Users' experiences with e-voting: a comparative case study

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Abstract: A system for electronic voting (e-voting) was developed and tested in 14 field studies. This enabled us to investigate the actual experiences of users when deploying this type of e-governance technology. Are users satisfied with e-voting technology and its usability? Do social groups have different opinions and use of the technology? Does this relate to a digital divide? Will e-voting technology result in increasing voter turnout? We identified serious risks of adoption of e-voting systems for the democratic process, and the assumption that e-voting will increase overall voter turnout is not supported by our research.

Keywords: user experience; e-voting; usability; voter turnout; digital divide.

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1 Introduction

Until recently, most e-voting[1] R&D projects focused primarily on technological aspects. Several voting election schemes have been proposed in the last 20 years but overall the chosen technical solutions for internet voting seem rather similar. All of the protocols use cryptography and, so far, none of the protocols has managed to satisfy all of the properties (e.g., secrecy, verifiability, simplicity, integrity, uncoercability, etc.), which should make e-voting as secure as traditional voting systems (Bruschi et al., 2002). Recent problems with e-voting technologies (Harris, 2003; Bishop and Wagner, 2007; Gonggrijp and Hengeveld, 2007) show once more that evaluating voting technologies is of utmost importance. As Ferguson (2004) states:

> "Poor design can easily prevent 20% or more voters from being able to complete a task successfully – and elections are often decided on margins as slim as a few percentage points. […] Lack of research often means that problems only surface *after* expensive systems have been purchased and put in place." (Ferguson, 2004)

Governments actively want to influence citizens' participation rates at elections. From most governmental policies, it is clear that there is a set of common assumptions underlying these policies that express the general belief that participation can be positively influenced through new Information and Communication Technology (ICT) tools. For instance, e-voting tools are expected to make voting easier and more accessible. No matter where voters are – at home, at work, abroad or in hospital – they are always able to cast their ballot. This should in return lead to higher turnout. However, reviewing the literature shows that most of these assumptions have either hardly been tested empirically (Oostveen and van den Besselaar, 2002a) or shows that e-voting have a positive influence neither on the *level* nor on the *nature* of turnout (Norris, 2005; Prevost and Schaffner, 2008; Trechsel, 2007; Gibson, 2005; Wilks-Heeg, 2008).

It goes without saying that the technical solutions for new e-voting systems are important for their success, but other issues might be just as decisive (Hague and Loader, 1999; Hacker and Van Dijk, 2000). Many designers of e-government systems develop tacit scenarios of the ways people will use systems that often differ from actual conditions and uses. If user feedback and input is not continuously sought throughout the design process, then a new system is unlikely to effectively handle overlooked exceptions, complexities and nuances. It is necessary to see what real users *do*, how things are *used*, to understand what the problems are and how design can improve matters (Ferguson, 2004). As is well known, but hardly practised, the organisational context of implementation and use of ICT-based systems will determine success or failure (Iacono and Kling, 1996; McLaughlin et al., 1999; Oostveen and van den Besselaar, 2002b; Gauld and Goldfinch, 2006). In this paper, therefore, we emphasise the socio-technical aspects of e-voting technologies in a variety of contexts.

Technology design and use require careful contextual analysis, as this may indicate how the technology functions in specific situations, and to what extent the first-order (intended) effects are attained, and second-order (unintended and unwanted) effects occur. One way to do this is through the use of small-scale real-life studies, in a wide variety of contexts. Here, we study 14 field studies in which an e-voting system was used in different contexts. In this e-voting case study, we had the opportunity to look at a broad range of issues, such as: logistics and organisational complexity, political struggles within the participating organisations, legislation, privacy, trust, turnout, the usability of the system and the role of digital divide. More specifically, in this paper we will address the following questions:

- Are users satisfied with e-voting technology and its usability?
- Do different user groups differ in using the technology, and in opinions about it? If so, which groups can be discerned? Does this point at a digital divide?
- Does e-voting increase turnout?

In the next section, we will describe the set-up of the field studies, and the research methods we used. Section 3 focuses on the main findings. Finally, in the conclusions (Section 4), we summarise our findings with respect to the use of e-voting systems and compare them with other e-voting evaluations.

2 Set-up of the study

2.1 Field experiments in five different environments

The system we study here is a Public Key Infrastructure (PKI) and smart-card-based system for internet voting. Our approach consists of a series of case studies and observational studies of internet voting in practice, in which we study, among other things, the factors that influence the way voters use (or do not use) e-voting systems, with the emphasis on naturalistic conditions and generalisability. E-voting experiments were organised in five different geographical and socio-cultural locations: a small French town in the vicinity of Paris (Orsay), a borough in London (Newham), an Italian trade union (CGIL), and two community networks: one in Italy (RCM) and one in Finland (OYK).[2] We used a variety of e-voting technologies, to be able to analyse the specific effects of the technology: a smart-card internet voting system (TRUEVOTE), which was used at home, work and in school; a web-based voting system (CAWI);[3] TRUEVOTE voting computers at a polling booth. Furthermore, the possibility existed in three locations to use traditional paper voting at the polling booth. The participants were a-select assigned to the different voting modes.

2.2 Set-up of the studies

Each of the five test-sites organised two or three ballots, which resulted in a total of 14 field studies (Table 1). The first and second voting sessions were on relevant issues, selected by the local organising institutions. This was quite critical, because although the pilots had a non-binding character,[4] the selected topic had to be important enough to encourage voter participation in the ballot. The final ballot was on the same topic in all five sites and took place in parallel.

