user was supposed to interact with the screens showed in Fig 2. When he/she had entered the candidate last digit code, the system presented a feedback screen (Fig 2b and 2d), inviting him/her to confirm vote by pressing the "Confirmar" button. Users could also correct their vote pressing the "Corrigir" [Correct] button. To cast a blank vote, users was simply supposed to press the "Branco" [Blank] key and confirm this intention in a blanking vote confirmation screen (Fig 3a). To invalidate the vote, the user was supposed to type an invalid code and then confirm this intention in the canceling vote confirmation screen (Fig 3b). In the councilmen election, users were specially authorized to vote in the party, using a two digit code or any other size digit coding beginning by the party code (two digits).



a b c

Fig. 3 - Confirmation screens to (a) cast blank vote, (b) cancelling a vote and (c) voting for a party in the councilmen 1996 elections.

2.1 Usability evaluation of 1996 BEVM's

The heuristic evaluation accomplished over 1996 BEVM user interface produced the following set of usability flaws, related to Bastien and Scapin Ergonomic Criteria [1]:

- lack of compatibility between the conceptual model of BEVM user interface and the user and task structure. In fact, elector could no longer write the candidate's name or nickname neither to choose the order for voting process.
- error protection flaw due to voting sequence. It is reasonable to consider that typing mistakes could occurs in great amount when user is entering long codes (councilman candidate) instead of in typing short ones (mayor), and that mistakes occurring first in interaction could disturbs last interactions. From this reasoning, why put the mayor election at end of process subject to disruption form prior and more probable mistakes;
- general readability problem specially to visual impairment people that are faced to a bad contrast generated by dark characters over a brightness background.
- insufficient users guidance performed by a simple blinking underscore corresponding to the first digit to be filled in with the candidate code (Fig.1a).
- insufficient distinction between modules, what could have made many users tried to vote for Mayor when the city councilman screen was still displayed.
- code meaning problem due to the "CONFIRMAR" [CONFIRM] key label, considered too much technical and abstract face to a such heterogeneous population.
- Missing of voting feedback to the end of the councilmen vote. As mentioned earlier, the fact to confirm the vote for councilmen caused the display of mayor vote screen.
- A flaw on quality of error messaging was however, a major issue pointed out in this study. The problem concerned specifically the proportional councilmen elections, where it was also possible to vote for a party, by means of a two digit code or any other size digit code beginning by the party code. An incident would occur when instead of typing the candidate code 97711, for instance, the elector typed the code 97771, as a consequence of using keyboards featuring automatic repetition. This code not corresponding to any candidate, and he/she not seeing the subtle feedback indication "VOTO EM LEGENDA" [PARTY VOTE] at the very bottom right of the screen (Fig. 3c), and pressing the "CONFIRMA" key, the vote was considered valid and cast to the party whose code was 97. However, that was not the voter intention. If it had been so, he/she would simply had typed 97 (party code) and pressed "Confirm".

2.2 Usability trials and statistical analysis (for further details see [2] and [3])

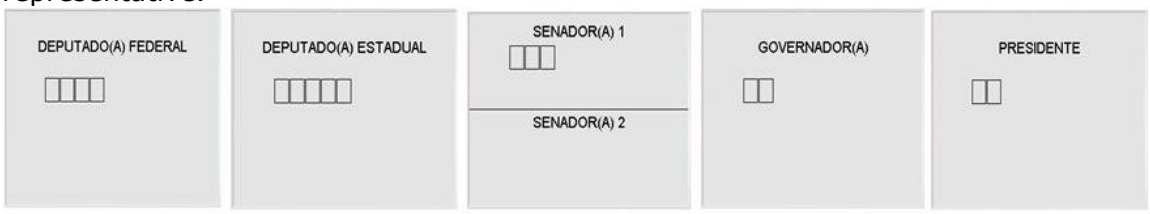
The expert-based judgment of 1996's BEVM user interface was that it could have caused a significant deviation between the real intention of the elector and the obtained results in the counting of ballots.Pulled by this hypothesis, authors decided to proceed user testing focusing on visually impaired, elderly or illiterate electors and anyone who is digitally excluded, i.e., not used to a computerized culture. They invited seven visual impaired and nine elderly and illiterate individuals to interact with BEVM to vote in pre-defined

candidates. The results showed that part of subjects (4 out of 16 electors) was not able to vote simply at all; another part of them (5 out of 16 electors) cast "residual" vote only (spoiled and incomplete vote). Even in the ideal test conditions (initial formation on BEVM, no noise, no queues and no time pressure), for the most part (9 of 16) of subjects of tests the BEVM represent a barrier or an obstacle to their civic manifestation. The conclusion of the study is that a great part of the elderly, visual impaired and illiterate individuals who dreamed to participate in 1996 elections and was faced to a BEVM was not able to vote correctly.

The last phase of this study featured a comparative data analysis conducted over the results of elections in seven cities in the state of Santa Catarina (south of Brazil). In three of them the elections were computerized in 1996. The analysis compared 1996 results to 1992 ones, when elections were still manual (paper-based) all over the country. Two groups of electors were formed; one which changed from manual to computerized voting process from 92 to 96 and other which remains in manual in both elections. The two groups were equivalent in number of electors. The main result validated the diagnostic of the error protection defect concerning vote for the party. In fact, in cities which the computerized voting system was implanted in 1996, there was a strong increase in votes for political party (65.73%) face 1992 results, while in the same period there was a decrease in this type of vote in non-computerized cities (-55.45%).

