Designing the Vote:
An Exploration of Electronic Voting as a tool for Political Participation

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Abstract

This thesis describes my attempt to envisage electronic voting as a tool for political engagement by challenging the conventional understanding of the role of technology in democracy as only facilitating 'politics' referring to the means, structures and mechanisms that enable governing. This entails the reappropriation of voting as a tool that embeds methods for dissent to be democratically manifested, and the discovery of novel ways with which voting systems can be designed to encourage citizen involvement in political processes; from setting up polls and political canvassing to voting and political deliberation.

I materialize this novel conceptualization of voting by introducing a design framework that enables us to rethink the capacities of systems to support various democratic contexts. We instantiate this framework for the design and development of novel voting prototypes that we later deploy in collaboration with local communities in Newcastle upon Tyne and Cambridge in order to gain an understanding of how their affordances and contextual parameters influence political participation.

As a result, in this thesis we present a number of case studies incorporating new designs, empirical methods and findings that begin to explore this conceptualisation of voting as a tool for political engagement. More specifically, we explore: (i) the reappropriation of voting as not only supporting the doing of politics, but also the participation of the involved stakeholders in a political process; (ii) the capacities of voting systems that enable this profound citizen participation to be materialised in local contexts and the possible change that might result from this; and (iii) the contextual parameters affecting citizen engagement in voting such as the system's ownership and the authority to drive political agendas. In doing so, we offer new insights into the potential of voting to support political engagement and participation.

Acknowledgments

The work presented in this PhD thesis would not have been possible without the advice and help of many very smart people. I would like to express particular thanks to Patrick Olivier for his support and inspiration throughout these years in Culture Lab. Also special thanks must go to Paul Dunphy who helped me see information security and e-voting from a different perspective, Rob Comber whose expertise allowed me to explore voting from its sociological outlook, and Nick Taylor who gave me a first indication of what HCI in voting means. I benefitted from their expertise and experience immeasurably.

Thank you to Karim Ladha and Dan Jackson who developed the hardware and firmware described in this thesis and supported me with their technical expertise. I would also like to thank my hosts in Microsoft Research Cambridge Alex Taylor and Tim Regan who in addition to Siân Lindley allowed me to work on a substantial e-voting related project in Cambridge.

To my colleagues in Culture Lab (recently renamed Open Lab), thank you so much for your advice, motivation and friendship over the past few years. I hope you know that I am grateful for your conceptual and technical contributions throughout these years. You reminded me a number of times that there are more important things in life beyond work that can easily be found in the nearest pub or on a squash court. Special thanks must go to Clara Crivellaro who through our discussions gave me a concrete example of how dissent can be constructively manifested, and Anja Thieme whose input helped with the thematic analysis and research undertaken in Chapter 7.

Finally, thanks must go to my parents who supported me so that I could go to university and come to Newcastle in the first place. Thank you all.

Contribution Statement

This PhD contains work undertaken in collaboration with a number of people from Newcastle University, Open Lab and Microsoft Research Cambridge. In the chapters in which such collaborative work is reported, the contribution of these people is clearly indicated with references and footnotes.

More specifically, Karim Ladha (Newcastle University) designed and developed the hardware and firmware described in Chapter 6, while Dan Jackson (Newcastle University) developed the decoding algorithm for downloading the data of the devices described in the same chapter.

Also, the case study reported in Chapter 7 was undertaken in collaboration with Microsoft Research Cambridge as part of the Tenison Road project. The BullFrog devices and Physical Charts were developed and designed by a team of developers in Microsoft including Tim Regan and David Sweeney (for more information see [1]). The Tenison road project was led by Alex Taylor (Microsoft Research) and Siân Lindley (Microsoft Research) who in addition to Anja Thieme (Newcastle University) contributed to the work presented in Chapter 7 by giving me their valuable insights and comments.

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Chapter 1.

Introduction

The principal concern of this thesis is the design of electronic voting systems to support local democratic practices. This involves a deeper examination of democracy and the different avenues that it can be manifested in, on a local and national scale, in addition to the distinctive participatory types that these democratic practices entail. These participatory types ranging from the mere act of casting a ballot to more prolific citizen involvement, such as political deliberation and contestation, require us to reconsider how technology can support democracy through the careful configuration and design of e-voting systems.

There are multiple interpretations and ways of doing democracy according to the type of politics that a person subscribes to. Even though this is a matter of academic and philosophical debate in the political and communication sciences, the physiognomies of an ideal democracy are highly subjective especially in fields of study with no strong theoretical background in politics. Apart from notable exceptions [11,14,45,90,91,110], computing science (computer security and HCI) research on electronic voting, intentionally or otherwise subscribes to an understanding of the role of technology in democracy as only facilitating 'politics' which refers to the means, structures and mechanisms that enable governing [135]. As a result, voting is designed to be a tool for the calculation of interests with a particular emphasis on reaching consensus. Consequently, participation of citizens in voting, particularly in computing science, is understood either as only the mathematically secure casting of a ballot in national elections (computer security) or as

their involvement in hierarchical top-down consultation exercises (HCI). The role of technology is thus supplementary, as it acts as an additional medium for voting without playing a significant role in motivating the participation of politically indifferent citizens or providing more meaningful ways for them to participate.

Alternatively, voting can also be considered as not necessarily a tool to facilitate consensus and politics but as a tool to engage citizens in the 'political'. According to C. Mouffe's theory of agonism, 'the political' in contrast with 'politics' refers to the societal condition in which opposition is on-going, rather than seeking the ideal of universal consensus, and expressed in a multiplicity of ways from political debates to protesting [135]. Design for the political [53] aims primarily at creating spaces of contest where different opinions can be disputed democratically. A politically designed e-voting system, instead of necessarily seeking consensus, should envisage a vibrant public space (described by C. Mouffe as an 'agonistic' public space) of contestation where the various political projects can be confronted [135:3]. In order to consider the form of such voting systems, detached from the impediment of consensus and focused more on the political process initiated during their use, we need to detach them from their traditional contexts and connotations. As a result, this thesis describes my attempt to envisage electronic voting as a tool for political engagement, from provoking debate about political issues to providing ways of campaigning and bottom-up collection of opinions. This entails: repositioning voting as not only a consensual tool of democracy but also one that embeds methods for dissent to be democratically manifested and the creation of spaces for contestation; the discovery of novel ways with which voting systems can be designed to encourage citizen involvement in political processes around the vote from setting up polls and coming up with questions to political canvassing.

In order to achieve that, I review related work in voting in the areas of computer security and HCI in which the majority of work supports a conventional design for politics approach. After highlighting the political decisions embedded in the design of these artifacts and systems I then illustrate the variety of ways in which the affordances of a system may vary according to context and politics, and I also attempt to reconsider the design of voting when seen under the lens of political participation. I materialize this framing with the design and development of voting systems that reflect this new conceptualization of voting. These systems are later used in three case studies in collaboration with local

communities in Newcastle upon Tyne and Cambridge in order to gain a deeper understanding of how they may support political engagement and debate. I expect the research outcomes of this thesis to be valuable to both HCI researchers involved in community engagement and practitioners and local communities who wish to either reuse the systems developed in this thesis or extend them to support their own needs.

1.1. Research Questions

The research described in this dissertation explores the parameters able to affect participation in voting. I begin by drawing on a conceptualisation of the politics and the political in voting, influenced by C. Mouffe's theory of agonism, and resume with materialising this conceptualisation through the voting systems' affordances and through the physiognomies of the voting context. This endeavour can be more thoroughly described in the research questions below.

1.1.1 How do we design for politics and the political in voting?

Extensive work has been conducted in human computer interaction (published in SIGCHI, CSCW etc.) in the area of voting. The majority of the work in HCI explores the impact of the voting interface on usability, accessibility and most recently participation, with participation being explored through the development of innovative voting interfaces that enhances the experience of voting (e.g. by the utilisation of full body interaction, media façades etc.). In contrast, there is a relative lack of work exploring how the assumptions about the nature of politics and the political are embedded in the design of these voting systems and how these affect the materialisation of participation. Only recently [51,52] has HCI research begun to engage with the political assumptions embedded in the design of artefacts and systems, with voting systems yet to be examined.

Voting, especially when thought of in the context of national elections, is heavily associated with consensus. Consensus is a necessary enabler of actionable decision-making in large-scale democracies, but it should not be assumed to be the ultimate focus of every voting system in all contexts. As I will discuss more thoroughly in the next chapters, different models of democracy afford different types of participation, which in turn have different actionable objectives. Consensus is only one of the possible objectives of voting, an objective driven predominantly by a single model of democracy: representative democracy. Other types of democracy might afford other objectives, for example in

adversarial democracy contestation is the aim of a voting process or in a deliberative model the need for voting to reach consensus might indicate an unsuccessful deliberative process.

In this thesis, and particularly in Chapter 2, I highlight that voting systems come with assumptions embedded in their design, which are informed by the type of democracy and participation that these systems attempt to achieve. I contend that the majority of research in computing science focuses on the facilitation of the politics of voting, referring to the structures and mechanisms that enable efficient governing. In this regard I introduce voting systems designed to question the typical assumptions of voting as merely a tool to support the doing of politics in a consensual democratic model. As a result, I suggest a design framework that will allow us to design voting systems to support different democratic models and participatory types depending on the physiognomies of the context.

1.1.2 How do systems' affordances affect participation in voting?

Building on my first question, which refers to the design assumptions of politics and the political in voting, the second question relates to the materialisation of this conceptualisation through the systems' affordances. In this regard, the affordances of conventional voting systems are minimal since from the voters' perspective they only allow casting a vote (a YES/NO vote for candidate(s) or question(s), or a ranked ballot). I contend that this is a result of the combination of the design assumptions of voting systems to serve the politics of representative democracy and the limitations of opinion collection by conventional means.

Technology can play a significant role in overcoming these limitations and extending the capacities of e-voting systems. So far, computing science research has only focused on either making it easier for people to vote – by making systems more usable, more accessible, providing more channels for participation etc. – or ensuring the security of e-voting through cryptography. I argue that these orientations undervalue the true potential of the application of technology in voting. For such potential to be fulfilled, we need to reconsider the design assumptions of voting systems that drive the way people participate politically.

Consequently, by taking conventional voting systems as a starting point and unpicking their political assumptions and security requirements, I attempt to extend the affordances of voting systems for participation. By participation in this case I refer not to the simple push of a button, but to the 'political' participation that creates spaces for citizens to debate their viewpoints and for the different political projects to be brought to light and confronted [135]. This also involves citizen participation in processes around the casting of the vote, including political debates, political canvassing, setting up voting agendas, etc. As a result, in this thesis I argue for the extension of the repertoire of political participation through carefully reconsidered e-voting systems.

1.1.3 How do contextual parameters affect participation in voting?

In my previous research questions I have mainly concentrated on the effect that the politics embedded in the design of systems has on participation and the utilisation of technology to extend the repertoire for political participation. As a result, I have focused on two aspects of system design: (i) the political assumptions embedded in a system's design; and (ii) the affordances of technology for participation.

My final research question engages with contextual factors affecting participation and as a result takes a more holistic approach in our interpretation of the system. This requires us to extend what we refer as 'system' to the context in which it is situated. By context I refer to the variables external from the actual voting system, its design and affordances, which can possibly affect its use. A contextual parameter is the type of question asked, which relates to whether the voting process will lead to something actionable, the stakeholders affected by the possible action etc. For example the same voting system (in terms of its design assumptions and technological affordances) will achieve different types of participation in a national election context compared to a local one. Other contextual parameters include, amongst others, the ownership of the voting system, the origin of the question, and the social and temporal geographies of the environment where the voting process occurs (contextual parameters are more thoroughly discussed in 0 and in each one of my subsequent case studies).

This thesis presents case studies that attempt to explore the politics and affordances (for participation) of voting systems by varying their configuration, and also studies the context in which these systems are situated. From voting for planning proposals to asking innocuous questions, and from workplace environments to local neighbourhood communities, I endeavour to take the first steps towards understanding the effect of contextual parameters on participation.

1.2. Summary of Contributions

In the course of responding to my research questions throughout this thesis, I have contributed new knowledge to the field of HCI and e-voting. A summary of my contributions is listed below (for a thorough review of the contributions of this thesis see 8.4).

1. Taking C. Mouffe's theory of agonism as a starting point, I introduced a new conceptualisation of 'politics' and 'the political' in the voting context. My empirical studies explored how this can be achieved through extending and adapting the affordances of voting systems, and how this might relate to external contextual parameters.
2. I proposed an innovative and extensible framework for designing e-voting systems for political participation. By applying this framework in designing novel voting systems in various contexts, I identified underexplored dimensions of digital vote design, and extended the affordances of voting for participation.
3. The design, development and evaluation of *BallotShare*[1]. Informed by the design framework I proposed, BallotShare is a novel e-voting system that allows the configuration of polls depending on the context that it is deployed in. BallotShare was used in two of my case studies, as an online voting system for a workplace environment (Chapter 5), and as an online channel of participation in a local community voting context (Chapter 7).
4. *PosterVote*[2], a novel 'situated voting' technology that enables the exploration of the affordances of voting for participation in the local and situated. The main contributions of PosterVote (for detailed contributions see 8.4) are: (i) The design

[1] http://ballotshare.com

[2] http://postervote.info

concept of PosterVote, comprises conventional paper posters and low-tech hardware. These can be put together to create a sustainable e-voting system (see 6.2); (ii) An online tool, allowing the easy design of PosterVote paper posters, which facilitates the appropriation of this voting tool by local communities[3]. (iii) The evaluation of PosterVote in three case studies as: a situated voting system on lampposts for the collection of data from community activists; a situated survey system on table stalls during a community festival; one of the situated voting devices used in my last case study, where PosterVote enabled the collection of votes on the street extending the reach of the voting devices to the wider community.

5. The evaluation of three voting devices that were deployed in parallel to explore how their capacities and contextual parameters mediate participation, and how participation is enabled and perceived in place[4]. I deployed: PosterVotes on lampposts to capture the opinions of passers-by; BullFrogs[5], situated playful voting devices in residents' households; and BallotShare for online voting, specially configured to allow multiple channels of online participation such as SMS voting and Twitter voting, and serving as the backend system for a set of Physical Charts[6].

1.3. Research Approach

To answer the above questions, after establishing the argument that voting systems encompass assumptions related to how politics is done and how the political is enacted, I propose a framework that materialises this conceptualisation through the voting systems' affordances and through the physiognomies of the voting context. This framework is informed by my review of democratic models and political systems in addition to related work in computer security, usability and accessibility. Finally, I utilise this framework to instantiate example e-voting systems designed specifically for the contexts that they are to be deployed in.

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[3] For details visit http://postervote.co.uk

[4] In collaboration with Microsoft Research Cambridge

[5] Designed and developed by Tim Regan at Microsoft Research Cambridge

[6] 'Physical charts' are mechanical data visualization charts developed by David Sweeney at Microsoft (see [157] for more information).