Table 1 Overview of the field studies

	Partner	*Orsay*	*Newham*	*CGIL*	*RCM*	*OYK*	*Total*
Type of technology	Paper voting paper ballots	X	X	X			3
	Kiosk e-voting	X	X	X	X	X	5
	Internet voting (TrueVote)				X	X	2
	Internet voting (CAWI)				X	X	2
1st round	Voting duration		2 days	2 days	7 days	22 days	
	Registered voters		83	326	190	310	909
2nd round	Voting duration	4 days	2 days	3 days	11 days	10 days	
	Registered voters	925	96	357	303	396	2077
3rd round	Voting duration	4 days	2 days	12 days	12 days	12 days	
	Registered voters	925	96	357	303	396	2077

Orsay, Newham and CGIL used kiosks with e-voting and traditional paper-based voting, while in the two community networks the large majority of voters used internet voting from home or the office. Additionally, in the latter two cases, some kiosks were installed to enable the participation of high school students and people in neighbourhood offices who had no access to remote e-voting equipment. Apart from the e-voting technology TRUEVOTE, we also used traditional paper ballots and CAWI technology, as this enabled us to compare the various media. In this paper, we focus solely on the experiences with the TRUEVOTE technology to determine the usability and user evaluation of the system and the unintended consequences of using (remote) e-voting technology.[5]

2.3 Research methods

Data collection was done using a variety of methods: pre-voting and post-voting questionnaires, observation, focus groups, log file analysis, analysis of the ballot outcomes, and interviews with ballot organisers and voters. Through this, we measured the relevant variables that influence the use of e-voting technologies on individual and organisational level (Table 2).

The pre- and post-voting questionnaires were designed to measure some theoretical constructs we expected to influence voting turnout and voting behaviour. Therefore, we created blocks of items to measure 'trust in privacy of the system', 'trust in security of the system', 'social identity' and so on. We used factor analysis to check whether the items indeed measure what they were expected to measure, and this proved to be the case. Table 2 summarises the variables used in our research.

Some of the questions in the surveys were based on topics brought up in focus groups with end-users. The voters completed the first questionnaire when they were registering for the smart card. They were asked to provide personal information about their gender, age, occupation, computer literacy, way of using computers, previous voting behaviour, their opinion about e-voting and about the role of ICTs in society. In the post-ballot surveys, the users were asked specific questions about the usability of the TRUEVOTE system, the quality of the system in terms of privacy and security (against fraud), and their viewpoints related to voting. Furthermore, we enquired as to where the voting took place (at home, work, school, kiosk, etc.) and in some ballots what the participants had voted for. We used different questionnaires for the various voting situations (e-voting from home or work; e-voting from a kiosk; voting with CAWI; traditional paper-based voting) and the questionnaires were translated from English to Finnish, Italian and French.

Table 2 Variables used in the research

Independent variables		
1	Characteristics of the voter	Age, gender, income, nationality, education, attitude, experience with new technologies
2	Voting technology/medium	Paper; CAWI, TrueVote
3	Voting place	Kiosk, home, school, work
4	Characteristics technology	Personal information needed for the smart card; availability of tools for audit and verification
5	Organisation of the ballot	Who 'owns' and organises the ballot
6	Experience with e-voting	Three subsequent ballots
7	Topic of the ballot	Level of sensitivity of the topic
Intermediate variables		
8	Trust in system	Opinion about privacy, surveillance, behaviour (participation)
9	Social identity	Collective vs. individual/social vs. individual
10	Participation in the ballot	Differences in participation between the various voting methods – turnout and demography
11	Result of the ballot	Different outcomes for the various voting methods
12	Opinion about e-voting	Acceptance, unavoidable, good or bad
13	Usability	Is it easy, quick, and transparent, in the various dimensions: use in general, access, vote, correct mistakes, send the vote, verify the vote, and so on

3 Findings

3.1 Usability

We investigated whether reactions of the users of the TRUEVOTE e-voting system are systematically related to their characteristics. If that is the case, e-voting technology may be more accessible for some user groups than for others. This may affect the demography of the turnout, and as a consequence the outcome of the vote. To study the possible demographical effect, we investigated the relation between several personal characteristics (gender, computer literacy, the opinion about the safety and privacy of e-voting systems), and the evaluation of the various dimensions of the TRUEVOTE system.

We focus on usability in the traditional sense, i.e., for the end-users, i.e. the voters. As Quesenbery (2007) emphasises on her voting and usability website: "Usability – the ability of everyone to use the voting systems easily and effectively – is a key to free and fair elections". To investigate the usability of the TRUEVOTE system, we observed the use of the system during the three consecutive field experiments. For a systematic evaluation of quality of the system by the users, we distributed a questionnaire after each ballot. These questionnaires consisted of 60 items, and we used them to measure several characteristics of the users, and characteristics that we expected would influence their assessment of the e-voting system. Apart from age and gender, we looked at self-reported computer literacy, trust in e-voting technology, political interest in terms of voting participation, and opinions about the role of ICT in society (see Table 3). Later in this section, we will relate the users' evaluation to these characteristics of the voters.