3. BEVM's voter interface in 2002

The conceptual model of the 2002 BEVM's user interface remained the same as the presented by 1996 BEVM, but in 2002 Brazilian federal and state elections, electors were supposed to vote for 6 positions: President; Governor; 2 Senator; Congressman; State representative.



(a) (b) (c) (d) (e)

Fig 4 – Home screens for the 5 different elections.

That year the dialog control imposed to the voter the following sequence of screens and basic entry actions: DEPUTADO(A) FEDERAL [Congressman] - 4 digit codes (Fig. 4a); DEPUTADO(A) ESTADUAL [State representative] - 5 digit codes (Fig. 4b); SENADOR 1 [Senator 1] - 3 digit codes (Fig. 4c top); SENADOR 2 [Senator 2] - 3 digit codes (Fig. 4c bottom): GOVERNADOR [Governor] - 2 digit codes (Fig. 4e); PRESIDENTE [President] - 2 digit codes (Fig. 4f); Note that one same screen was defined to support the entries for the two senator positions (fig 4 c).

3.1 – Analysis of BEVM's usability evolution from 1996 to 2002

The BEVM usability's evolution, from 1996 to 2002, was characterized by some improvements, a series of unfixed problems and a lot of worsening.

The good improvement relates to the way systems give guidance to the voter. The 2002's BEVM featured a sound interface which was accessed through headphones intended especially to visually impaired, elderly, illiterate and even temporarily impaired people. A timid improvement was related to the way system prompts user's actions: a sequence of blinking boxes instead of a sequence of blinking underscores. The last good new was related to the quality of error messaging problem by which the interface failed to signal a mistake when user tried to enter a candidate number and assumes users wanting to vote for a party (presented in Fig. 3c). In the 2002 voting screen a "(Numero errado)" [wrong number]

lowercase indication was displayed at the side of the partially faulty entry, featuring a screen very similar to that intended to confirm a canceling vote intention in 1996 elections (Fig 3b). A good improvement, from both usability and security points of view, was tried with the adoption of a printer assembled in a container with a visor. Unfortunately, the Brazilian congressmen approved the law #10740 of October 2003, establishing the electronic signature instead of printers in Brazilian electronic voting system.
The unfixed problems concerned the lack of readability face to elderly, blind and visual impaired people and the failure of code meaning imposed by the "CONFIRMAR" command key. The aggravated problems concerned the error protection failure imposed by voting sequence and the miss of general feedback of votes cast. In fact, as the amount of elections mediated increases is natural to suppose that a greater number of complex and less important interactions could produce more incidents and propagate it over the last and more important ones.

Fig. 5 – Two senators voting screen, presenting two data frames and one command frame.

The main usability problems emerged in 2002 BEVM however were consequence of having only one screen supporting votes for two senator positions (Fig 4c). Here it is possible identify failures concerning: *consistency,* since all others BEVM screens support voting for only one position; *item distinction by localization*, that makes difficult to the voter assign the relationships between the data frames and the command frame presented in this screen; and *Information Density,* with a lot of data and command options being presented.

4. Discussion and conclusion

The design errors identified in the ergonomic inspection and the difficulties observed in the interactive trials with a sample of elderly and visually handicapped voters, proved that the chance that these citizens would correctly express their voting intentions is small, often non-existent, even with the latest voting system used in 2002. The use of the computerised vote appears to be an obstacle for this population unlike the manual voting system. However, for the set of subjects participating in this study, the will to participate in the Brazilian electoral process was unanimous.
This study proved that the computerised voting system, is, in its current state, an important factor for social exclusion, particularly for the elderly and the blind. It' s probably the same for other handicapped people, or illiterate people, (for example, Indians in the Amazon, living in distant villages, accessible only by boat, were obliged to vote with the machine), and people living far from a technological environment. And we are sure that for this complex session of voting (6 votes in one day) some "normal" people will make mistakes too. A lot of people in Brazil (see www.Voto.e web site) contest the official government publicity that insists on the reliability of the system. The arguments against the BEVM are based mainly on the evidence that a total electronic voting system didn't follow auditing procedures and that a unique user interface simply couldn't accommodate everyone, especially in a country with a high proportion of illiteracy (16,7%), handicapped (16,3 %) and elderly people (6 %). It is not possible, in a short period of time, to change the profile of the Brazilian elector. New BEVM interface concepts should evolve and be examined to satisfy more sensitive parts of the Brazilian population and avoid the "blind" voting practices

as observed during usability tests. New devices could be placed in poor regions of the country, where the proportion of technologically excluded people seems to be great: maybe the use of the old manual system (drawing on a paper) should be conserved in certain situations.

The Brazilian electoral process is a complicated one and surely this is an aggravating circumstance. Another complication is that the Electoral Department mainly takes into account speed, security and quantity over electronic vote quality. Too much attention is given to fraud prevention while the fact that some votes may not correspond to the real intention of the elector – in a certain way, another type of fraud - is considered as secondary. This study proves that the reliability of any electronic electoral system depends on the usability proposed by its voter interface as much as on any other type of requirement.

We think that the experience of the usability of the BEVM could be used in other countries, because all countries have technologically excluded populations and usability problems and we believe that it's certainly impossible to create a universal system that crosses all cultures. However a lot of research groups and companies are working on this field and some requirements and evaluations have already been put into place ([2]), [3]).

Voting should be a natural civil act and thus the technology should not be an obstacle. The system should not cause any change in one's vote, nor discourage one from voting. This study clearly shows that these objectives were not met by the computerised ballot system. And in a real democracy, a sensitive system like a voting machine must be tested and certified by neutral experts, as well as for the voting process in "non-democratic" countries.

ACKNOWLEDGEMENTS

Include any acknowledgements here

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