I adopt a case study approach to explore how the affordances of the designed voting systems had an impact on participation and whether a more vibrant democratic space was facilitated. As indicated by the third research question that I endeavour to approach in this dissertation, my case studies were chosen to represent a cross section of contexts in order to understand, in addition to the affordances of technology and influence of design, the contextual parameters affecting participation. The contexts and communities I worked with range from: (i) our research workplace environment[7], that I could observe closely, serving as an initial exploratory case study that allowed refinement of the proposed design framework[7]; 2) a local community in Newcastle upon Tyne, UK[8] where the questions were decisive and actionable due to an oncoming regeneration project; 3) a local community activism context in Newcastle upon Tyne, UK[8] in which the voting system acts as a tool for the collection of data for campaigning; 4) and a local community in Cambridge, UK[9] where a series of voting systems were deployed in parallel to explore how the affordances of various voting technologies mediate participation in terms of how it is enabled and perceived by residents. My methodology is primarily empirical and qualitative but where appropriate, a mixed-methods approach has been used, with the prototype voting systems' logs and access data being used to support the qualitative findings or structure the semi-structured interviews conducted throughout this research. As a result, the voting prototypes described in this thesis act as technology probes [95] to explore in depth the contexts in which they are deployed and reflect on their participatory nature.

Probes, a research method first introduced by Gaver et al. (1991) [72] in the form of cultural probes, differ from traditional scientific investigation as they are placed in an environment and left unattended to collect data. Instead of aiming specifically at collecting quantifiable data for statistical purposes, cultural probes aim to provoke inspirational responses from participants and take a snapshot of their lives. The probes themselves are deliberately left vague and open to interpretation to provoke participants' imagination

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[7] Vlachokyriakos, V., Dunphy, P., Taylor, N., Comber, R., & Olivier, P. (2014). *BallotShare: An exploration of the design space for digital voting in the workplace*. Computers in Human Behavior, *41*, 433-443.

[8] Vlachokyriakos, V., Comber, R., Ladha, K., Taylor, N., Dunphy, P., McCorry, P., & Olivier, P. (2014, June). *PosterVote: expanding the action repertoire for local political activism*. In Proceedings of the 2014 conference on Designing interactive systems. 795-804.

[9] Taylor, A. S., Lindley, S., Regan, T., Sweeney, D., Vlachokyriakos, V., Grain-ger, L., & Lingel, J. (2015, April). *Data-in-Place: Thinking through the Relations Between Data and Community*. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (pp. 2863-2872). ACM.

rather than drive them to a specific direction. The quick adoption of cultural probes as a research method in HCI resulted in the adaptation of the method in a variety of ways, the most relevant for this thesis being technology probes [95]. Technology probes replace the cultural probe pack with an open-ended and vague technology with very limited functionality, which is left in an environment for participants to interact with as they please. The goal of this approach is not to develop a fully functional system but to gain a better understanding about the deployment environment and inspire design ideas from participants' interactions with the probe.

Action research, also relevant for this thesis, is a combination of action and research with an imperative of understanding the environment whilst also provoking change through action [71]. Research participants are encouraged to participate as co-investigators and action researchers immerse themselves with the subjects and context under investigation. In an action research approach a problem is explored through a series of iterations of problem diagnosis, intervention and reflection aiming at improving the problem of interest for the user (action) and also at generating theory, primarily of interest for the researcher.

For the case studies, action research through the development of prototypes that act as technology probes is used. I use technology probes to gain a better understanding of the context and needs of my participants while working with them to bring change in their environment. Another area of particular interest is the development of sustainable technological tools in collaboration with my participants, informed or iterated by technology probes that can act as agents of change even without the researchers' involvement. Simply put, I pursue an action research approach which has a tacit outcome for the participants and environment not only during the research project but beyond it. More specific details about the methodology and approach followed in this thesis as well as the limitations of some of the predominant HCI methods in politically sensitive contexts (e.g. participatory voting prototypes for national elections) will be discussed in subsequent chapters (data chapters 5, 6 and 7).

1.4. Methodological Inquiry

HCI research, even though typically sensitive about socio-political issues and the role of technology in coping with them, in many cases fails to design and develop systems capable of being sustained in the contexts that they were designed for after the research project ends or the researchers' technical support is no longer available. In most cases this is because the scientific endeavour of an HCI community engagement project and its limited resources only allows for the development of systems that serve as research prototypes (with some notable exceptions, e.g. [14,45]), and thus as probes to gain further and deeper knowledge about a context and a technology. There is therefore a cost in developing systems that are only useful while the research project is ongoing and are proven to be unusable when the research funding ends (as indicated by Taylor et al. [188]). This can be attributed to the traditional notion of science as a field that produces boundary-pushing knowledge without necessarily defining the avenues through which it can be harnessed by citizens themselves (i.e. democratization of science). In most cases, HCI research is based on the assumption that existing technology firms or new start-ups can utilize the retrieved knowledge from community engagement case studies to build products and systems informed by the research undertaken. Whether this model can also work for technology designed to support grassroots movements is a matter of debate. I believe that the possible misalignment of interests between technological firms and local communities may play a significant role in the advancement of this area of research.

In the case studies reported in this thesis I designed and developed technology to act as 'probes' in order to gain deeper understanding of the context and the designed technology. However, these systems were also designed under the lens of developing systems that can serve as sustainable data collection tools. This involved taking into consideration the future cost of the developed devices and non-technical ways of maintaining the voting and political process at a local level (e.g. PosterVote described in Chapter 6). As a result, even though technology probes might be described as the predominant style of enquiry in this thesis, the prototypes developed serve not only as probing devices, but also as adaptable and sustainable tools that allow the democratization of the contexts that they are deployed in, thus approximating an action research approach.

Finally, studies aiming to not only quantify engagement but also raise awareness and engage the local community in the political, face methodological difficulties of measuring the political engagement of participants and assessing the effectiveness of these technologies for change. Political engagement of the community and discussions provoked by the in-situ deployment of prototypes cannot be easily captured, a problem that results in the utilisation of only quantitative measures (e.g. number of votes) for community feedback. This leads to further concentration of political engagement around the vote, which in many cases plays a more significant role for democracy than the vote itself.

For the purposes of this thesis, even though quantitative data about the systems' use was collected (through logs etc.), it was used only to inform and structure the qualitative research questions and findings. This was a deliberate decision as focusing on quantitative data would result in equating a percentage representing voter turnout or other quantitative data with political participation, which is an approach that I attempt to raise questions about in this thesis. Contrastingly, attempts were made to capture political participation in qualitative ways by interviewing the stakeholders involved in running the voting process and via observations.

1.5. Research Journey and Thesis Structure

Coming from a highly technical background (BSc in Computing Science and a MSc in Computer Security and Resilience), I started my PhD with a highly technical and conventional approach. A PhD in e-voting in a computing science department involves the invention of novel encryption algorithms or interfaces that allow the secure and verifiable casting of a vote. After engaging with most of this literature I focused on the motives of introducing digital technology in voting. This, in addition to the HCI perspective in my PhD, led me to focus on citizens' participation instead of security and unpick how participation can be an important variable in assessing the security of voting system for political participation. As a result, I shifted towards more politically oriented literature with a particular interest in the design assumptions embedded in systems. If appropriately questioned, this can lead us to more participatory types of system, able to empower democracies through technology. The result of this was the design framework that I report in Chapter 4, which I use to instantiate and assess the systems designed in the later chapters.

To structure this journey I have organised this thesis as follows: In Chapter 2 I introduce the role of design in democracy and C. Mouffe's argument on the differentiation between politics and the political. I support this argument by revisiting voting machinery from voice voting to internet voting and identifying the trajectory of citizens' participation from political engagement to simply voting. Then I review the various democratic systems relevant for this thesis and introduce the types of participation that each one of these systems entail. I argue that most of the work done in the area can be considered as "design for politics". The goal of this chapter, rather than searching for the ideal democratic system, is to underline the lack of understanding, especially in HCI and in more computing-oriented disciplines (e.g. computer security), of the politics embedded in the design of voting systems framed as solutions to the socio-political problems of today's democracies. Moreover, I attempt to unravel the design space of voting when seen as a tool to support democracy through the creation of politically vibrant democratic spaces, rather than solely enabling representation.

Chapter 3 comprises a literature review of the application of technology in voting, which encompasses what I perceive as work relevant to "design for politics" with a particular focus on voting security, usability and accessibility, and confidence and trust. Rather than arguing that these vocabularies are irrelevant for the focus of this thesis, I want to stress that a different understanding of them is required if we want to design voting systems with a different emphasis. I begin by discussing the requirements for voting security by visiting the three pillars of computer security research: confidentiality, integrity and availability, in addition to the voting specific requirement of verifiability. Then I briefly review some of the most important technical advances in the area with a particular emphasis on the ways that these systems unintentionally configure participation through the provision of special voter interfaces. Finally I review how some of the proposed secured election prototypes are perceived by voters and their impact on usability and accessibility.

Chapter 4 contains my proposed design framework for participation in voting which embodies the points raised in chapters 2 and 3. Taking into account the assumptions for doing 'politics' embedded in the design of conventional voting systems (discussed in Chapter 2) and their traditional requirements originating from security and participatory boundaries of representative democracy (discussed in Chapter 3), I unpick a design framework of voting serving as a toolkit for the design of participatory systems. After a

review of the various affordances of voting systems found in a range of contexts, I propose the design categories of *eligibility*, *fairness*, *secrecy* and *expression* as possible design categories that encapsulate the necessary decisions that any poll initiator needs to make when designing a poll. This framework equips us with the necessary tools to instantiate and assess, depending on contextual parameters, the voting systems that I describe in chapters 5, 6 and 7.

In Chapter 5 I introduce my first voting prototype that we call BallotShare. BallotShare is a first instantiation of the design framework and is designed to serve as a technology probe [95] allowing for the exploration of the context in which it is deployed. This first instantiation is specifically configured to reflect on the democratic practices of a workplace environment. As a first instantiation of the proposed design framework, BallotShare questions some of the conventional security assumptions of voting and also serves as a tool to engage participants in political discussions about the workplace environment. In this chapter, I discuss the design decisions embedded in the design of BS and report the result of semi-structured interviews and log data from the use of the system over a five-week period.

In Chapter 6, I introduce our second voting prototype, called PosterVote. In contrast with BallotShare, which is designed to serve as an online and remote voting platform, PosterVote is a situated voting device designed to politically engage users in place. In Chapter 6, I report on two case studies in contexts related to local community activism and regeneration planning. PosterVote, in addition to reflecting on the design framework of participatory voting, is also designed for sustainability with respect to the monetary costs and technical skills required to maintain it. To assess PosterVote as a system to support local planning and activism, I deployed multiple devices in two local communities in Newcastle upon Tyne, UK. Through these case studies, I reflect on how its materiality and affordances affected participation in a local community.

In Chapter 7 I continue this inquiry towards designing voting systems for political participation through the deployment of various voting systems and data representation technologies in a local community in Cambridge, UK. The work reported in this chapter is the outcome of the collaboration with Microsoft Research Cambridge in the Tenison Road project. The initial stages of this project were designed to explore how the production and use of data is bound up with physical and social notions of place (more details at

[186]). In the final phase of the project reported here, we deployed a group of voting technologies (online, situated in residents' households and on the main neighbourhood street) for data input and output. During a five-week period deployment of three voting systems, providing six channels of input and five channels of output, I explored how residents experienced the different voting mechanisms, made sense of the data collected, and how these related to community participation. I later present our insights into how contextual parameters of the deployment and the various capacities of the deployed systems impacted residents' participation in the project and their engagement with, and understandings of, the technologies and data.

Finally in Chapter 8, I conclude by discussing the implications of this work, revisiting our research questions, listing our contributions and suggesting possible directions for future work.

1.6. Prior Publications

Significant parts of this PhD thesis have been previously published in peer-reviewed conferences and journals:

1. Vlachokyriakos, V., Dunphy, P., Taylor, N., Comber, R., & Olivier, P. (2013, May). Unpicking the design space of e-Voting for Participation. In *Conference for E-Democracy and Open Governement* (p. 357)
2. Vlachokyriakos, V. Designing Voting Technology for Participation. *In proceedings of the 14th Annual International Conference on Digital Government Research.* 2013, Quebec, Canada
3. Vlachokyriakos, V., Comber, R., Ladha, K., Taylor, N., Dunphy, P., McCorry, P., & Olivier, P. (2014, June). PosterVote: expanding the action repertoire for local political activism. In *Proceedings of the 2014 conference on Designing interactive systems* (pp. 795-804). ACM.
4. Vlachokyriakos, V., Dunphy, P., Taylor, N., Comber, R., & Olivier, P. (2014). BallotShare: An exploration of the design space for digital voting in the workplace. *Computers in Human Behavior*, *41*, 433-443.
5. Dunphy, P., Vines, J., Coles-Kemp, L., Clarke, R., Vlachokyriakos, V, Wright, P., McCarthy, J, and Olivier, P. (2014). Understanding the Experience-Centeredness of Privacy and Security Technologies. In *Proceedings of the 2014 workshop on New Security Paradigms Workshop* (NSPW '14). ACM, New York, NY, USA, 83-94.
6. Vlachokyriakos, V., Comber, R., Crivellaro, C., Taylor, N., Kuznetsov, S., Kavanaugh, A., Le Dantec, C. & Kim, B. J. (2015, April). Designing Alternative Systems for Local Communities. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems* (pp. 2333-2336). ACM.
7. Taylor, A. S., Lindley, S., Regan, T., Sweeney, D., Vlachokyriakos, V., Grainger, L., & Lingel, J. (2015, April). Data-in-Place: Thinking through the Relations Between Data and Community. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (pp. 2863-2872). ACM.

8. Regan, T., Sweeney, D., Helmes, J., Vlachokyriakos, V., Lindley, S., & Taylor, A. (2015, April). Designing Engaging Data in Communities. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems* (pp. 271-274). ACM.
9. Lindley, S., Thieme, A., Taylor, A., Vlachokyriakos, V., Regan, T., Sweeney, D. Materialising Multiplicity and Fixity through Data-in-Place. (under submission)
10. Vlachokyriakos, V., Thieme, A., Taylor, A., Lindley, S., Regan, T., Sweeney, D. Voting-in-Place: Designing Multiple Channels of Community Participation. *(under submission)*

Chapter 2.

Politics and the Political in Voting

‘Design for Democracy’ is used as an umbrella term for every practice of design in a democracy related setting. The term may refer to the graphical design of paper ballots, political parties’ campaign posters, the design and functionality offered by online websites of politicians (e.g. Obama campaign) and the design of electronic voting systems. In this chapter I argue that voting systems are designed and thought of mainly for one type of democracy, representative democracy, which translates to voting systems mainly seeking to reach consensus through the quantification of opinions.

I begin by reviewing a number of models of democracy and highlight how, depending on context and political decisions, various types of participation can be required. I attempt to rethink how voting can be practised when removed from the frame of supporting conventional politics and electoral efficiency. Following this, I rethink how technology can help overcome some of the disadvantages of conventional voting mechanisms and also require us to contemplate what we consider as appropriate citizen participation. The latter also involves a further exploration of the context in which participation is executed: What type of participation does representative democracy require to be considered as successful? What type of participation and democratic system is adequate for various decision-making contexts other than national elections? Even though a high turnout is required in order to ensure that an election is representative and legitimate, is the act of voting and thus the turnout rate the ultimate measure of citizen participation? We argue that this depends on the model of democracy that the voting system serves.

In order to explore these issues and questions I introduce the role of design in politics and revisit the differentiation between design for politics and political design, which plays a significant role in current e-democracy research and practice. Then, after a review of the evolution of participation through voting machinery, I introduce different models of democracy in order to highlight the misinterpretation of election turnout as participation.