Table 3 Characteristics of the voters[6]

	CGIL	*Orsay*	*RCM*	*OYK*
Female voters (%)	30%	48%	34%	48%
Voters above 65 years old	2.6%	18%	1%	2.2%
Between 50 and 65	3%	36%	12%	17%
Active voters (voted 3 out of 3 times)	93%	83%	73%	66%
ICT is important	80%	87%	84%	89%
ICT is unavoidable	87%	82%	86%	80%
N	*154*	*620*	*379*	*179*

3.1.1 Usability of remote voting

Let us first focus on usability and trust in the TRUEVOTE system by *remote* voters at RCM and OYK. Factor analysing (orthogonal rotation, varimax) the matrix with the item scores shown after the first ballot resulted in several latent variables.[7] Three variables measure levels of trust in e-voting systems: trust in security, trust in privacy and trust in accountability of the system. Four other variables represent various dimensions of usability of the TRUEVOTE system, such as ease of use and experienced vulnerability (Table 4).

Table 4 Opinions about usability of the TRUEVOTE system: the remote voters (OYK, RCM)[10]

	Yes	*Neutral*	*No*	*N*
Intensive computer use almost every day from home	58%		42%	428
Intensive computer use almost every day from work/school	64%		36%	393
Trust in security (against fraud and hackers)	60%	17%	23%	431
Trust in privacy	5%	11%	84%	433
Trust in accountability (verify the vote)	62%	16%	22%	279
TRUEVOTE is easy to use	92%	4%	4%	281
TRUEVOTE is fast	77%	13%	10%	279
TRUEVOTE is easy to install	65%	15%	20%	260
TRUEVOTE is vulnerable for pincode/pincard loss	27%	21%	52%	280

First of all, the questionnaires showed that a large section (60%) of the users trust the security of the TRUEVOTE e-voting system against internal fraud and external hackers, whereas some 23% did not trust the security of the system. The remaining 17% were more or less neutral. The level of trust in the privacy of the vote was much lower. Remote Electronic Voting Systems (REVSs) "must ensure that the voter is correctly registered, assure that the one remotely voting is that person, accurately capture her or his vote, but not link any particular vote to a particular voter" (Yao and Murphy, 2007, p.110). However, a large majority (84%) did not trust the privacy levels, only 5% were confident about the privacy protection of the vote, and the other 11% were neutral. The effects of this are analysed elsewhere (Oostveen and Van den Besselaar, 2005). Many users think that they can easily verify their vote and correct mistakes. Although verification was included in the systems specifications, it was not implemented in the prototype used in our study. So, here we only measure the perception that respondents have of the application (Oostveen and Van den Besselaar, 2004).[8]

As far as the usability of the system is concerned, the factor analysis results in four variables, which clearly represent different dimensions of usability. It is also interesting to note that the users clearly assess the usability dimensions differently. Yao and Murphy (2007, p.110) define *ease of use* as

> "the degree to which a person believes that it is easy to understand and potentially use REVS to execute his or her vote. It requires that the interface of REVS should be easy enough for all eligible persons to understand and operate the systems correctly without special technical skills, prior experience, or more than cursory instruction."

Ease of use scores very high among the remote voters with 92% of the users finding the TRUEVOTE system easy to use.

Slightly fewer users (77%) think that the system is fast. The more complex aspects of usability are clearly less well developed: installing the system is only considered easy by 65% of the respondents, and also the loss of smart cards or Personal Identification Number (PIN) codes turned out to be a specific user issue. Losing the smart card or forgetting the PIN code is perceived as a problem by 27% of the respondents. At the first voting session, a number of people had already lost their cards or forgotten their PIN codes. At the second and third session, this number increased significantly. Since the project did not support smart card re-issuing, these voters were excluded from the voting sessions. However, this only partially explains the decrease in voting from one session to the next one.

Summarising, we can state that the opinions of the remote voters about the usability of the TRUEVOTE system are relatively positive, given that we were testing a prototype. But, the more difficult issue of installing the application is considered rather difficult by quite some voters, and trust in privacy is absent. Within this context, it is important to remember that the data analysed here are from two community networks, with probably a higher rate of computer literacy than can be expected in average.

3.1.2 Usability of e-voting in kiosks

Besides the group of *remote* voters, we also had a large group of *kiosk* voters in the project. How did these voters judge the different aspects of the TRUEVOTE system? In Table 5, we present an overview of the same issues as in Table 4, but now based on the questionnaires of the kiosk voters from Orsay and CGIL. We see not only some interesting similarities, but also some striking differences. As expected, the online communities showed a more intensive computer use from home as well as from work. The answers from the kiosk voters show that only a third of them trust the security of e-voting systems against fraud and hackers. This is in stark contrast with the remote voters group, where the trust in security is much higher. Unlike the security variable, the variables 'trust in privacy' and 'trust in accountability' show comparable outcomes with those of the remote voters, with trust in privacy being very low and trust in accountability being quite high.

Table 5 Opinions about usability of the TRUEVOTE system: the kiosk voters (CGIL, Orsay)[9]

	Yes	*Neutral*	*No*	*N*
Intensive computer use almost every day from home	37%		63%	498
Intensive computer use almost every day from work/school	47%		53%	449
Trust in security (against fraud and hackers)	33%	17%	50%	506
Trust in privacy	4%	10%	86%	327
Trust in accountability (verify the vote)	75%	13%	12%	277
TRUEVOTE is easy to use	91%	7%	2%	277
TRUEVOTE is fast	39%	46%	15%	277
TRUEVOTE is easy to install	N/A	N/A	N/A	0
TRUEVOTE is vulnerable for pincode/pincard loss	41	36	23	274

It is interesting to see that even though the kiosk voters have less experience with computers, they still rate the usability of the system as positively as the remote voters. Apparently, the system was built in such a way that it is also easy to use for people who do not use computers very often. But although the kiosk voters had no problems with the use of the system, they did not rate it as very fast. Interviews with the kiosk voters revealed that the reason for this was to be found in the comparison they made between e-voting and using traditional paper ballots. The respondents pointed out that it was faster for them to mark their ballot papers with a cross (X) beside their favourite candidate before folding it or putting it into an envelope and then into the ballot box, than to insert a smart card, type in a PIN code, scroll through a number of computer screens, tick a choice, and finally confirm their vote.

Finally, the kiosk voters are more concerned about the vulnerability of the TRUEVOTE system with regard to PIN code and PIN card loss than the remote voters. Losing the smart card or PIN code is perceived as a problem by 41% of the respondents. Only 23% did not see a problem with the vulnerability to PIN loss. This finding is comparable with recent research on password security. Many users have to remember a lot of different passwords for different applications and this reduces their memorability (Adams and Sasse, 1999). Han et al. (2007, p.1191) explain that there are three main ways to authenticate and identify: knowledge-based (something you know, like a password or PIN code; token-based (something you have, like a smart card); biometric-based (something you are, like a fingerprint). The TRUEVOTE system used a combination of knowledge-based and token-based identification to prevent impersonation through theft or loss of the smart card. Han et al. point out that despite their wide usage, passwords/PINs have a number of shortcomings. While complex and arbitrary PINs (like the TRUEVOTE pincode) are more secure than simple or meaningful PINs, they are also more difficult to remember (Han et al., 1191). Although some researchers recommend the use of passwords composed of data realistic and meaningful to the user (Sater Carstens et al., 2004), others have shown that this does not necessarily reduce human error associated with password authentication (Just and Aspinall, 2009). Research on alternative solution such as biometric, graphical, location or recognition-based authentication systems is still ongoing.

Summarising, we can state that the opinions of the kiosk voters about the usability of the TRUEVOTE system are less positive than the opinions of the remote voters. The fact that the kiosk voters trusted the security of the system less, and found it more vulnerable could be related to their level of computer literacy. Testing this, our analysis showed that there is a significant (but not very strong) correlation between the opinions about security and vulnerability, and the level of computer literacy of the respondents.

The analysis shows that the opinions of the voters correlate with characteristics of the voters. First in all sites, women tend to be more positive about the usability (navigation, number of screens, readability of screens) of TRUEVOTE than men. This applies to the remote voters as well as to the kiosk voters. Second, we find national differences between the voters' opinions. Finnish remote voters are more positive about TRUEVOTE than Italian remote voters, and whereas Finnish voters tend to become more positive over time, the opposite is the case for Italian voters. In the group of kiosk voters, we see that the Italian voters are in general more positive about the TRUEVOTE system than the French voters. The French see more risks in losing their PIN code or smart card; have less trust in the privacy of the system, and far less trust in the security. Third, the age of the voter correlates moderately with the evaluation of the various usability and trust dimensions. The older the people are, the more negative they score on usability and on trust. This by the way does not relate to the opinion about e-voting in general, which does not correlate with age. The set-up of the study did not enable us to have representative samples of participants in all of the five locations. As a consequence, it is difficult to separate the effects of various independent variables on the opinion about the system, such as nationality and computer literacy. More research is needed here.

The more frequent respondents use a computer and the internet, the fewer problems they have with installing the application. This implies that the digital divide remains important, but not in terms of access but in terms of experience and skills. Development work to make installation easier is probably needed, but also a good support system to help voters with installing. Finally, trust in the security of the system influences the voters' opinions about the TRUEVOTE system considerably. Voters who trust the security of the system also have a higher trust in the accountability of the system, a more positive assessment of its speed, find it easier to use, and find the application less vulnerable. As we have discussed elsewhere (Oostveen and van den Besselaar, 2004), this shows that the *trust* in the security of the system may be more important for success than the nature of technical characteristics of the e-voting system. Trust in the privacy of the system is not related to the users' evaluation of the quality of the system. Obviously, users see privacy as an issue independent from all the other usability and trust issues.

3.2 The digital divide and the need for support

On average, casting the ballot took less than 5 min per participant. Every kiosk voting session had a tutor standing by, who could, if necessary, help the participant with each and every step. However, only very basic help was needed, since the on-screen instructions were both simple and clear. As a CGIL organiser remarked:

> "Some of the users were amazed about the ease and speed of the voting system and literally stared at the screen at the end of the voting process wondering 'is this all?' Maybe there is a common place about weird technology and strange voting procedures associated with e-voting. Some participants asked specific questions about the future use of smart cards and some speculated about the future use of the smart card they were holding."

Analysing the organisers' feedback, voters can be grouped in three distinct categories – based on their computer literacy and the kind of voting studies they are involved in. First, there are the *computer literate home voters*: people who are not necessarily computer experts, but who have good confidence and who use their computers frequently. Voters from RCM and OYK mainly belong to this category. Second, there is the group of *computer literate kiosk voters*: this is a different category because kiosk voters, differently from home voters, do not need to install the voting kit themselves. Voters in Orsay and CGIL belong to this category. Finally, we have a group of *(computer) illiterate kiosk voters*: part of the voters in Orsay and most voters in Newham belonged to this category; the meaning of the parenthesis is that the illiterate voters in Newham were also people with difficulties with the English language.