2.1. Design and Politics

L. Winner in his work "Do artifacts have politics?" [197], discusses the political qualities embedded in the design of technical objects and explores the claim that machines, structures and systems can be assessed not only in terms of their contributions of efficiency and productivity but also in the ways that they embody authority and power [197]. He argues that there are two ways in which artefacts can embed political properties: instances in which the design of technology (or technical device) serves to settle an issue in a community; and political technologies that appear to inherently require specific types of political association. In the first instance, the design acts as a convenient way of establishing patterns of authority and thus 'designed' technologies have a flexible material form. In the second instance, the properties of the technology are strongly and possibly unavoidably linked to specific patterns of hierarchy. Simply put, there are no alternative designs of the technology that would make a significant difference in relation to political effect.

To exemplify how technical arrangements can be used as forms of order and thus as settling an issue in a community (i.e. *artefacts embed politics*), L. Winner uses the example of the extraordinarily low bridges over highways in New York. These bridges were deliberately designed to be very low in order to achieve a particular social effect. More specifically the master builder for city planning, from the 1920s to the 1970s in New York, designed the bridges in a way that discouraged the presence of buses on the highways for reasons of social-class and racial prejudice – car-owning upper and middle-classes were free to use the roads, however poor and black people were kept off the roads as they were using public transport. After decades these structures are still serving as a way of engineering social relations between people, which over a period of time have become embedded in the society and landscape and are perceived as the norm.

According to L. Winner, the assumption that technology is introduced into a specific context to achieve increased efficiency has been historically disproven. He continues: "*Technological change expresses a panoply of human motives, which is the desire of some to have dominion over others, even though it may require an occasional sacrifice of cost-cutting and some violence to the norm of getting more for less."* [197:124]. This is not to say that technologies with political consequences are designed intentionally or unintentionally favouring one end of the political spectrum: "*Rather one must say that the technological deck has been stacked long in advance to favor certain social interests, and that some people were bound to receive a better hand than others*" [197:126].

Instead of seeing the advancement of technology and equipment solely as a cost-cutting and efficiency process, L. Winner concludes that technologies around us are ways of building order in our world. Intentionally or unintentionally, societies embed specific structures in technological artefacts that affect peoples' everyday lives, from how they work, communicate, transport and participate. As a result, emphasis on rules, political roles, laws and relationships in politics is reflected in the design of material equipment:

> *"The issues that divide or unite people in society are settled not only in the institutions and practices of politics proper, but also, and less obviously, in tangible arrangements of steel and concrete, wires and transistors, nuts and bolts."* [197:128]

In order to understand which technologies are important for society, why, and in which contexts, we need to better grasp both the technical elements of these systems and their embedded political assumptions.

An argument against the one discussed above, on the other hand, is one that perceives certain kinds of technology as inflexible, and thus, if decisions are made to use these in a given society, a particular form of political life is chosen with it. Examples of this way of considering technological and material evolution can be traced back to Friedrich Engels who in his paper "On Authority" develops his argument that strong authority is the necessary condition for modern industry [60]. He develops this argument by using examples of railways and ships at sea which both require the subordination of workers to an authority that manages whether everything goes according to plan. Many years prior to Engels, Plato used the same analogy of a ship sailing in the sea and the need for such vessels to

be steered by a firm hand. Plato used this analogy to suggest that governing a state is similar in that it requires a central authority to function [9].

According to L. Winner, whether Plato and Engels are right in saying that a decisive captain and an obedient crew are required for a ship to sail depends on moral claims of practical necessity that should be weighed up against questions such as whether its good for sailors to participate in command or that workers have the right to be involved in the management of the factory [197:133]. All these moral claims apart from the ones based on practical necessity, appear increasingly idealistic or even obsolete in modern societies. In various contexts these arguments concerning moral claims of justice, equality and liberty can be confronted by arguments such as: “Fine, but that’s no way to run a railroad”. These arguments exemplify the ways in which people perceive acceptable and essential measures and practices for something to work reliably based on the affordances of the technology. On the subject of inherently political technologies L. Winner concludes:

> *“In many instances, to say that some technologies are inherently political is to say that certain widely accepted reasons of practical necessity especially the need to maintain crucial technological systems as smoothly working entities have tended to eclipse other sorts of moral and political reasoning.”*

Relating these philosophical remarks about the political design of technology to democracy and voting, arguments for reconsidering how democracy is practised today and what it means sound idealistic and irrelevant to the practical problems that modern countries face. Various alternative democratic models have existed for years with some of them being deeply scrutinized by political scientists without however being practised or taken seriously. For example, a recently proposed way of practising democracy, called ‘delegative’, has been suggested as a possible alternative to representative democracy. The assumption behind it is that instead of having representatives fixed for a number of years who represent citizens in all matters of concern, representation can happen in a more ‘liquid’ manner depending on the context and decision [38]. Instead of trying to materialise these new concepts into technologies that might possibly bridge the gap between citizens and their representatives, such new models are confronted with an argument which has an effect such as: “Fine, but that’s no way to run a democracy” as could have

been written in L. Winner's book. More radical alternatives find it even harder to be considered as viable democratic alternatives for particular contexts. Below I reflect on how this discussion about the politics of design relates to democracy and more specifically, to voting.

2.2. Design for Democracy and Participation

The increased interest in 'Designing for Democracy' in the last few decades has resulted in the development of a research area in HCI exploring the design of civic technology to support democracy. Within these practices of 'design for democracy', the discourse is mostly concentrated around 'design', with the notion of 'democracy' or politics embedded in these designs being under-examined or taken for granted (for an exception see e.g. [110]). However, democracy can be manifested in different forms in different contexts, which places designers in the critical position of having to be aware of and adequately select the political assumptions that they wish to embody in their artefacts. Is the purpose of the design to support representative or alternative forms of democracy and participation? Does the system facilitate consensus or contestation? In this thesis I contend that designers when designing for democracy need to explicitly engage with such questions.

The majority of research on e-democracy is related with either developing secure e-voting systems for national elections or designing systems to support local democratic practices. One of the common characteristics of both strands of research is the focus in supporting representative democracy in a hierarchical top-down approach. For security in national elections this is more or less inevitable as elections are a process driven by representation, even though we can envisage different types of democracies having different requirements in respect of technology and voting.

In other contexts, such as local democratic practices, other types of democracy might be appropriate. Using L. Winner's lexicon, I contend that the design of technology and material equipment for democracy, especially at local community level, acts as settling an issue. As discussed earlier, these designs act as a convenient way of establishing patterns of authority but due to their flexible material form they could be thought of and designed differently.

In this section, I briefly review the types of democracies relevant for this thesis. I start from representative democracy, and the parliamentary deliberation that is required for its

healthy operation. I later discuss some of the efforts to involve more citizens in representative democratic processes by making these processes more direct. Finally I argue that a more agonistic approach to design for democracy is underexplored, with most current work having a primarily consensual focus. The purpose of this section is not to explore the democratic models thoroughly and extensively, but rather to highlight exemplar democratic models and their associated participatory types that play a significant role when designing systems with socio-political implications (for a thorough review of democratic models, consider reading *Models of Democracy* [87]).

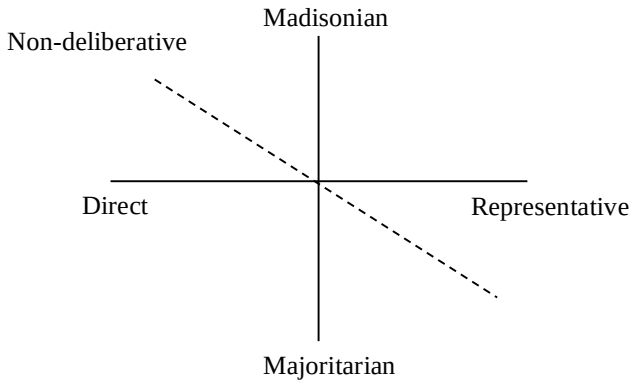

Figure 1. Types of Democracies [68]

2.2.1 Representative and Direct Participation

As Figure 1 depicts, democratic systems can be classified in a three dimensional space [68]. The vertical axis describes systems from Deliberative Madisonian to Majoritarian. Madisonian systems represent impediments for majorities, whereas Majoritarian ones allow them to take decisions that could violate the basic rights of a minority. The horizontal axis categorizes democratic systems as direct or representative. Finally, the z-axis classifies democratic systems as deliberative and non-deliberative: systems that promote and require deliberation to reach a decision versus those that allow decisions to be made only by registering participants' preferences. In reality, this three-dimensional space can only depict the variety of democratic systems. Most modern democracies are a mixture of all of these dimensions.

Representative democracy is the dominant system of democracy. It is a type of indirect democracy as sovereignty is held by citizen's elected members, rather than citizens themselves. Citizens' participation is by definition reduced as the power of governance is delegated. Voting is typically executed via the mechanism by which voters elect their representatives, with an alternative but rare method being sortition [56], which involves a random selection amongst citizens.

Citizens' participation in an election-based representative democracy is performed principally through periodic elections, typically held once every four years. Deeper political participation and debate, at least at the formal level, is thus delegated to representatives who are required to deliberate political issues. One of the assumptions of representative democracy is that effective and decisive deliberation about the issues at stake can only occur between an elected body of individuals (later in this chapter I discuss efforts to facilitate deliberation on a large scale). By definition a gap is created between citizens and their representatives, a gap which in some degree is a requirement for representative democracy to operate.

Research and practice in the design of technology to support representative democracy is focused on two main strands of enquiry: firstly the digitisation of voting systems in ways that maintain their integrity and voter trust (for exemplar concepts see [122,152]), with an additional goal being increasing turnout via additional digital channels of voting [8]; and secondly making representative democracy more participatory by using technology to get more frequent feedback from citizens in consultation exercises. Evidently, both these strands of work reinforce the practices and assumptions of representative democracy. It is interesting however to consider technological designs that instead of taking these underlying assumptions as the starting point, question them and reconsider how technology can provide other avenues of doing democracy.

To give an example, one of the assumptions of representative democracy is that to be effective, in terms of cost and consensual decision-making, deliberations can only be practised by elected representatives in parliaments where certain requirements of deliberation can be met. I propose that this assumption originates from perceived limitations of technology and deliberative methods rather than deliberation being an inherently political method that requires specific political associations – in this case a parliament with a citizens' representative body. Another assumption is that elected members represent

citizens and debate and vote for them for a fixed period of time for a particular topic of concern. An alternative is delegative or liquid democracy [38], which is a relatively modern democratic system where the electorate delegates power to delegates in a liquid and temporary manner. Key differences between this and representative democracy include: having the possibility of direct participation; delegates power is liquid – depending on the level of citizen participation; delegates' power is recallable at any time; and a voter can delegate specific voting powers to a delegate [79].

Athenian or *direct* democracy is believed to be the first known type of democracy in the world in which participating citizens are able to vote directly on legislation and executive bills [98]. Direct democracy, sometimes also called pure democracy is a form of democracy in which citizens form consensus on policy initiatives directly. Even though direct democracy represents democracy in its purest (most original) form and can be considered as its idealistic state, the size of modern democracies, the lack of tools and methods to practice it on a large scale and other political reasons have contributed to a shift from direct to representative democracy.

The most common ways in which direct democracy influences politics today is by complementing representative democracy through methods such as referendums, initiatives[10] and recalls[11]. Such attempts to transform representation to more inclusive types have the capacity to delegate some of the representatives' power to the public if appropriate legislation is also put into place. Obviously this form of direct participation inherits all the assumptions of representative democracy as it serves as a way to facilitate it. Problems with methods such as petitions and frequent referendums include the lack of motivation of the public to participate and the low turnout rates resulting from this.

The evolution of technology and telecommunications recent decades has facilitated citizen communication and provided additional channels for citizens to interact with their political systems. Digital democracy or electronic direct democracy (some times also

[10] Initiatives, also called citizen initiatives, are petitions which when signed by a certain number of citizens can force an action from the government (e.g. a public vote).

[11] Recall is a process by which voters can remove an elected official from an office before his or her term has ended. Usually it is in the form of a petition, which has to be signed by a certain number of citizens. Recalls date back to Athenian democracy and are still used in many modern Western constitutions.

found as collaborative or open source government when the focus is on governance rather than political system) are terms often coined to describe this tendency towards utilizing technology to move closer to a more direct form of democracy. Electronic direct democracy usually involves an e-voting system for citizens to vote on legislation. Electronic deliberation tools also allow citizens to collaboratively author and suggest new laws. Even though there has been progress in this area in the last few decades (e.g. [102,103,104,185,191]), electronic direct democracy is not fully implemented anywhere in the world. However some of the developed tools act as ways of moving towards a hybrid model of representative with direct e-democracy.

Even though direct democracy is usually seen as an ideal state, the implications of such a model are sometimes overlooked. Direct democracy entails the direct participation of citizens in democracy, however some of the impediments for its implementation, such as informed and 'motivate-to-participate citizens', are yet to be resolved. The success of these technological and communication tools, aside from the necessary political will, also depends on the appropriate design for an informed and deliberative participation, as well as the embodiment of necessary motivators of participation. The failure of uptake for some of these initiatives relates to the failure of providing viable options and alternatives to citizens, as in most cases the agenda for a direct or deliberative democracy initiative is set out beforehand. C. Mouffe in her book "On the political" talks about this lack of alternatives and particular focus on consensual methods of participation: *"A democratic society requires a debate about possible alternatives and it must provide political forms of collective identification around clearly differentiated democratic positions. Consensus is no doubt necessary, but it must be accompanied with dissent.* […] *In a pluralist democracy such disagreements are not only legitimate but also necessary. They provide the stuff of democratic politics"* [135:31]. Given the current emphasis of direct, participatory and deliberative methods regarding consensus, according to [135:24], there is no doubt why the rate of abstention is growing, as mobilization of the public requires politicization, which cannot exist without a conflictual representation of the world.

2.2.2 Participatory and Deliberative Democracy

Participatory and deliberative types of democracy are categorisations based on the level of participation that the system allows. Even though both relate to delegating more power to the public, and thus both convey a more direct democracy, participatory democracy

can be interpreted as an umbrella term for both. Deliberation focuses specifically on the deliberative element of participation, which involves the careful consideration and discussion of the alternative options before a decision is reached.

Participatory democracy, originally inspired by Rousseau, was first formulated as a theoretical framework by Pateman (1970) [146] and Macpherson (1977) [123]. Literature on participatory democracy is vast, and I do not intend to cover it thoroughly here; an excellent discussion on participatory democracy can be found in [87]. Participatory democracy is a model of collective decision-making that combines elements of both representative and direct democracy. The cohesion with representative democracy lies in the presupposition that an elected body exists and will implement decisions, while the direct element is implemented through the participation of citizens in forming proposals. Consequently citizens can monitor political performance by comparing the policy proposals with the ones actually implemented. The extent to which participatory democracy resembles direct democracy is aligned with the level of participation of citizens in the process [10]. As a result, motivational factors for citizen participation in such processes are pivotal for their actualization in today's constitutions.

The materialisation of participatory democracy today can be seen in participatory budgeting (PB) [180]. The process of PB was first developed in Brazil in 1989 and today there are over 1500 PB projects around the world, most of which are at a city level, funded by the municipal budget [204]. Other contexts in which PB has been used include counties, states, housing authorities, schools, universities and public agencies. In PB, citizens, in collaboration with the government, directly decide how to spend part of a public budget. Most PB projects follow a basic process of first brainstorming ideas, then developing proposals based on these ideas, and then voting on proposals. The government has to implement the top projects that resulted from this process [180,204].