The reaction of these different user categories to the e-voting experience can be summarised as follows. Computer literate home voters and computer literate kiosk voters were both quite satisfied with the ease and speed of the voting procedure. Remarkably enough, people who were less computer literate (many of the participants in Orsay and Newham) also rated the ease of use of the system very high. Some of the kiosk voters in Orsay (especially elderly citizens) and CGIL requested support to help them insert the smart card. An organiser from the city of Orsay said:

> "We were happy and surprised to see a lot of elderly people! The voters were not only young and involved with the internet revolution. For some of the people it was their very first experiment with a computer. So this test was also a pedagogical lesson."

The voting sessions, besides having some technical problems, ran smoothly in most cases, requiring only a few minutes for the login process associated with the smart card, a quick reading of the on-screen instruction and ballot page, and the voting part itself: the voting decision was the quickest part of it all.

Computer illiterate kiosk voters in Newham had very basic problems. First of all, the user did not understand where, when and how the smart card had to be used. A general problem was associated with the perception of the PC accessing the smart card: although several on-screen signals are given, users often tended to remove the smart card before they were told to. Organisers from CGIL worried whether this could lead to electrical shocks or a malfunction of the on-board chip in the long term. The voters in Newham had difficulties with the number of screens. We did not encounter this problem at any of the other sites and can assume that it is related to the difficulties a lot of the voters had with the English language. The computer illiterate voters were helped by the staff and once they had completed the voting successfully, they were excited and positive about the system. At the kiosks, no questions were asked about the voting procedure, privacy and security issues.

Further work on similar data is needed for a better understanding of the factors underlying the users' opinions. This may teach us to what extent the voting technology is equally accessible for different user groups. However, we can summarise our findings with respect to usability and the digital divide. From our analysis, we learned that the opinions of the voters are related to their characteristics. We made a distinction between the usability of remote voting and of kiosk voting. We saw that in both situations the users found the TRUEVOTE system very easy to use, independent of how computer literate they were. However, differences in computer literacy of the remote voters were related to the amount of difficulties with installing the system. Age was also a factor in the sense that older voters needed more support with using the system. This result is supported by other research, which found that internet voting provides an electoral bias towards younger voters and to the more affluent (Caporusso et al., 2006; Reniu, 2005; Alvarez and Nagler, 2001; Gainous and Wagner, 2002). The main difference between the remote voters and the kiosk voters was that the less computer savvy kiosk voters have a significantly lower trust in the security of the TRUEVOTE system than the remote voters. Overall, women are more positive about the systems' usability. The opinions about the system are also related to the country people came from and to the general trust they have in the security of the system.

3.3 Issues influencing turnout

In many countries, decreasing political participation and turnout in elections is a general tendency. One of the claims of the proponents of e-voting technology is that the use of new technologies will make voting easier and therefore may increase the turnout in elections. This is also a major argument behind much of the efforts to develop and deploy e-voting technology. What did we learn in this respect from our study?

First of all, there is the issue of recruiting participants for the ballots. If the appeal of new technology is as high as proponents believe, we would expect an easy *process of recruiting*. However, we experienced a large variation in the willingness of people to participate. The ease or difficulty with which one can get people to participate in a project like TRUEVOTE shows how involved people are with e-democracy. The ones that decide to participate are also the ones that are already relatively politically engaged. This was illustrated by the number of times they had voted during the last three elections.[11] The medium apparently does not attract those citizens who are not already politically engaged. This could indicate that the appeal of a new voting system is in general not very high and that turnout is not based on the voting method, or that there are other more organisational issues that play a part. In Orsay, the high number of registered voters may be explained because the City Hall organised the voting session, and all residents received an official letter of invitation. Many members of the two community networks were willing to participate and test the new voting system, but time and organisational constraints such as problems with the distribution of the card readers among the participants lowered the number of volunteers.

Another obstacle was the *registration of voters*. In Orsay, every citizen over the age of 18 was seen as an eligible voter and was therefore allowed to take part in the project. Each eligible voter received an official letter from the Municipality inviting him/her to participate in the e-voting experiment. In Newham, eligible voters were the residents of the Carpenter's Estate. CGIL involved some groups of members and local officials in the studies but the new board was against e-voting and therefore the participation remained low. In the two community networks, all the registered members were invited to participate, while others, interested in the e-voting experiment, registered especially to RCM and OYK to be able to participate. All ballot organisers did a further recruiting of voluntary voters between the first and the second ballot. No further recruiting was done after the second ballot, so the number of registered voters in the second and third round is the same (see Table 6).

Table 6 Turnout

	Test site	*Orsay*	*Newham*	*CGIL*	*RCM*	*OYK*	*Total*
1st round	Voting duration		2 days	2 days	7 days	22 days[4]	
	Registered voters[1]		83	326	190	310	909
	Voting attempts[2]		7	231	130	238	606
	Votes		6	221	125	215	567
	Turnout[3]		7%	68%	66%	69%	62%
2nd round	Voting duration	4 days	2 days	3 days	11 days	10 days	
	Registered voters[1]	925	96	357	303	396	2077
	Voting attempts[2]	N.A.	N.A.	155	207	224	586
	Votes	628	10	145	188	210	1181
	Turnout[3]	68%	10%	41%	62%	53%	57%
3rd round	Voting duration	4 days	2 days	12 days	12 days	12 days	
	Registered voters[1]	925	96	357	303	396	2077
	Voting attempts[2]	477	12	137	168	197	991
	Votes	462	12	135	158	187	954
	Turnout[3]	50%	13%	38%	52%	47%	47%

[1]Number of people registering for the vote.

[2]Registered by the server.

[3]Votes as percentage of registered voters.

[4]Period was extended due to logistical problems.

Voters, who voluntarily accepted the invitation to take part in the experiments, received a personalised smart card carrying their digital signature. Votes could be cast either from a kiosk or from a PC (at home or at work) equipped with a smart card reader provided by the project. The difference between kiosk and PC voting is that in the second case it is the voter himself who installs the smart-card reader and the software (the smart-card reader drivers and the voting application) whereas in the case of kiosks the project staff took care of this. Since the voting application was still a prototype unable to support all hardware and software architectures, some eligible voters could not participate because their PC did not satisfy the requirements. Even though people were already registered as community members, they had to register again as voters. Also, as we shall see later, hardware and software constraints caused a further reduction in the number of participants. CGIL's recruiting, on the other hand, was simple, as they could use membership lists to select groups of participants that were easy to contact for distributing the smart cards and readers.

Second, registering is one thing; voting is another. We found that the turnout at the first voting session was quite high. However, in the second and third voting sessions, the turnout went down in varying degrees in various sites, and this suggests that factors, other than using the new technology, are decisive. In Newham, turnout was exceptionally low, despite the fact that the choice of topics for the ballot was relevant for the residents of the Carpenters Estate, and despite the participation of the Tenant's Association in organising the ballot. Political participation and computer illiteracy may be explanatory factors. As one of the organisers explained:

> "Due to the amount of personal information required to register, not many voters registered. The test area is in a multi-cultural and cosmopolitan society, and therefore not all residents speak English. Due to limited resources and budget, a translation of the documents could not be organised."

Also, it proved to be difficult for CGIL to get its registered members to vote, especially in the later ballots. This might be caused by the fact that the commitment of the (top of the) organisation had disappeared. In the case of RCM, the participation remained relatively high and stable, possibly because of the strong identification of members with their community network (Casapulla et al., 2001), and the strong interest of the staff of RCM in the e-voting technology.

Table 6 shows that the decline in participation is a general tendency in the different locations. After the first burst of interest in a new technology (further enhanced by the large amount of publicity), people get used to the new system and lose interest. Other underlying problems and factors become more important in explaining the low turnout.

Turnout is also related to the issue of getting the technology to work. Because of the experimental status of the system, one cannot fail to encounter examples of technical glitches, however it is important to distinguish between 'expected' technical problems and unforeseen technical problems. We will first discuss the expected problems. *Hardware and software constraints* were part of the software prototype. It was not in the scope of the TRUEVOTE project to develop e-voting software, which could run on all PCs with all the possible operating system versions. Therefore, we expected limits in recruitment as some potential voters were bound to encounter barriers in hardware (the need for a parallel port and a PS2 port, both being available to install the voting kit) and in software (only some versions of the Microsoft Windows operating system were supported).

Another category of expected technical vulnerabilities concerns the issue of *interoperability*. One of the major goals of the TRUEVOTE software was to test software portability from one Certification Authority (Postecom in Italy) to another (Certinomis in France).

Table 7 Problem analysis (RCM – first ballot)

Total number of registered voters	190
Total number of people who did not vote	65
Problems encountered	
No Show (forgot, ill, away, personal matters)	25
Failed voting attempts (see Table 6)	5
Smart-card delivery problems	7
Not able to come and get reader	7
PC crash (not due to TrueVote system)	73
Firewall/net settings	6
Technical problems with the reader (error 401)	12
Correct votes	*125*

The second category concerns technical vulnerabilities that were not foreseen. We distinguish here between client-side and server-side problems. It must be borne in mind that the client-side problems affect turnout rate, while the server-side problems are the sole factor to determine the successful voting rates. RCM carried out an analysis after the first voting session to discover why registered voters did not cast a ballot. They phoned those people whose certificate number was not included in the list of valid votes at the end of the voting session and discovered that 44 people did not vote due to 'personal' or 'organisational' problems and 18 people because of a client-side problem with the voting application (see Table 7). Not including the 25 'no show' voters, there were still 40 people out of a total of 165 who were not able to participate in the voting session. This means that a very high percentage, 25%, of the voters were unable to cast their ballot because of technical problems. The most frequent *client-side error* was due to a conflict between the smart-card reader drivers and the drivers of some version of the Microsoft operating system. An RCM organiser noticed:

> "Some people agreed to install the reader without first checking whether their PCs satisfied the correct hardware requirements and were thus unable to hook up the reader."

Another quite frequent problem at CGIL, RCM and OYK was due to the configuration of the firewall.