The degree to which citizens choose to be involved in this process is ultimately the determining factor in their success. Technology has been suggested as a possible avenue to increase participation by providing additional channels for citizens to be involved in PB. According to [148], the desire to innovate via participatory budgeting may in itself be a driver for participation and could allow citizens to be involved in more salient public works beyond local districts. In [147], the authors report the results of an e-PB project in which (with significantly less resources) a participation level seven times higher was

achieved. It is important to highlight however that there are great differences between a conventional PB process and the e-PB that was performed. As one citizen suggested electronic participatory budgeting is "*more participation and less participatory*". Technology provides an additional channel for participation in the voting processes of PB, however its bottom-up nature comes from the collaborative formation of proposals that are still problematic online.

Participatory budgeting, when it comes with the binding legal framework for developing the ideas generated during the participatory process, is a good example of participatory process that could revitalize representative democracy. However, PB requires strong political will to be put into place, especially for non-trivial matters of debate. Finally, PB has been criticized for being a voting procedure where citizens vote on proposals formed by policymakers and administrators, therefore making it a consultation exercise rather than a truly bottom-up idea-generation procedure.

E-deliberation platforms attempt to bridge this gap between conventional and technologically mediated PB processes and bring more collaborative planning in online, typically voting based processes. In *deliberative* democracy, deliberation is at the centre of the decision making process with the ultimate goal being to find consensus whilst practising "authentic" deliberation. It originates from ancient Greece and Aristotle, with the work of German philosopher Jürgen Habermas, on communicative rationality, however, being one of the first main contributions in this area. Deliberative democracy differs from others types of democracy in that "authentic" deliberation is the main source of legitimacy rather than merely voting. There are multiple interpretations of what "authentic deliberation" means with its requirements being a matter of debate among political and communication scientists. According to Cohen and Ethan, authentic deliberation entails deliberation between decision-makers that is free from distortions of unequal political power, for example power obtained by economic wealth or public support [39]. If consensus cannot be reached after the deliberative process, participants vote on proposals generated during the process. One of the methodological limitations of deliberative democracy is the fact that in large-scale deliberations, voting is often a necessary evil in order to reach consensus. This means that the deliberative process consequently acts as an educational process, which aims to inform participants about the issues to be voted on at the end of the process [68].

One of the most popular ways that deliberative democracy is performed today among citizens is through deliberative polling. Deliberative polling (first introduced by J. Fishkin in 1988 [67]) is a method of randomly picking a representative sample of citizens and, instead of asking them questions directly as in conventional opinion polling, it engages them in a deliberative process in order to create a more informed and reflective opinion. It is important to mention that instead of reaching a consensus or an agreed verdict, the goal of deliberative polling is to measure opinion change and thus its goal is mainly educational rather than actionable. Several deliberative opinion polls have been conducted by the Center for Deliberative Democracy at Stanford University[12].

Critics of deliberative polling argue that the briefing materials distributed before the deliberation can be biased and the sampling of the participants not representative of the public. In addition, the need for moderators to facilitate discussions is seen as a shortcoming as moderators can introduce additional biases in the deliberative process. Finally, although deliberative polling is primarily a process with educational functions, critics argue that the process only affects a low number of people rather than the wider general public.

More recently, technology has been suggested as a means of supporting deliberative polling by lowering the costs of participation and by opening up the process to citizens not involved in the in-situ deliberations. As a result, a number of e-deliberation platforms have been developed over the last few decades, ranging from online deliberative forums and online spaces where physically bounded communities can be informed and deliberate, to innovative visualisations of online and offline deliberations (e.g. [32,46,99,102,107,185,202]). Research in the area focuses on understanding the needs of local residents (through interviews and questionnaires) around such deliberation platforms and designing accessible platforms that allow information seeking, information dissemination and public discussions. In [107], the authors highlight the problems that social media technologies often create when applied to complex controversial problems such as: disorganized content, low signal-to-noise ratio, quantity rather than depth, polarization and dysfunctional argumentation. Finally, an alternative way of dropping the costs of participation (in addition or without the digital element) is dedicating one day each

[12] Center's website: http://cdd.stanford.edu/

year to the purpose of deliberating political issues. “Deliberation Day” [2] is proposed by J. Fishkin and B. Ackerman as a national holiday dedicated to this purpose.

At a higher level, participatory and deliberative democracy faces the same problems as those discussed regarding the distinctions between direct and representative democracy. Due to the focus on mechanisms of government, consensus is at the epicentre of the discussion with most of these attempts resulting in consultation top-down exercises with an additional educational benefit. We need to raise questions as to the meaning of words such as ‘deliberation’ and ‘dialogue’ when there is no real choice at hand for consensus and when participants are not able to decide between clearly defined alternatives [135:3].

2.2.3 Agonistic Pluralism

The level of citizens’ involvement in decision-making processes (e.g. representative versus direct) and the type of such participation (e.g. focus on deliberation or participation) have been the main distinctive elements of the political systems discussed so far. They all resemble each other however in their emphasis on consensual decisions and mechanisms for governing. In this section I will talk about a different approach, one that utilizes contestation instead of deliberation as the key principle. *Agonism* or agonistic pluralism and agonistic democracy is a political theory recognised by political theorists as oppositional to deliberative democracy as it emphasizes the existence of political conflict and seeks ways in which such conflicts can be accepted and positively channelled [134,135].

C. Mouffe in her book “*The democratic paradox*” describes agonistic pluralism:

> *"I use the concept of agonistic pluralism to present a new way to think about democracy that is different from the traditional liberal conception of democracy as a negotiation among interests and is also different from the model that is currently being developed by people like Jürgen Habermas and John Rawls. While they have many differences, Rawls and Habermas have in common the idea that the aim of the democratic society is the creation of a consensus, and that consensus is possible if people are only able to leave aside their particular interests and think as rational beings. However, while we desire an end to conflict, if we want people to be free we must always allow for the possibility that conflict may appear and to provide an arena where differences can be confronted. The democratic process should supply that arena."* [134].

Her argument is that instead of trying to design institutional methods that will reconcile conflicting interests, we should envisage the creation of a vibrant public space of contestation where the various political values and projects can be confronted. This confrontation, facilitated by the identification with a collective identity, allows for the emergence of alternative options that the public can affiliate with, and may therefore mobilise them to participate in.

Consequently, at one end of the spectrum deliberative democracies have as a governing principle the pursuit for consensus with associated concerns being those of access to information and procedures of deliberation. At the other end, in agonistic pluralism, contestation and the creation of spaces of contest are key principles with main concerns being those of revealing and challenging hegemony. Mouffe also discusses the distinct interpretations and meanings of "politics" and "the political" in discourses of agonistic pluralism. Politics refers to the means, structures and mechanisms that enable governing. This involves methods of holding together organizational and social order. On the contrary, the political is more a condition of society rather than a set of methods and procedures. The political is a societal condition where oppositions and contests are ongoing and expressed from political debates to protesting and acts of resistance.

C. Disalvo, in "Adversarial Design" [53], introduces Mouffe's conception of agonism and the differentiation between politics and the political, and interprets them in terms of designing artefacts to engage people in the political. More specifically the author focuses on how the design of technology engages with the democratic endeavour and identifies that in design the majority of projects fall within the realm of politics. That is design and technology with a particular focus on improving structures, facilitating or mediating the mechanisms that enable governing [52]. The ways of practising methods of governing that we have discussed so far include representative, direct and participatory democracies, and all fall under one category of design: design for politics.

A good example of design for politics is the Design for Democracy initiative [53:8] which aims to apply design tools and thinking to increase civic participation by making the interactions between government and citizens more efficient and trustworthy. The initiative encompasses a number of broad reaching projects, projects that exemplify how the initiative is aimed at designing for democracy in a hierarchical top-down manner. Example

projects relating to voting include the "Get out the Vote" program[13], which attempts to increase voter registration and turnout; the "Polling Place Photo Project" which utilizes citizen journalists to document the voting process and experience; and the "Ballot and Election Design" project which attempts to improve the experience and efficiency of voting by the redesign of ballots, polling signage etc. It can also be argued that a large volume of e-voting research exemplifies this tendency of designing for politics rather than for the political. E-voting research in the last decades is focused on designing systems to facilitate and complement existing structures of government by making the voting systems more secure, and by increasing trust in the voting system. However there is a significant lack of work on the political design of voting systems: How can we design voting systems to serve opposition and argument rather than seeing voting systems as only a tool for reaching consensus? How can voting systems open up contestational arenas?

One of the highlighted examples of successful political design in [53:9], is the "Million Dollar Blocks" project in which the developers map crime related data by mapping the origins of prison population rather than asking the anticipated questions of "Where does the crime occur?" or "Who are the victims of the crimes?". In this sense, the "Million Dollar Blocks" project does not intend to support conventional means of government, by asking questions that could lead to a more efficient government, but critically investigates an issue by raising questions about its conditions. According to C. Disalvo: *"The Million Dollar Blocks project can thus be considered as exemplary of political design because it functions to reveal, question and even challenge conditions and structures in the urban environment, that is, it opens a space for contest, and too, it suggests new practices of design in mapping and urban planning"* [52].

Examples of political design in voting are rare, some of which I will discuss later in this chapter. Designing voting systems that enable contestation rather than consensus and aggregation of opinions is uncommon, with this manuscript, however, serving as a step in this direction.

[13] "Get out the Vote" program website: http://www.aiga.org/get-out-the-vote-2008/

2.3. Misinterpreting Voting as Participation

Voting has been indisputably one of the most essential tools for the operation of democracies from ancient Athenian demos to western democracies today. The design of modern voting systems for elections and the politics embedded in them reflect our understanding of democracy as a political system in which power is exercised through a periodical scheme of representation. Simply put, our voting systems are designed to facilitate one particular type of democracy, representative democracy. As a result, our understanding of voting is a restricted one; we understand voting as a tool to support representative democracy through the quantification of interests with a particular focus on reaching consensus. In other words, voting is seen as a method to facilitate doing 'politics', which refers to enabling effective governing and organization. Consequently citizens' interaction with the formal political system (i.e. representative democracy) is limited in periodically choosing a candidate between a fixed number of options, resulting in election turnout being one of the only determinants of satisfactory participation and democratic legitimacy.

Although I acknowledge the need for voting systems which are designed for consensus in order to facilitate politics and governing – we call this "consensual voting systems"[14] – I contend that consent is only one of the design goals of voting for democracy. Alternatively, and primarily for this dissertation, voting can be considered as a tool to engage citizens in 'political' participation. A politically designed e-voting system, instead of necessarily seeking consensus, should envisage a vibrant agonistic public space of contestation where the various political projects can be challenged. In order to consider the form of such politically engaging voting systems we need to detach voting from its traditional contexts and connotations. This entails repositioning voting as a tool that embeds methods for dissent and debate to be manifested democratically and the creation of new spaces for contestation and participation.

Typical assumptions that drive the misinterpretation of voting as participation, which I attempt to question in this dissertation are as follows: (i) e-voting primarily refers to and has a particular focus on national elections in a representative democracy; (ii) high turnout

[14] Consensual voting systems here not to be confused with consensus decision-making which typically relates with decision rules such as majority rule, Borda count etc.

rates in elections and other participatory exercises are determinants of successful citizen participation; (iii) voting primarily functions as a tool of reaching consensus, and as a result the application of technology should facilitate the access of the voting apparatus and the efficiency of achieving a decisive option; and (iv) the capacities of voting systems are well established, drive information security and enable only particular models of democracy.

In the remainder of this chapter I will briefly review the evolution of participatory methods, spanning voting from ancient democracies to modern democracies. I attempt to highlight the function of voting as not only a tool for consensus but also a highly political one. By doing so, I continue to build the case that the design of voting systems is far from being 'politics neutral' and consider ways of repositioning voting as a tool for political participation.

2.4. The Evolution of Participation through Voting

Throughout the evolution of democracy, from ancient Athenian to modern democracies, voting systems have been developed to reflect the needs of society and context. These advances of the voting apparatus have been propelled by a number of factors, including the need for election security and less voter coercion, voting accessibility, usability, political will and recently, increased citizen participation. Some of these factors will be discussed more thoroughly in Chapter 3. In this section I will focus on some of the voting innovations that exemplify a shift from voting being a highly political method of participation to voting as a method of facilitating governance.

2.4.1 Oral Voting

Voting, as a decision-making tool and social practice, was first introduced in Athenian and Roman democracies in the form of oral voting. With oral voting voters need to voice their preferred candidates. Saltman in his book "*The History and Politics of Voting Technology: In Quest of Integrity and Public Confidence*" describes oral voting:

> *"On the day or days of election, each voter would make his way to the table where the judges of election and their clerks sat. A voter would be asked to verify his financial and residence status, and then requested to declare his choices* [in public]. *Votes would then be written down by the clerks, and any candidate present might publicly thank a voter who voted for him."* [169:43]

To this end, oral voting, apart from possibly being a technological necessity, was also serving a particular political goal: initiating a political debate between citizens and their possible representatives, initiating contestations of divergent viewpoints, publicly showing responsibility, etc. Obviously the form in which this was practiced was problematic. As the quote from Saltman demonstrates, suffrage was far from being universal, with only citizens with confirmed residential and financial status allowed to vote. The public nature of oral voting has been open to all kinds of threats and most frequently, voter coercion and disenfranchisement. Even though the security vulnerabilities of such a voting system are apparent for today's modern democracies, the need for transition to other forms of more secure forms of voting has not been self-evident. The main reason for the transition was citizen literacy and ballot stuffing as after anonymizing ballots, stuffing ballot boxes with illegitimate ballots became possible.

A particularly interesting case is Britain, where oral voting was practised for nearly forty years until it was eventually replaced by secret ballots. A thorough examination of this transition is reported in [12,81], with Britain objecting to the introduction of the secret ballot for cultural and transparency reasons. The main objections were that the secret ballot was inconsistent with the "manly spirit and the free avowal of opinion which distinguished the people of England" [144:56]. More specifically, it was thought that the secret ballot would remove public scrutiny and that members of parliament would depend on the election officials [144:61]:

> *"If there is ballot there can be no scrutiny, the controlling power of Parliament is lost, and the members are entirely in the hands of returning officers. A representative will not be able to tell who are his instructors (i.e. the persons who elect him). People who do not wish to be suspected of voting on the wrong side will stay away.* […]*"*

It is of particular interest that voters are perceived as instructors. Instructors can voice their opinions to their representatives and the elected members of parliament know the group of citizens who have instructed them. As in Ancient Greece, oral voting facilitated not only consensus and electing representatives but was also utilised as a communication channel between citizens and politicians. Citizens could voice their opinions to their representatives in order to instruct them on how to operate. As a result voting was perceived

as more than just a method to facilitate consensus, and was considered to be an important tool for controlling parliament by instructing representatives during the election process.

The 'secrecy' of the vote was believed by some to encourage the removal of responsibility around voting, and could even lead to hypocrisy and deception [12:662]:

> *"The principal objections which have been advanced against the ballot as applied to our elections are, that the act of voting is a public duty and should involve a public responsibility; that it would lead to hypocrisy and deception; that it would do little to restrain the practice of treating; that it would encourage bribery by making it more difficult to detect; that it would be wholly inoperative in the case of spiritual intimidation such as that which is allowed to exist so extensively in Ireland; that it would afford facilities for personation."*

The reference to voting as a public duty to oppose the introduction of the new ballot exemplifies how oral voting was perceived as first and foremost a political method for citizens to voice their opinions publicly. Voting was perceived as a duty inherently public, that as we have seen in [135:5], had the capacities to allow citizens to identify with a collective identity. The emergence of contesting collective identities entailed the creation of a we/they discrimination that if constructed appropriately, as in oral voting, could strengthen democratic confrontation and as a result revitalise citizen participation [135:6].

Perceptions of election security are of particular interest in oral voting. The writers of that period viewed a possible modernisation of the electoral system as a challenge to election security, although with a modern understanding of security changes become apparent and imperative. The same reaction can be identified in modern electoral system reform in the US, with the perceptions of security however being exactly the opposite: instead of interpreting the inability to trace back votes to citizens as a security flaw as is the case in Britain, in the US tracing back votes is unacceptable as it leads to electoral fraud and vote buying. Consequently, electoral security, at least in the first years of voting evolution, had a different connotation and value.

Another argument against the transition was that the secrecy of the vote might cause negative affects on turnout as: "the elections would be too "orderly" and thus not exciting enough; and there would be no possibility of publishing interim results to convince people to come and vote" [144:84–85]. I find this account fascinating as it concisely embeds a

number of arguments used by proponents of agonistic pluralism. More importantly the author relates this new "orderly" approach with a lack of excitement, which if we use an agonistic pluralism lexicon, relates to the passions that can lead to political mobilisation. The validation of this concern, resulted in establishing the UK Electoral Commission, which amongst other things aimed at the modernisation of the voting system to tackle dwindling turnout levels.

2.4.2 Paper and Mechanical Voting

The introduction of material-based voting and the elimination of oral voting is not necessarily synonymous with voter anonymity and ballot secrecy. For example in Ancient Greece an additional method of voting was by using coloured broken pieces of pottery that revealed voter preferences. The first paper ballots were unlike those of today, as they were not standardised for all candidates. Each candidate could print their own ballots, in most cases resulting in having various colours of ballot papers depending on the candidate's affiliation. Indeed a common practice was to distribute the ballot papers by preprinting them in newspapers, thus the design of each candidate's ballot was known and could be detected while a citizen was casting a vote. This was the last instantiation of a voting system in elections that allowed voters to publicly declare their support for a candidate. The conventional paper ballot system that most countries use today, called Australian ballot, was introduced in the state of Victoria in Australia in 1856 [169:96], standardising the ballot papers and voting process for all political parties. It first appeared in the US in 1888 and by 1896 only a few US states had not passed legislation to mandate the Australian ballot. This was a pivotal moment for election security as this secret ballot ensured voter anonymity and election secrecy and consequently contributed to the integrity of the election process. However, it is our contention that the secret ballot, as the proponents of oral voting would argue, contributed in disconnecting voting from its political grounds.

Voting machines in the form of mechanical levers and punch cards started to appear in elections in the late 19th century. State and local government officials justified investment in voting machines to replace conventional Australian ballot papers and ballot boxes by noting the increasing length and complexity of ballots with multiple candidates and referenda, as well as the doubling of electorates with the enfranchisement of women. Mechanical lever machines and punch cards tallied the votes faster than a manual count

and they were assumed to be less error prone than hand counting. Their disadvantages included the increased voting times (as only one voter could vote at a time) and the requirement of a paper-based system in case of machine failure. Finally, mechanical lever machines as the first mechanical way of counting the votes introduced some non-security related restrictions on the form and design of the ballots: the Electors list was removed from the presidential ballot due to space restrictions [151,169:121].

On 7th of November 2000, in the US State of Florida there were widespread problems resulting from the use of punch card machines. Inaccurate registration lists, many spoiled ballots and unclear ballot designs that raised questions about voter intent on the cards (where the chads had not been completely punched out of the paper) were the most important problems [31]. In addition, in Palm Beach County a usability problem with the "butterfly ballot" designs raised questions about voter intent. To be able to use a larger font for the candidate names, the candidates were placed in a "butterfly" layout with the holes for punching in the middle making it hard to distinguish the proper punching hole (see Figure 2).

The usability problems of the 2000 election in the US mark another pivotal moment in the history of voting. US congress passed the Help America Vote Act (HAVA), the first law addressing voting technology, to establish a program and provide funds to States to replace punch card and mechanical lever voting systems [105]. From that moment onwards the debate about voting systems, instead of being on the grounds of its purpose (political participation), became about the effect that a new system would bring (our focus in chapter 3). Usability, accessibility and security have a predominant position in such a debate. I acknowledge that this debate is imperative to ensure the democratic nature of voting, however voting seems to have become detached from its highly political origins that used to play an instrumental role in citizen participation in democracy.

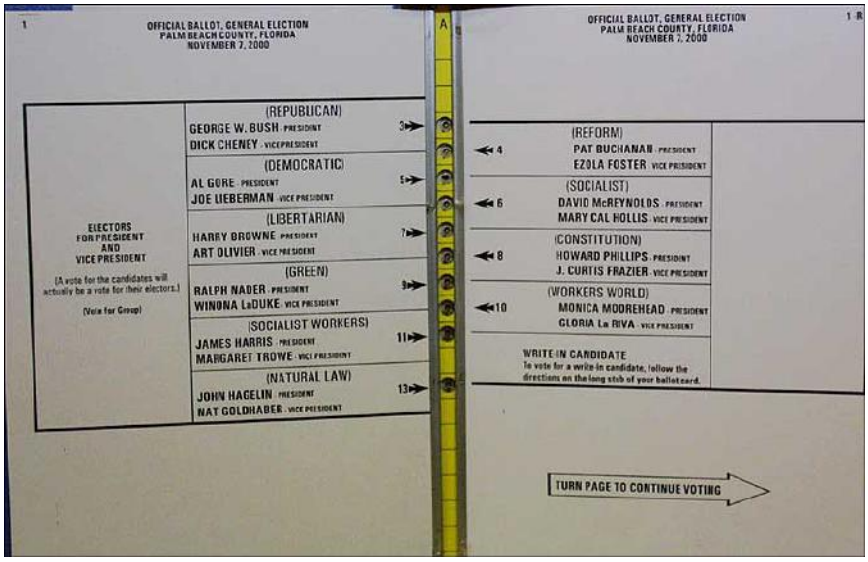

Figure 2. "Butterfly" ballot design with candidates listed in a butterfly layout with punching holes in the middle.

2.4.3 Digital Voting

In 2002, Georgia became the first US State to use digital voting machines state-wide (called Direct Recording Electronics - DRE) [178]. The need to modernise the voting apparatus, in addition to the provision of funding, was an opportunity to revitalize voting by re-embedding some of the political elements that had become lost throughout ballot design evolution. However, states rushed to implement DRE touch-screen based systems that ultimately unleashed a series of problems and controversies.

In 2003, a source code of one of the DRE systems was found and analysed by security researchers T. Kohno et al. [109] revealing various security vulnerabilities, the publication of which triggered a chain of events involving the media, electoral staff, researchers and manufacturing companies [41,109,162]. Providing Voter Verified Paper Audit Trail (VVPAT) was one of the proposed methods to increase trust in e-voting systems and election outcomes [133]. A VVPAT is a paper ballot printed by the DRE after casting an electronic vote that serves as a receipt for the voter and a failsafe in case of recount. As a result, Nevada became the first State requiring e-voting equipment to provide a voter-verifiable paper audit trail and since then, the requirement of a form of paper receipt has become a legal requirement in many US states, with contradicting opinions on its usability and effectiveness [77].

One well-cited benefit of digital voting is the provision of multiple channels of participation, presumably able to increase turnout by dropping the transactional costs of participation (i.e. transportation to polling stations, limited time to cast votes, long queues etc.). Whether the minimisation of the transactional costs of voting is favourable for democracy is questionable, as the methods currently used further detach voting from its political grounds; i-voting has been accused of removing the rituality of voting. The most prominent example of i-voting is Estonia, which despite the security concerns raised by earlier i-voting trials, was the first country to allow citizens to vote online in October 2005. Estonian authorities sacrificed a level of security to keep the system transparent to citizens [151:25]. To cope with the problem of coercion, they allowed internet voters to alter their votes by casting a ballot multiple times (with only the last one counted). The Estonian government's attitude towards election security can be summarised in the following quote:

> *"To start from the assumption that the State must 'trust the people' and not interfere if at all possible in any of their decisions.* […] *the problem that e-voting would facilitate some families, friends or colleagues voting together, i.e. practice collective voting, as well as the buying and selling of votes, was said to hinge on the question of whether the State would have to protect an individual only from other individuals or also from her- or himself."* [57:4]

As a result, one of the main parliamentary debates on i-voting was questioning the state's responsibility towards protecting its citizens from collective forms of voting, that can be considered as a means of citizen politicization and following from this political participation in the election process.

In the United Kingdom an electoral commission was established in 2000, in order to explore the modernisation of the electoral system and the possibility of increasing voter turnout through the provision of additional channels of participation. Pilots for e-voting, i-voting and all-postal voting were conducted in 2000, 2002, 2003, 2006 and 2007 with questionable results in terms of their effect on turnout.

2.4.4 Conclusion

In this section I have revisited the evolution of voting systems in elections from oral voting to digital and internet voting. Even though there are multiple accounts of these

systems to be discussed and further analysed, from their security to voters' perceptions and trust, it was my intention not to engage with the problems introduced by the application of a voting method in a democratic context but only with the its fundamental goal: citizen participation.

When all the secondary requirements of voting are extracted, our incapacity to embed participatory methods in our voting systems becomes apparent. We have seen how first instantiations of voting in forms like oral and paper-based voting were able to engage the public in political discussion and create spaces where political projects could be publically challenged. Their technological limitations in regards to their security, their efficiency, their accessibility etc. enabled the creation of political spaces around the vote: political discussions on election day with citizens advising politicians on how to represent them, political canvassing, direct association of representatives with their voter demographics and others. This political dimension was not distilled out from this voting process and was significant. The need for coercion resistance and election efficiency resulted in disconnecting voting from its inherently political grounds and consequently transformed it into a normative process for doing politics. It is my contestation that this detachment of voting from its naturally political origins makes it increasingly less relevant for citizens to participate fully in the political process.

2.5. Summary

In this chapter I started by discussing the relationship between design and politics. I introduced L. Winner's theory of the political assumptions embedded in the design of everyday artefacts and we discussed how this is extended into the area of social relations and the reinforcement of hierarchical structures. Then I introduced design for democracy and reflected on how tools, methods and structures for democracy also embed politics that might conflict with its participatory nature. I argued that work in the area has focused extensively on "design", which although necessary, is problematic when not considered in relation to democracy and participation. Subsequently, I introduced agonistic pluralism, a democratic theory of particular interest for this thesis and contrasted it with the more consensual systems of deliberative democracy and representation. I highlighted the misinterpretation of the act of voting as equating to citizen participation and I listed some of the assumptions inherited as a result. Finally, I revisited the evolution of voting systems

when seen under the lens of political participation by emphasizing the extraction of the political from voting practices that results in its devaluation from a political tool to one for the facilitation of politics.

As a result I can now make a clearer distinction between political design and design for politics in voting. Design for politics in voting can be defined as the area of research that prioritises: (i) the efficiency of the voting process, in terms of its cost and speed; (ii) increasing the reach of the voting process by facilitating access through multiple channels of casting votes; (iii) the focus on the quantitative accumulation of voters' opinions, with an ultimate aim to reach a consensual decision; and (iv) the hierarchical, top-down approach of the system's use, including the eligibility of asking questions and driving voting agendas. By contrast, political design aims at: (i) achieving the sustainability of the voting designs, including their monetary cost and the technical expertise needed to set up and maintain them; (ii) increasing participation instead of merely increasing turnout by providing additional communication channels, involving "qualitative voting" and the provision of spaces in which opposing political viewpoints can be visualised and contested; (iii) highlighting the political process generated from the application of voting in a context rather than the consensual decision resulting from it, which involves the constructive utilisation of dissent; and (iv) focusing on facilitating the bottom-up approach, which relates to the enablement of self-organization, the questioning of power relations and the openness of technology to allow anyone to drive their own political agendas.

In the next chapter I focus on the application of digital technology in voting by reviewing related research areas: computer security, usability and accessibility, confidence and trust, and HCI. By doing so, I highlight the focus of conventional e-voting research on either easing the problems introduced by the application of electronic means of voting in national elections, or on inventing additional channels and novel interfaces for registering opinions.

Chapter 3.

The Application of Technology in Voting

A number of factors contributed to the introduction of digital technology in voting. The proliferation of digital technologies in everyday life and their use for context-sensitive applications, such as banking and shopping, paved the way for accepting electronic voting as a means of resolving some of the problems that our democracies are faced with. In a national election context these involve a number of issues, amongst others the need for increased efficiency at the polling station, more accurate vote counting, increased accessibility of the voting apparatus, the usability of ballots, confidence and trust related factors, and the desire to increase turnout through multiple channels of participation. The majority of development in an elections context, however, puts an emphasis on either facilitating the electoral process or resolving electoral security problems. In recent years e-voting is also an active area of research in HCI in which researchers explore the application of technology and voting for civic engagement at local community level.

In this chapter I review some of the most active areas of research and development in e-voting, starting from the national election context and finishing with voting for local community engagement. Whilst doing so, I critically discuss the political implications of each of the reported developments to emphasize the lack of work that examines the design of e-voting systems for political engagement, which barely provides additional channels and interfaces for the registration of opinions.

3.1. Security

The significance of voting for the operation of modern representative democracies resulted from the need for the development of methods to facilitate the structures and processes of voting – what I have so far referred to as the 'politics' of voting. This was particularly the case after the introduction of electronic systems with non-transparent internal operations such as DREs (Direct Recording Electronics) and remote internet voting. Following from this, security has been the point of departure of any voting related context with a significant amount of computing science research concentrated on defining security requirements and inventing innovative cryptographic methods of ensuring a high level of electoral security.

In this section I will briefly introduce some of the main technical developments of voting towards the implementation of a secure e-voting system for elections and their principle underlying security requirements. Through this I explore how security and participation are intertwined and how this intervention might affect the conventional interpretation of information security principles for e-voting. I argue that political engagement and information security may find themselves in conflict with each other, and consequently a trade-off between security and participation needs to be investigated.

3.1.1 Security Evaluations

Collaborative work between researchers of varying backgrounds and electoral officials and government agencies (especially in the US) resulted in conducting multiple and thorough examinations of e-voting systems. The main focus was reporting security flaws but also accessibility and user-related issues. Reporting all the published reports for countries with an e-voting program or trial is not the aim of this dissertation, especially due to the cultural and socio-political idiosyncrasies that make the findings of these reports non-generalizable and relevant only for their equivalent contexts. Instead, I briefly report on two large collaborative voting projects in the US, project EVEREST (Evaluation and Validation of Election-Related Equipment, Standards and Testing) and the California Top-to-Bottom review.

The aim of project EVEREST was to examine touch-based and optical scan electronic voting systems across the state of Pennsylvania [26]. Researchers gained access to the source code running on the three e-voting systems used for elections in this state in 2007.

This allowed them to perform source code analysis and security penetration testing. Significant technical weaknesses were identified with the researchers advising that procedural security at the polling points would not be able to prevent a security breach. More specifically they highlighted the lack of adequate safeguards against insider attacks; and a pervasive lack of quality in the coding and engineering of these systems [26]. Researchers identified security flaws that if exploited would allow voters and poll-workers to cast multiple votes, alter the voting results, and corrupt previously cast votes. The server of the systems was also found to be insecure against viruses, as the 'off-the-shelf' operating system had known security vulnerabilities.