The most important *server-side problem* concerned a bug in the closing of the voting session Secure Socket Layers (SSLs) connection (voting from kiosk caused the saturation of the maximum of allowed concurrent sessions and the crash of the application). The problem was fixed but some of the votes were lost due to the lack of a resume procedure (not implemented in the prototype). The system had breakdowns at other moments as well. For example, on several occasions the voters were not able to cast the vote because of technical problems at the server site, and therefore not all voting attempts resulted in a counted vote. The number of missed votes was in average 6.3%, 7.4% and 1.6% in the three waves, respectively. Although these are substantial percentages, the good thing is that the figures show a decline, suggesting a learning process in operating the technology. If we look at the failed votes in the field study sites individually, we see a similar pattern. However, on top of this, we have to count the large number of technical breakdowns of the system at the voters' site, indicating that users of the technology may need considerable support to have proper elections.

As the user's survey showed, installing the hardware and software by the users themselves was not unproblematic. Both in RCM and in Finland, we observed that the large majority of requests for help came from home voters in need of assistance with installing the hardware and software. This is confirmed by a comparison of turnout of TRUEVOTE users with turnout of voters registered for using the CAWI technology. The latter technology is much easier to use (most people have no problem going to a WWW page, and clicking a button to vote), requires hardly any registration or no registration at all, and no installing of hardware and software. Whereas the average turnout of voters using TRUEVOTE went back from 63% to 51%, the turnout of CAWI voters remained at a level of 80%.

The lesson seems obvious. Much more attention should be given to usability when designing and implementing applications for the general public. If we do not want technology to be a barrier, we have to design it as a tool that people can use without being aware of it. In other words, ICT applications should become 'invisible' (Norman, 1998; Winograd and Flores, 1996). This was clearly not the case with the TRUEVOTE system as a Newham organiser points out:

> "It was found that computers were not widely used by the residents, hence some of them had problems navigating through the voting session, and others had to be helped inserting their smart card, selecting buttons, or using the mouse."

The implication is that even if the technology is not the most relevant factor in increasing voting turnout, it obviously may be an important factor that can reduce or change turnout, if not well designed or not well embedded in the existing socio-technical infrastructure. Other researchers have also shown that hardware and software constraints can cause a reduction of the number of participants (Norris, 2005) or a change in the demographics of voters. With respect to the last point, scholars have shown that a shift from traditional modes of participation to internet voting affects the nature of turnout, whereby e-voting decreases with age (Prevost and Schaffner, 2008) and is systematically used more frequently by men than by their female counterparts (Trechsel, 2007; Gibson, 2005).

4 Conclusions

The 14 experiments with the TRUEVOTE system provided an opportunity for ballot organisers, as well as voters, to practise e-voting. This paper has shown that when designing and introducing e-voting technologies both technical and social issues have to be considered.

We established that there were quite a few user-related problems. People had difficulty in installing the hardware and software. Other users had difficulties in understanding the new technology (How do I insert the smart card?). This problem could be solved by increasing the usability of e-voting systems by making the 'technology invisible' (Norman, 1998). Norman points out to us that the device should fit the task and the person who uses it, rather than requiring that the person adapt to the technology. Another solution is to make sure that there is enough support available for the users, and that they have easy access to this support. When technology is not well designed and properly embedded or if the usability of the new technology is insufficient, it may result in lowering participation.

The usability of the technology also relates to the issue of the digital divide. According to many observers, the digital divide is declining. Although the 'digital divide' might seem to narrow, internet connections are still not distributed evenly across racial, gender, age, regional and socio-economic lines. Furthermore, the narrowing of the digital divide is generally measured in terms of *access* to the internet. However, divides may be much more subtle and related to skills required to install the software and hardware, learning, social networks that provide help, ownership of advanced vs. older types of computers, insights into the security and risks, and so on (Wellman and Haythornthwaite, 2002). In our study, we saw considerable differences in computer literacy and this is related to the amount of difficulties with installing and using the system. We, therefore, cannot assume that every citizen has similar access to e-voting possibilities. Technical and organisational solutions should be investigated, to overcome these barriers.

From the former, we can discern that there is a serious risk that if e-voting systems replace the traditional voting systems in the future, it may have the unintended effect that it will exclude large groups from participating in the democratic process, thereby strengthening the already large digital divide. However, the prospect of saving money (or of being 'modern') is often dominant in the introduction of e-voting, and the inclination to keep expensive parallel systems alive may therefore in practice be low. Experiences in other sectors support this. Whereas, for instance, the credit card was introduced as an additional means for paying bills, transactions have increasingly become exclusively related to credit cards, such as reserving a hotel room or renting a car. And, e-voting in the polling booth has replaced paper voting completely in countries like Brazil and the Netherlands, so there is a clear tendency of new voting technologies replacing older technologies. This may also be the case in the future with remote e-voting.

The question, which interested us after 12 focus group discussions with end-users and an extensive literature review, was to what extent empirical proof could be found for increased participation (voter turnout), particularly through the use of remote voting over the internet. We organised three consecutive e-voting tests to find evidence, which would show whether turnout increased, decreased or remained unchanged. The expectation that e-voting will increase participation is not supported by our study. We actually found indications for the opposite effect. The decline in participation was a general tendency over the field studies. So, if an effect of the new technology on turnout exists, it seems that people quickly get used to the new technology, which then loses its special appeal. Also, if the usability of a new technology is insufficient, it may further result in lowering participation.