Another big scale evaluation was the top-to-bottom review conducted by the state of California. The evaluation included most of the e-voting systems certified for use in the state in 2007. The secretary of state engaged a number of computer security researchers mainly from the University of California to conduct security evaluations of the voting systems. "Red teams" were also developed aiming to identify worst-case scenarios on election day. The purpose of the review was "[…] *to restore the public's confidence in the integrity of the electoral process and to ensure that California voters cast their ballots on machines that are secure, accurate, reliable, and accessible"* [205]. The resulting final reports include comprehensive security and accessibility evaluations of the certified systems [20,92,96]. In terms of security, the security experts identified significant security vulnerabilities across all systems. More specifically for one example voting system (Diebold's voting systems) researchers identified the following security issues [92]: (i) the documentation of the manufacturing company presented numerous usability impediments, which affected its secure and accurate management; (ii) the testing labs that were contracted to evaluate the system for certification produced reports that differed greatly from the actual performance of the system; and (iii) the system version that the manufacturer provided for use had significantly different security configurations from the one tested for certification.

The aim of this project was also to perform a usability and accessibility analysis of the Diebold's AccuVote TSx, the Hart eSlate and Sequoia Edge I and II for voters with disabilities and different language needs using usability heuristics and user testing. The findings of this report indicate that even though the systems included some accessibility accommodations, none of them met the legal accessibility requirements [163]. The report

highlights that future e-voting systems should analyse voting as an integrated system of technologies with social practices and recommends that manufacturing companies use expert heuristics and user testing before delivering voting products [163:38]. To summarise, the three analysed systems were not compliant with the requirements of the HAVA (Help America Vote Act) [105]. Other state and countrywide projects exploring the security, accessibility and usability of certified voting systems have been conducted [6,40,82] with similar findings.

3.1.2 Security Implementation

Most electronic voting systems, either used in national binding elections or only being proof of concepts in computer security, use some form of cryptography. There are multiple encryption algorithms for achieving confidentiality and integrity. One of the most well known is PKI (Public Key Infrastructure) [179], widely used in security and privacy-sensitive online applications such as online banking. Other encryption methods include blind signatures [34], mix-nets [168], and homomorphic encryption [44].

In this section I report on the most common security mechanisms with a particular focus on system interfaces rather than security and the associated mathematical details. By doing so, I underline the ways in which these security mechanisms have implications for use and maintenance of voting systems. A thorough review of the advances in information and computer security for achieving the security requirements of e-voting can be found in [4].

3.1.2.1 Using public and private keys

The Estonian i-voting system uses PKI for ballot encryption and signing. The election officials publish a public key that can be used by voters to encrypt the ballots to ensure ballot integrity. To ensure ballot authenticity the voters need to first “sign” their ballot by using their private keys. In the Estonian case the voters’ private keys are embedded in electronic identity cards. On election day each voter needs to use his/her card with a card reader and a personal computer to cast a vote. This dependence on additional hardware has an impact on the system’s accessibility, as the voter needs to be computer literate or capable of seeking help to vote.

Estonia’s election officials consider the use of PKI for the Estonian election to be successful [124,206]. The i-voting system has been used for six consequent local, national

and European elections with the official statistics reporting a significant increase in voters choosing to cast their votes online. In addition, according to election officials, all elections have been conducted without any detected incidents that would have been capable of influencing the final outcome of the vote [206]. Security researchers, however, have highlighted a number of security flaws, related not only to PKI but also to the lack of adequate procedures for operational security and handling anomalies. More specifically, by using the publicly available software used, researchers demonstrated server-side attacks able to rig the vote count [181]. Consequently, they criticise the measures in place to ensure transparency, (e.g. releasing the voting software as open source and streaming the set up of the elections) and suggest that e-voting in Estonia should be withdrawn.

The PKI in Estonia and also elsewhere, is mainly used to enable citizens to vote remotely and as a result increase voter turnout through the provision of additional channels of casting a vote. Results indicate that the use of online voting in Estonia is increasing, however internet voting has so far had insignificant influence on voter turnout [8]. This indicates that providing additional channels of voting has a positive impact on efficiency but questionable effect on encouraging participation of indifferent citizens.

3.1.2.2 Detaching parts of the ballot

Another category of encryption-based e-voting is visual cryptography. One of the first visual cryptography schemes was invented by Chaum at 2004 [35] and other systems followed with popular ones being Prêt á Voter and PunchScan [152,166]. Visual cryptography refers to ballots consisting of two parts, which individually do not reveal one's vote. Voters are asked to mark their selections on one of the paper parts and either destroy the remaining one or use it as a receipt. Most of these systems allow voters to verify that their vote was included in the final tally by visiting a website and using a cryptogram printed on the collected receipt. The secret lies in the randomised order of the candidates and ballots, allowing the destruction of half of the ballot (e.g. the candidate list) to conceal one's intentions. The candidate list can be reconstructed after the scanning of the ballot through processing by a mix-net [168] in order to ensure the secrecy of individual votes.

Even though visual cryptography is a promising technique for paper-based and situated elections, only one such concept has been trialled in binding elections so far [28,33]. The

trial was reported as a technical success, however the election and usability reports identified a number of issues that disrupted the normal operation of the election process [28]. The use of paper ballots in ways that voters are unfamiliar with (i.e. splitting the ballot paper in two) increased the difficulty of using these systems and affected their usability. Voters could not understand why their receipts did not include the content of their vote and were not confident that their votes had been included in the final tally, in spite of the fact that they had followed the verification procedure.

3.1.2.3 Using online cryptograms

For remote internet-based systems, an equivalent to visual cryptography is using electronic receipts. These are mainly strings of characters called cryptograms, usually sent to the voter by email and used to verify that the cast vote is included in the final tally. One such system, 'Helios' [3,5], was developed by computer security and voting researcher B. Adida. Helios as a remote verifiable internet voting system that uses "smart ballot trackers" as receipts for the voter to check his/her vote. These trackers guarantee that the ballot was received and tallied appropriately. Voters receive an encrypted string of their cast ballot, which is also published next to their name on an online bulletin board. Everyone, including the voter who cast the vote, can check the bulletin board to verify that the encrypted vote is included in the final tally.

The voting system should, without question, be coercion-resistant in regards to not providing any document that proves the contents of one's vote (thus preventing vote selling). However, if the encrypted ballot receipts, online or paper-based, are reconsidered to allow the disclosure of less sensitive data (e.g. the vote cast metadata), voters might see value in using them to engage in political processes after the casting of votes – for example by posting the receipts on social media to utilise social pressure for participation, or as part of a political canvassing process. Simply put, I argue that it is possible to incorporate conventional methods of doing politics, in this case verifying a cast vote, with features that enable participation in the political process.

3.1.2.4 Reading voter verifiable papers/audio audit trails

DRE machines and the arguments against their obscure operations has led to, amongst other things, a proposal to introduce paper receipts after the completion of electronic voting which can be used for further checks by the voters and in any manual counts. These

paper receipts are widely called Voter Verifiable Paper Audit Trails (VVPAT) [132,133]. There are now many versions of this simple concept, which vary according to when the receipt is printed, whether printing the receipt is optional, encrypted, or used for verification counts. Most DREs that include VVPAT print an unencrypted ballot, capable of being read by humans, so that the voter can check for inconsistencies. These can also be used later for manual counts. The effectiveness of such mechanisms has been questioned, with usability researchers highlighting the high probability of errors occurring when checking paper audit trails, and the difficulty of conducting manual counts with thermally printed, small font, paper receipts.

An audio trail has also been proposed as a possible verification method [174], although this doesn't enable manual counts. Verifiable trails have also initiated the discussion around which count, digital or manual, we have to prioritise and in which circumstances, for example Pieters [151:112] has suggested that manual counts are perceived as more trustworthy (as they are more transparent), but that digital counts should be preferred for close races (as they are more accurate).

3.1.3 Security Models

There are many frameworks for undertaking an analysis of a system's security; a generic one, where most of the security evaluations and implementations are based on the CIA triad: Confidentiality, Integrity, and Availability. Other frameworks have also been developed specifically for e-voting (for an example, see [80]) in which verifiability plays a more prominent role. In this section I discuss the CIA triad and e-voting verifiability by taking NIST's [85] remote e-voting requirements as a starting point. I then extend the discussion centred around this framework by highlighting the political implications of each one of the security principles.

3.1.3.1 Confidentiality

Information security implications

Fulfilling the seemingly contradictory goals of (i) voter anonymity and (ii) the integrity of the voting result, is the main reason why verifiably secure e-voting has a major research topic in computer security over the last few decades. Confidentiality, in the e-voting and i-voting contexts, relates to the maintenance of privacy, the anonymity of voters and the secrecy of the vote. There are multiple mathematically defined and/or abstract definitions

of confidentiality (for example Jacobs et al. [97]). Here I list the i-voting confidentiality properties reported by the US National Institute of Standards and Technology [85] as an example of such a definition. Voting confidentiality refers to: (i) the protection of the secrecy of cast ballots; (ii) the protection of voters' personal information from unauthorized disclosure; (iii) prohibiting voters from being able to provide convincing evidence of their ballot selections to third parties; (iv) allowing access to all sensitive system information handled by the voting system only to authorized administrators or election officials; (v) the storing of only the sensitive information necessary to ensure the correct functioning of the voting system; and (vi) limiting communications traffic to a minimum regarding the entities participating.

Consequently, confidentiality includes preventing the disclosure of personal and sensitive information, and ensuring the anonymity of the voter, thus not linking personal information with other types of information (e.g. the content of the vote). Neither the content of the vote itself, nor the identities of the voters are confidential: the system should be able to read the content of the vote to compute the tallies and the people who voted to maintain an electoral roll. Confidentiality in the voting context refers to the *unlinkability* property [151:117] of keeping this data relation separate.

In addition to unlinkability, *receipt-freeness* [85:16] makes it impossible for voters to prove how they voted, thereby addressing issues of coercion and vote selling. Receipt-freeness is a particularly hard problem when voting occurs outside the controlled environment of a dedicated polling location, especially when voters consent to sell their votes. In Estonia, in order to ensure coercion-resistance, multiple voting and prioritisation of polling station voting is used. Multiple voting allows voters the possibility of changing their vote by re-voting before the end of the polling period. Re-voting results in not being able to prove to a third party that a vote is cast in a certain way (if there is still time to alter the vote). Even in conditions where the voter has been intimidated to vote in a certain way, until the end of the online voting period there is still the option to vote by physically visiting a polling station and casting a physical ballot with increased priority .

Political implications

The significance of maintaining the confidentiality of the voting system's data and the voter's anonymity, and the application of confidentiality when framed in terms of information security, has political implications. To enable the political we should aim at creating spaces of contest where different opinions can be democratically confronted. Consequently, in order to create voting systems capable of engaging the political, system (meta)data can be used to 'reveal' rather than hinder the various opposing viewpoints. That is not to say that the vote itself should be disclosed or that the receipt-freeness of the voting system should be violated, at least in the context of an election, but it is imperative to consider how some less sensitive information can be used to foster political engagement. This point raises potential conflict between conventional security models and political models of digital voting, with the former constructed in terms of information ownership, privacy and control, and the latter seeking to form collectives.

Although established security practices advise against any election data disclosure whatsoever, from voter lists to system logs, it has been shown that some such data has been disclosed and used to foster online and offline citizen interactions. R. M. Bond et al.'s 61 million participant Facebook experiment [22] explored political mobilization through social networks by testing whether political behavior can spread through an online social network. To test this hypothesis, the authors conducted a randomized control trial by assigning all adult US Facebook users to three groups: a 'social message' group, an 'informational message' group and a control group. The 'social' group received a banner message encouraging them to vote, also including a link to locate their polling station, a button with the label 'I Voted', a counter indicating the number of Facebook users who had previously 'pressed the button', and finally up to six pictures of user friends who had also voted. The 'informational' group received the same banner message but without the friends' pictures and the control group did not receive any election-related banner. The results suggest that the 'social message' directly increased turnout by 60,000 voters, and

via social contagion[15] [37,184] indirectly increased turnout by 280,000 voters, representing a total of 0,14% of the electorate. Although this is a relatively small percentage, it is indicative of how powerful election data can be for political engagement.

This study was designed to explore the possibility of increasing voter turnout through social contagion. However, other types of participation from political deliberation to agonism can also be accelerated through the use of such methods, relating to social network theory. A political design approach to voting data emphasises the huge potential of such data in terms of enabling political self-expression and mobilization via online and offline social networks. Collective efficacy can also be increased, and ultimately citizen participation.

The distinct physical location of a polling station and the bounded (and relatively short) time frame of an election period are also important determinants of political engagement. With polling systems being situated locally, communities are able to come together physically to vote. The temporality of elections can also allow for the creation of a period in which the public is highly politically engaged. Spatial and temporal factors facilitate modes of political campaigning that stimulate engagement. For example, in the UK local face-to-face canvassing in the run-up to an election has been widely used by political party activists, in part to engage voters on election issues, but primarily to identify supporters who are then "knocked-up" on election day (and in some cases provided with transport to the polling station) [21]. Research in politics and sociology, indicates the experiential factors embedded in the act of casting a vote at polling stations instead of doing so remotely, with findings suggesting that when collocated, voters are more likely to vote for the common good instead of personal benefit [165]. Additionally, although during the election period the systems of mass media and governance successfully manage to politically engage a significant proportion of the electorate, this political engagement is distilled out of the system with the act of voting. On election day, all the political debate that this complex system of information dissemination, campaigning and

[15] 'Social contagion' refers to the susceptibility for certain behaviour to be copied by others who are either in the vicinity of the original actor, or who have been exposed to media coverage describing the behaviour of the original actor [184].

political canvassing has generated, is only used if anything, to inform citizens' vote rather than as a channel of communication between citizens and representatives.

3.1.3.2 Integrity

Information security implications

According to NIST [85], e-voting integrity relates to:

> *"*[…] *Maintaining integrity involves implementing safeguards to ensure data and software on a system are not modified by unauthorized parties.* […] *Integrity includes the concept of the origin or source from which the integrity is based upon. […] Tracing integrity back to a particular entity is closely related to identification and authentication."*

There are multiple methods of ensuring that a computer program does what it is supposed to be doing, and this generally involves mathematically defining the specifications of such a program and testing whether its implementation conforms to its specification. A number of tools have been developed for this cause (e.g. [19]), however the complexity of these tools, consisting of many lines of code, raises questions about conformity to a program's specifications. Do we need more verification software to verify the correctness of the verification tool itself? Even if we manage to get an acceptable level of assurance regarding the correctness of the software code, this is only one part of the problem. Are we confident that the translation of the software code to machine-readable language is correct? Are any hardware errors which might affect the operation of the software easily detected? The difficulty of predicting all the possible system failures makes verification a property with special significance for e-voting. Finally, integrity also relates to authenticity and authentication a preserve equal voting power, an authentication mechanism needs to be in place to preserve it.

Verifiability is an additional measure of election integrity and it refers to the ability of the system to provide evidence about the integrity of its internal operations. NIST's report section refers to verifiability as being associated with the auditability, privileged verifiability and public verifiability of the voting system [85:24].