Our finding that e-voting systems will not increase public participation is supported by other research (Barrat and Reniu, 2004; Electoral Commission, 2003; Electoral Reform Society, 2004). For instance, serious doubts with respect to increased voter turnout as a result of the introduction of e-voting were raised by Phillips and Spakovsky (2001). Both they and the Internet Policy Institute (2001) concluded that previous reforms designed to make the voting process more convenient had hardly any effect on voter turnout. Likewise, the first sentence of the chapter on e-voting in a British governmental consultation paper reads: "Electronic voting will not solve the problem of low turnout in elections" (United Kingdom Cabinet Office, 2002, p.41). In her paper "E-voting as the magic bullet? The impact of internet voting in

European parliamentary elections", Norris is also very sceptical about any potential revolutionary benefits from e-voting on turnout. She compares levels of turnout in 70 national parliamentary or presidential elections held during the 1990s in 25 established democracies (Norris, 2002). Her analysis shows that only polling on a rest day provided a significant boost to turnout. Proxy voting (when a person is authorised to act for someone else) and the number of days that the polling stations were open were negatively associated with turnout. More important to our argument – that e-voting will most likely not improve turnout at elections – is her finding that:

> "Other special voting facilities, such as the availability of postal or advance voting, as well as the use of automatic or voluntary registration procedures, proved to be unrelated to levels of electoral turnout."

Norris notes that e-voting at home or at work can be seen as analogous to the use of postal ballots, and she points out that the evidence suggests that the use of such facilities has had no or very little effect on turnout.

> "If European elections are widely regarded as largely irrelevant to the policy outcome, or if people do not feel that they are presented with choices which represent their interests, then no matter if casting a ballot becomes as easy as clicking a mouse, participation levels will, unfortunately, probably remain miserably low." (Norris, 2002, p.12)

Other research supports Norris' finds. For instance, a recent report by the Joseph Rowntree Reform Trust found that the benefits of e-voting have been exaggerated particularly in relation to claims about increased turnout and social inclusion (Wilks-Heeg, 2008). Poor levels of turnout are a reflection of wider attitudes in society and therefore solutions to the underlying problem are unlikely to be found through changes in procedures and voting systems (Henn and Weinstein, 2001). Pratchett (2002, p.35) argues:

> "Reasons for voter turnout are concentrated more upon cognitive explanations: those around civic duty, information, skepticism and political efficacy. This finding dispels any suggestion that there is great public demand for e-voting and casts doubt upon whether it would radically change voter turnout."

Summarising, we can state that government policy to increase public participation by e-voting is grounded on too simplistic assumptions. Policy-makers should, therefore, be aware of the more complex interrelations and interactions between technology and society. Van Dyck and Gimpel (2005, p.534) explain that the reason why politicians are still keen on changing voting procedures is because, from a policy standpoint, it is a lot easier than resolving the issue of low efficacy and motivation: "Institutions are easier to 'fix' than attitudes".

E-voting may soon be the dominant mode of voting, which could hamper the participation of specific user groups. Demographic groups with less access and less familiarity in using computers might find some types of (remote) e-voting difficult or intimidating. In the field studies, we saw considerable differences in the frequency of use of ICT. This frequency of using ICT is related to the amount of difficulties with installing and using the system. Therefore, we cannot assume that every citizen has equal access to remote e-voting possibilities. This is a serious matter, as Alvarez and Hall (2004, p.52) point out: "If internet voting affected who voted, then it clearly would affect who was elected". All these issues open the debate about the benefits of e-voting. Given the complexity and the implied costs to organise e-voting in a reliable way, one may argue that the traditional paper-based vote may be for many countries the better option: cheaper, transparent and accountable.

Concluding, our study has shown that real-life experiments in an early phase of technology development are relevant because they help to point out the first- and second-order effects of new technologies. The pilot studies helped us to establish some unanticipated consequences of remote e-voting systems. Discovering potential effects early in the development is important because at that point there is still time to elaborate on different choices that can be made. There is never just one solution possible for complex problems. Our results suggest that early experiments and extensive user-involvement can yield insightful, rich and usable data, even when applied to complex and large-scale e-government systems. Real-life studies, therefore, should become a standard activity in technology development projects.

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Notes

[1]E-voting refers to casting a ballot via a broad range of electronic telecommunications technology including the internet, (mobile) telephones, cable and satellite television, and computers without internet connections (Gibson, 2002).

[2]Italian General Confederation of Labour (CGIL), Rete Civica di Milano (RCM), The Learning Upper North Karelia (OYK).

[3]Computer Assisted Web Interviews.

[4]Similar to the e-voting pilot studies done by Barrat and Reniu (2004) and Caporusso *et al.* (2006).

[5]The participants in the field studies constitute a self-selected sample. By choosing a highly relevant topic for the local constituency, we expect to have also attracted voters who were not particularly interested in new voting technology as such. The variety in opinions about the technology supports this. Unfortunately, we were not able to survey non-participants and therefore we do not know whether opponents of e-voting abstained from participation more often than others. If so, the conclusions may have a slightly pro-technology bias.

[6]Based on questionnaire 1.

[7]We found some 17 new variables, of which we use nine in the analysis presented in this paper (Table 4).

[8]We do not pursue the issue of accountability further, but this is a central issue in the discussion of e-voting. The main critique of e-voting is that – in case of doubt about the correctness of the outcome – a recount of the ballots is impossible. Critics, therefore, want to abandon internet voting, and demand a paper trail in case of kiosk based e-voting.

[9]Based on questionnaire 3, after the third voting session.

[10]Based on questionnaire 2, after the first voting session.

[11]Based on questionnaire 1, before the first voting session.