Auditability: *"The voting system provides evidence of its behavior before, during and after an election.* […] *The voting system must also provide evidence to auditors that the system functioned in the way it was supposed to."*

Privileged Verifiability: *"The voting system provides evidence that allows the election auditors to independently check the outcome of the election."*

Public Verifiability: *"The voting system provides evidence that allows the general public to independently check the outcome of the election."*

Although auditability is related to verifiability, classic verifiability research focuses on individual and universal verifiability. Individual verifiability refers to the voter being able to determine whether their vote was included in the tally. This requirement and interpretation of verifiability conflicts with the need for coercion-resistance and receipt-freeness. As a result, most verification systems in security research (and in practice) attempt to provide a form of verification receipt without revealing the actual vote cast (i.e. the voters' selections on the ballots). For example, verification alphanumeric strings are given to voters to verify that their ballot was included in the tally, but the actual content of the vote is hidden. Individual verifiability with receipts that also reveal the content of the vote can be found in VVPAT, although the voter needs to put the receipt in a ballot box or destroy it to ensure coercion-resistance.

Universal verifiability relates to publishing election results to allow any party to verify that the tally is correct. Classical examples of universal verifiability relate to publishing the breakdown of the votes from which the final result was calculated. Such systems typically use ballots encrypted with public keys that indicate the existence of votes corresponding to the published tally. The operations required to calculate the tallies are kept secret in order to ensure the secrecy of the vote.

Political implications

When we 'foreground' participation, the mathematical and technical integrity of the tallying mechanism becomes only one of a number of (often competing) factors that characterise the actual integrity of the electoral system as a whole. For example, election integrity, might relate to: the integrity of the voting mechanism; the integrity of the election officials; the turnout; the type and level of engagement with politics; the voter-perceived integrity of the voting system; and the digital and literacy divide that the system

creates. Dwindling levels of political participation and the continuous fall in election turnout rates in many countries has led to questions as to the integrity of election results.

It is worthwhile to assess the integrity of a voting result in terms of how well it serves democracy: is a mathematically proven result with less than half the electorate having participated more successful than a system with only a threshold of verifiable integrity, but nevertheless with a much higher level of citizen participation? Can the potential votes of disengaged citizens be considered as 'integrity flaws' if viewed as missed votes? To answer these questions we need to consider whether having a high turnout and an increased citizen participation in every election is beneficial for democracy; and also whether we value missed voters as much as the ones already engaged and motivated to participate.

Prior work in political science suggests that universal participation (wherever possible) benefits democracy. This takes into account the belief that in a healthy democratic society citizens will have a multiplicity of opinions and choices to select from, participation can be measured not only by casting votes but also by other means of political engagement (thus participation is not equal with mere turnout), and citizen indifference is a problem to be resolved from a system perspective rather than from an individual standpoint (see footnote[16] for opposite viewpoint). In addition, a pessimistic view of elections and turnout which is based on a rational actor model states that:

> *"essentially nobody should vote at all, because voting in any form has a real cost, while the probability of any voter casting the decisive vote is essentially zero. In this view, voting is basically irrational and so a 60% turnout is already remarkable."* [Anonymous paper reviewer]

Although the purpose of this thesis is not to focus on the benefits and limitations of rational choice theory, the argument that turnout is already high is valid only if we assume the validity of rational choice theory [64] in the area of citizen participation in elections.

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[16] *Anonymous paper review*: "[…] very high turnout could actually _threaten_election integrity. If voters with no preference show up and vote anyway, they add noise to the system, and that noise has the potential of burying the signal from voters who actually do have preferences, thereby destroying the integrity of the election. […] Universal voting was not the goal of most electronic voting systems--more importantly, it should explicitly not be one of those goals. The goal should be to make it as easy and secure as possible for those voters who have preferences to express them."

However, extended research from multiple disciplines (i.e. politics, economics, sociology and psychology) has highlighted the false assumptions of the rational actor theory and provided alternatives that better predict election behaviour. For example Foley argues:

> *"The concept of rationality, to use Hegelian language, represents the relations of modern capitalist society one-sidedly. The burden of rational-actor theory is the assertion that 'naturally' constituted individuals facing existential conflicts over scarce resources would rationally impose on themselves the institutional structures of modern capitalist society, or something approximating them. But this way of looking at matters systematically neglects the ways in which modern capitalist society and its social relations in fact constitute the 'rational', calculating individual. The well-known limitations of rational-actor theory, its static quality, its logical antinomies, its vulnerability to arguments of infinite regress, its failure to develop a progressive concrete research program, can all be traced to this one-sidedness"* [69:340]

To summarise, actual election integrity as seen from a participatory and socio-political perspective, refers to both the voting system's integrity as reported in computer security publications and the integrity of the voting results in terms of the voters' participation as defined earlier.

3.1.3.3 Availability

Information security implications

Availability is the last security principle of the CIA triad and refers to the time that the system is available for use. A traditional interpretation of systems' availability includes: the up-time, reliability, recoverability, fault tolerance, fail-safe and scalability of the voting system [85:38]. Citing a NIST report on availability:

> *"Availability is used to describe the proportion of time a system is functioning and operating, including times when the system is performing at reduced capacity. Due to resource overload, malicious attack, and system malfunction, a system may become unable to function, and thus is considered unavailable."* [85]

Availability of voting systems in general, including traditional paper ballots and punch card machines, refers to a system's safety as opposed to security considerations. Safety refers specifically to a system's resistance to physical and environmental conditions able to disrupt its normal operation. With electronic and remote internet–based systems the factors that affect a system's availability increase significantly. For this reason availability is one of the hardest security principles to measure, as it requires making important assumptions about the conditions that the system is utilised and maintained in..

The availability of e-voting systems is associated frequently with denial of service (DoS) attacks in which malicious individuals try to intentionally disrupt the normal operation of a system. When a network of computers is used to perform a DoS we call it a distributed DoS (DDoS) which represents one of the largest problems in networked computer security. Solutions exist that mitigate problems of DDoS, but there is no solution yet to guarantee freedom from denial of service, especially for high-risk systems.

Political implications

As with 'integrity', 'availability' of systems when seen from a participatory perspective relates to a number of factors, seemingly unrelated, with the availability of a given system measured by its percentage of up-time and the existence of fail-safe barriers. To address how availability can be interpreted from a participatory perspective we need to question what availability encompasses for citizens and democratic participation. I argue that participatory citizen-centred availability also refers to properties such as the system's affordances and accessibility, making the up-time availability only one of the affecting variables.

By 'affordances' I refer to the actions that the system is designed to permit, a decision with potential political implications. A conventional voting system allows minimum user interaction. Spoiled and blank ballots are historically used as protests votes: voters not represented by the candidate options choose to cast an invalid or blank vote to register their opposition to a system that doesn't have the affordances to allow them to participate in a valid way. For example, existing conventional voting methods (due to the technical limitations of election infrastructure inherited from the Australian ballot of 1856 and political decisions embedded in its design) enable citizens to participate only by casting a

preferred vote (or by ranking candidates) rather than allowing for more political participation. Consequently the political elements of the vote are filtered out of the election process. The introduction of technology in voting allows us to rethink how the voting apparatus can be politically designed to give voting systems additional affordances and channels of communication.

Information security measures availability as the proportion of time that the system is running and available for use. This is an accurate definition of voting availability when investigated as a monad rather than as part of a larger socio-political system. If we position voting availability in a socio-political context, the "up-time" of the system also becomes a function of participation: Is a technically 'available' system perceived as such by citizens who abstain from voting? Even though we should acknowledge the multifaceted nature of the reasons behind citizens' indifference towards voting, it can be argued that the design and affordances of e-voting systems could and are currently affecting turnout and citizen engagement. The missed opportunity to better motivate participation, other than simply lowering transactional costs, should also be considered as a system's availability flaw (when it is perceived as a whole with its socio-political relations).

The "up-time" of the system for non-indifferent voters can also be a function of its accessibility. The proportion of the time that the system is available should be a measure that includes how accessible the system is to the users who are willing to participate. This is one of the areas where the application of technology and the introduction of remote internet voting has by definition improved its availability in terms of reach. Obviously improvements are still needed to build a system accessible to all citizens independently of digital literacy and personal ownership of technology. However, it has to be acknowledged that a great deal has been done over the last two decades towards developing usable, multilingual and physically accessible voting systems for every politically motivated citizen (e.g. [17,27,163]).

3.1.4 Concluding Remarks

In this section, by reviewing two substantial e-voting evaluations, I have acknowledged the problems that conventional e-voting research has been faced with as well as the need for technical solutions to address the problem of security (in order to ensure the correctness of the voting systems designed to facilitate politics). I later introduced some of the

most common security methods, focusing on how they configure citizens' interactions with the system and how they can be complemented to engage citizens in political processes before and after the vote. Finally, by taking NIST's definitions of confidentiality, integrity and availability as a starting point, I endeavoured to unpick these security principles when seen as part of a larger socio-political problem rather than part of a very well defined and contextually detached problem.

In the remainder of this chapter I focus on recent advances in the remaining two areas of e-voting research: user acceptance of e-voting systems used in national elections, including usability, accessibility and trust; and HCI work on innovative voting interfaces for community engagement.

3.2. Usability, Accessibility and Trust

Although the focus on security research continues to dominate research and discussion around e-voting, usability, accessibility and trust have been vivid areas of research in information security with work, in some cases, exploring the contradicting properties of system usability and security.

3.2.1 Usability and Accessibility

Research papers and reports on usability and accessibility are plentiful, with most of them focusing on assessing either the usability of conventional voting systems [63] or the usability of secure prototypes designed as possible alternatives [50,101,153].

Usability is defined as *"the effectiveness, efficiency and satisfaction achieved by a specified set of users performing specified tasks with a given product"* [116]. Accessibility then consists in defining those "specified users" as inclusive as possible [163]. Usability researchers, electoral commissions and standards organizations have been developing usability requirements for user friendly, accessible e-voting for years, with their definitions and prerequisites being a function of the needs and understanding of usability in different socio-political contexts.

In this section I briefly review the usability assessments of voting systems being used in elections based on mechanical and material methods of voting (e.g. paper, lever machines and punch cards), DREs and cryptographic-based voting prototypes.

3.2.1.1 Paper, Lever and Punch Cards

M. Byrne in his paper published in 2007 [27], identified the need for baseline data of conventional voting systems in order to assess the usability and accessibility of the newly introduced ones. In this paper, they report on an experiment assessing the usability of two types of paper-based ballots (arrow ballot and bubble ballot), mechanical lever machines and punch cards. One of the findings suggests that paper ballots appear to rank better in usability scales when compared with mechanical lever machines, punch cards and direct recording electronics. The error rate of paper-based voting systems was 1.5%, much lower than mechanical or electronic alternatives. In addition, it was noted that this usability comes with no cost in terms of system efficiency and perceived usability. On the negative side, paper ballots are not always usable by people with impairments or disabilities. Being able to read the paper ballots is a key requirement for all conventional voting systems, with DREs affording additional channels for these user groups. In terms of ballot completion time, the four voting methods had no significant differences. Finally, the report highlighted that across a number of usability studies, no voting technology achieves an accuracy with an error rate under 1% [27], which suggests that even the most secure system is subject to usability constraints.

3.2.1.2 DREs, VVPAT and VVAAT

Another strand of usability research is focused on performing usability evaluations of DRE voting technologies. This involves assessing whether the systems built by various vendors meet the requirements imposed by certification agencies and electoral commissions. As a result there are nearly as many usability reports as the number of DRE systems developed. In this section I will mainly focus on the usability problems that the shift from conventional voting methods to DREs introduced and also briefly discuss the more recent shift from voting seen as a ‘technical only’ problem to one with socio-political dimensions.

F. Conrad et al. [42], report a laboratory usability analysis of six e-voting systems (DRE-based) chosen to represent the different features of systems in use at the 2008 elections, aiming at assessing their usability and user satisfaction. The main outcome of this study indicates that for all six voting systems tested, voters experienced a series of problems that increased the effort required to cast a vote, or disenfranchised voters from voting at

all. The usability problems identified led to voter frustration, which reduced the voting satisfaction and potentially the possibility of voting in subsequent elections. It can be concluded from this that observed inaccuracies can alter the outcome of a close election, thus usability has a direct impact on elections' integrity. Herrnson et al. [88], focused on the usability of commercial DRE systems in use and found evidence of serious usability problems, with error rates reaching as high as 4.2%. Even though different voting systems by different vendors rate differently in usability scales, it is common for most of them to have serious usability, accessibility issues with high error rates and non-inclusive designs.

Other studies compare DRE systems with conventional paper-based and punch card based systems. S. Everett et al. indicate that the efficiency and effectiveness of DREs is notably worse than traditional methods of voting due to the high rate of post-completion errors [63]. An interesting disassociation between performance and satisfaction has been noted - even though voting performance was lower with DREs, voters were reported to be more satisfied with electronic means of voting versus traditional mechanical levers and punch cards. DREs, possibly because of their novelty, achieve higher satisfaction rates when compared with paper-based and mechanical methods of voting, however paper-based voting rates highly in all areas (efficiency, effectiveness and satisfaction). These findings question the assumption that mechanical methods of voting and their electronic alternatives are able to facilitate voting. Researchers agree that DREs can improve voting accessibility for people with special needs, however there are reasons to doubt that current commercial systems actually facilitate access to the voting apparatus [164]. Approaches to make paper-based voting more accessible, for example by using Braille ballots, and technologies specifically developed for paper ballot accessibility, might be more appropriate.

Finally, other usability studies explored the feasibility of lowering error rates and increasing subjective and objective usability by using voter verifiable audit trails either in the form of paper (VVPAT) or audio (VVAAT). Goggin et al. [77] compare effectiveness, efficiency and user satisfaction of VVPAT, VVAAT and optical scan ballot systems. Results suggest that citizens are more accurate in counting optical scan ballots rather than paper or audio audit trails. The authors suggest that if the optical scan ballots are to be replaced by other forms of voter verification, safeguards need to be particularly well employed in order to cope with the substantially greater need for error mitigation. In the case

of VVPAT and video based verification systems specifically, only half of the voter counts were actually correct, which questions whether any procedural solution can address this substantial error rate. Other reports also highlight the prematurity of voter audit mechanisms [40], and call for a more user-centred approach in designing these systems with the involvement of all stakeholders in the election process (i.e. voters, poll workers and election officials).

3.2.1.4 Cryptographic Systems

Advances in information security have resulted in the development of a number of cryptographically secure e-voting schemes. Apart from the work that scrutinizes their mathematical background, these systems have been extensively tested in terms of their usability and accessibility. The results are far from promising, with most of them being flawed in regards to their accessibility and usability.

A number of usability studies have been published citing popular end-to-end (E2E) verifiable systems such as PunchScan, Scantegrity, Prêt à Voter and Helios [5,33,61,66,166]. Most of these studies converge around the central point that E2E verifiable systems still have a long way to go to make their benefits obvious to the voters. Karayumak et al, performed one of the biggest usability analysis studies on Helios [100,101] by using the cognitive walkthrough method. The analysis revealed usability problems with wording, misleading information on the e-voting pages, missing voting information and user interface problems [101]. C. Acemyan et al., assess the usability of three of the most well known E2E verifiable voting systems: Helios, Prêt à Voter and Scantegrity II [1]. Findings highlight severe problems across all three systems with many participants in the study perceiving that they had successfully cast a vote when they had failed to complete all the necessary voting steps. More specifically for Helios 85% of the participants thought that they had successfully cast a vote when only 60% of them had actually done so. Results are similar for Prêt à Voter, whilst in the case of Scantegrity, from 95% of the voters that reported casting a vote only 50% of them actually completed the voting process successfully. This effectively means that half of the votes were lost due to usability flaws, even though these systems were designed to be leading paradigms in election integrity. Low success rates are also observed for the voter verification part of voting across most E2E verifiable systems. Studies suggest that the additional system-voter interactions

required for verification adds complexity that introduces more opportunities for voters to fail [1]. The authors suggest making security invisible, trying to model the conventional voting system to the greatest degree possible, automating verification output to minimize user mistakes, giving more instructions to voters, and giving formal specification to the system usage rather than focusing only on the security of systems [1].

A. Essex et al. conducted a usability study of Punchscan [66], a visual cryptography system used in the context of binding university elections [61]. There were widespread problems with verification receipts as the voters expected the receipts to indicate their vote rather than its encrypted representation. Also, the destruction of part of the ballot – a step that is used by many visual crypto systems to ensure voter anonymity – was perceived as a destruction of the vote. Finally, poll workers reported significant organizational issues, for example increased time spent in the voting booths. Scantegrity [33], a deviation of Punchscan specifically modified for national elections, was used in Tahoma Park, Maryland on 3rd November 2009, making it the first E2E verifiable system to be used in national binding elections. The election in terms of encryption mechanisms and technical functions was assessed as a success. However, a number of usability problems were raised, including extended voting times, misunderstanding of verification techniques, and interface problems [28].

3.2.2 Confidence and Trust

The introduction of technology in voting initiated the discussion about voter confidence in the newly introduced voting systems and the trust that someone needs to have in both the election system and election officials.

3.2.2.1 Defining Trust and Confidence

Sociologists, computer scientists and computer security researchers have in many cases presented contradicting accounts of how e-voting trust is defined and measured, and what might be the ideal aims for research in this area. A philosophical analysis of confidence and trust and its implications for information security can be found in [151:91]. As W. Pieters indicates [151:92], in a section named "*Increasing Trust*" (in [62]) the following sentence talks about decreasing trust: *"One way to decrease the trust voters must place in voting machine software is to let voters physically verify that their intent is recorded correctly"*. This exemplifies the different perspectives that computer science researchers

have relating to the problem of trust, as something that needs to be decreased in order to ensure that voters' trust on the system will be increased. For example, one of the recent trends in information security and cryptography is lowering the trust citizens and the system needs to put on election authorities [84].

This can also be framed as a tension between "objective" and "subjective" trust: trust as a system property, which can be measurable and defined mathematically and trust seen as a voter belief which is abstract and not well defined. W. Pieters [150], questions this distinction between objectivity and subjectivity, expressed differently in terms of actual and perceived security, by arguing that actual security can never be "actual" as the methods and tools used by security researchers for measuring security can be flawed and biased. As a result, the limitations of these systems may be revealed after years of successful operation with severe socio-political repercussions. A more more security-oriented approach can be found in [62], where D. Evans and N. Paul argue for the need to explicitly differentiate actual and perceived security in security sensitive applications.

N. Luhmann [121] provides an extensive model of trust, distinguishing several types of trust relations (for an extensive discussion on trust and its relation with technology and voting see W. Pieters' thesis [151]). Familiarity according to Luhmann is a trust relation with an orientation towards the past: we trust things because they have always been done this way and thus they are socially accepted. Contrastingly, trust has an orientation towards the future as it is based on expectations. For example we trust ATMs because we expect them to serve us faster than bank employees. According to Luhmann, trust involves an assessment of options and risks before a decision is made and as a result, trust requires the existence of alternatives. If no alternatives are available trust is replaced by confidence. A typical example of confidence is in driving, where the drivers have no alternative but to be confident that the car will not break down or act unexpectedly.

3.2.2.2 Engineering Trust

In the voting context, there are multiple factors which can influence voters' trust [151:98]. Apart from philosophical matters relating to trust and security, extensive research has been conducted on assessing the possible impact that voting technologies and processes have on citizens' confidence, trust and participation.

B. Randell and P. Ryan in [156] suggest a paper-based secure system drawing on the assumption that the familiarity (and materiality) of a paper interface might have a positive contribution on trust – thus trust with an orientation towards the past. They suggest a scratch card voting scheme that preserves the paper interface of conventional ballots and "*provides high assurances of all aspects of voting accuracy and secrecy and needs only minimal trust in the system components*" (for mathematical details regarding use see [166]). Other researchers have focused on investigating trust when interpreted as a socio-otechnical problem. In [140,141], A. Oostveen et al. question the assumption that people have blind faith (or trust) in scientific objectivity and through the TruE-Vote project they assess voters' opinions in topics related to security, verifiability and trust. The authors highlight the impact that a potential wholesale attack could have on trust, as conventional offline system errors are on a small scale and addressed by social rather than mathematical structures and methods. The report concludes that for a system so crucial to the existence of democracy, trust in technology alone is not sufficient. This view is also shared by some well-known security researchers in the area, who after thirty years of mathematical and crypto-based research, acknowledge that the problem of trust is more complicated than the development of a technically secure voting system.

A. Oostveen et al. in [143], in a study comparing how three voting technologies affect trust (paper, computer-aided and a PKI-based voting system), found that voting technologies did not influence voting behaviour. Contrastingly, the context in which the polling occurred influenced voting behaviour as citizens voted privately did so differently than those who voted in a public polling station. This has implications for remote e-voting as voting from home might have an impact on how people vote, in other words for personal interests rather than for the collective good. Y. Yao and L. Murphy in [200], explore voters' perceptions of use when remote e-voting is used for governmental elections. The study shows that increased availability is not sufficient to motivate indifferent citizens to participate. On the contrary, ease of use was a possible predictor of voter participation, with web-based remote voting being perceived as less usable than other voting alternatives such as telephone voting.

Finally, another area of interest is the effect of procedural security on trust – defined as the social and physical methods of ensuring the integrity of the elections in the polling location. In [199] and [198], the authors conducted interviews to explore voters' beliefs

on procedural security and how technology might play a role in complementing it. Participants cited procedural security as contributing to the transparency of the elections, accepted and understood by all agents (technical and non-technical). The authors concluded that when considering procedural security in e-voting, the element of trust that it fosters can be greater in value than the increase in actual levels of overall security [199].

3.2.3 Concluding Remarks

What are the political assumptions embedded in work assessing the usability, accessibility and user trust of traditional and novel voting systems? Quantifying usability, accessibility and trust requires a definition of the baseline condition against which novel systems can be compared. Under a baseline condition, paper-based ballots are chosen as the point of reference. This evidently implies that either the usability of paper-based ballots is the ideal state of usability, or that any novel voting technology should aim to overcome the paper based one. Most, if not all usability studies contrasting the performance of novel voting systems with paper-based ones, result in significantly inferior usability. Considering that the introduction of technology in voting was particularly driven by usability problems and questions concerned with voter intent on punched out ballot papers, currently implemented systems fail to meet the specifications for which they were initially developed.

It is clear that usability of voting systems should be measured against a variety of demographics to ensure the fairness of the electoral system. If we interpret usability as a function of the system's use, additional variables should be taken into account such as the achieved turnout and the demographics of people excluded. One example can be found in the design of voting systems and electoral ballots with a particular focus on their accessible design for the elderly. An equivalent measure might have been engaging young voters to participate. The main difference of this understanding of usability is its relation to motivational factors of participation in addition to accessibility ones. An equivalent association can be found in usability and user experience in HCI. Whilst usability is mostly task-oriented and a measure of a user performing an action easily and intuitively, user experience refers to the users' emotional connection to performed tasks and the meaning and value that users place on their actions. For example a product (e.g. a website) can be particularly usable without necessarily being very engaging to use, thus failing in

providing a satisfactory user experience. AS in UX research, I contend that in participatory and democratic sensitive contexts such as voting we need new methods of assessing the meaningfulness of a system and its design for citizens across various demographics. One example is the self and collective efficacy of the vote. It can be argued that perceived self and collective efficacy (that is subjective efficacy reported by the voter unrelated to the political efficacy of the vote) can be affected by the design of the voting system. Should a system's failings in increasing voter efficacy have an impact on its usability rate?

Finally, I argue that it is important to question the interpretation of usability and trust-related data collected by using the existing, mostly quantitative methods of research. A mixed methods approach can supposedly be a more adequate approach of capturing users beliefs while collecting quantifiable data about system use. Focusing only on questionnaires and surveys, even if they are well designed ones, might lead to a false perception of user approval or disapproval due to the complex socio-political context in which systems are situated. For example, questionnaire data related to the confidence that voters place in the voting system might describe voters' trust within a broader socio-political context rather than in the voting system specifically. Outcomes can obviously be altered by designing quantitative data collection methods more carefully. Nevertheless citizens' political beliefs and the complexity of the socio-political context can still play an important role in biasing the collected data [7].

3.3. Voting in the Community

There is currently an agreement amongst political theorists on the importance of enlarging the domain of politics outside traditional political contexts and national politics. A. Giddens argues for the necessity of democratizing the main institutions of society, such as the family, the workplace etc., by opening them to debate and contestation [76,135]. He argues for the promotion of the value of autonomy in a wide range of social relations with the establishment of small-scale public spheres in which conflicts can be resolved through dialogue. The probability of a dialogical resolution of these conflicts is a matter of debate amongst political theorists with E. Laclau and C. Mouffe in *Hegemony and Socialist Strategy* [114] having diverging opinions concerning the way political struggle should be envisaged. I have already discussed this tension between dialogical forms of democracy

and agonistic ones. It is essential however to highlight the agreement for enlarging the domain of politics in contexts which are traditionally assumed to be apolitical. A. Giddens [75] contends that this process of democratization is driven by social reflexivity and de-traditionalization which can already be identified in particular contexts including: personal life (i.e. sexual relations, friendship, and parent-child relations) where there is an emergence of 'emotional democracy', organization where some of the highly hierarchical structures are replaced by more decentralised models of organization, the development of social movements and self-organized groups where spaces of dialogue can emerge that question forms of authority and power hierarchies, globally where social reflexivity, autonomy and dialogue might result in a cosmopolitan global order.

Design for democracy in HCI can be specifically framed in this political model of extending the domain of politics in traditionally less political contexts. Human computer interaction research focuses on both big 'p' Politics and how politics is practised at local level, with a particular focus on the latter, and a more specific focus on facilitating community building and community engagement. A lack of research can be detected in political design, referring to the lack of research in engaging citizens in political debate and the creation of public spaces where divergent political viewpoints can be confronted. In this regard, it can be argued that work in HCI, just like in security, usability and trust, also converges around the facilitation of politics in terms of the means, methods and structures that enable effective collection of community opinions.

Regarding electronic voting systems, a number of variables possibly affecting community engagement and participation have been explored, to name a few of the different types of opinion input (e.g. buttons, gestures, steps etc.), the type of data output (e.g. projections of the data, painted charts, mechanical situated charts etc.) and the location of the voting system (i.e. situated in the community or remote online access). The context in which these technologies are deployed range from work environments and family contexts, to geographically bounded local communities.

It is apparent that even though technology has the potential to support community engagement and community building, it is a matter of interaction design as to whether this potential is capable of being reached [159] and what politics can be embedded in the design [54]. Saad-Sulonen et al. [167] address the move towards designing politics, first introduced in HCI by Dourish [54], by using collaborative design and design of politics

[55] to explore how an interactive system might reflect on citizen participation in urban planning. One of the authors' conclusions highlights the need for making flexible systems (capable of being adapted by users) by applying technological participatory design.

3.3.1 Online

The technological mediation of voting has been particularly explored as a process of group decision-making in an organizational context in 'computer supported collaborative work' (CSCW) and 'computer mediated communication' (CMC) [15]. One particular area of interest in CMC is the effect that mediated communication has on group decisions and group performance. Recent studies have considered real-world data sets from collaboration systems such as Wikipedia [25,115,201] to examine how consensus is achieved in open source collaborative projects, and how different variables such as group size, group formulation, and experience can lead to better decisions. The main findings suggest that larger groups, with more diverse contributions and more experienced members are more likely to reach better decisions.

In HCI there has also been an active program to explore the impact of online voting and decision-making systems on community engagement and community building. A wide range of technologies has been used from online deliberative platforms (e.g. [103]) to online community forums to support offline practices. A well-cited example of an online portal aiming at increasing access to and participation in community life is the Blacksburg Electronic Village. One of the portal's main goals is to facilitate offline community practices and bonding by bringing a community's history to the forefront and allowing anybody to add content and create their own community page on the portal [30]. The use of an online portal by residents has resulted in the collection of historical and other community material used by a local school for educational purposes, and from new residents moving into the community to help them settle in. The authors report an increased level of communication in the community and participation in its offline activities. Another popular online platform is Netville [83], which instead of augmenting an existing offline community online, attempted to create a sense of community in a newly built area. Some of the houses were not connected to the network, providing the authors with a control group to assess the effect of the online platform. Their case study concluded that the online platform increased communication, participation and community recognition of

neighbours. Amongst the advantages of the platform use was the grassroots self-organisation of the community for community matters. One characteristic example was the use of the network for organising action against the developers and applying pressure for the repair of a number of problems with the new houses.

In addition to geographically bounded local communities, voting and collective decision-making have, to a limited extent, been studied in the context of 'idea management systems' (IMS), primarily in formal contexts such as work environments. Bailey & Horvitz [13] describe the use of idea management systems in a large organization, and after identifying patterns of use they propose design recommendations for facilitating grassroots participation in IMS. IMS provide particularly good examples of a class of systems that incorporates voting not only as the means by which to reach consensus, but also as a tool to support discussions.

While on the one hand there is a reinvigorated enthusiasm for designing technology for socio-political change in a variety of contexts [113,145], there is also growing concern for the potentially negative impact of digital online technologies regarding civic engagement [117,161]. In particular, in the context of technology for supporting activism, activities such as re-tweeting a political message, or changing one's profile picture on a social networking site (pejoratively called 'slacktivism'), are viewed as low-cost, low-risk routes to action (there is some evidence of ipositive impact) [117]). Other types of online activism (hacktivism or sometimes called disruptive electronic contention [43]) such as cyber-attacks, virtual sit-ins, denial of service attacks etc. are of higher cost and questionable legality and require specific skills and motivation from the organizers. Although online activism is more likely to inform offline action in authoritarian or repressive contexts as it is a form of freedom of speech [94], in western societies it is viewed with scepticism, as the link between online participation and offline action is unclear. This is particularly the case where the pathways to participatory social change are limited, for instance via existing political structures [189] or the politics embedded in the design of technology.

More recently, interaction design researchers have examined how the introduction of additional voting channels, such as SMS voting, situated devices and online platforms can lower some of the barriers and costs of participation. A subset of these systems utilizes both online and offline interfaces that allow citizens to either interact in-situ or ex-situ.

The most prominent examples of such systems use personal devices as input methods (e.g. posting a response on social media) and use public displays to visualise the discussions and motivate participation. An equivalent method of multiple channels of participation has also been practised in national elections, traditionally with postal voting and over the last few years through the introduction of the internet and mobile voting.

3.3.2 Situated

In-situ technologies are of particular interest due to their accessibility. Situated voting systems in HCI have been deployed in a number of contexts, in libraries [160], classrooms [36], shops [187,189], universities [93], and other locations [189,195] in attempts to promote and support different forms of civic engagement [93,131,189]. Taylor et al. [189] demonstrated how simple situated voting interfaces can encourage participation in local communities and identified a number of key design considerations for such systems, including efficacy, credibility and a range of practical matters related to the design and physical location of voting devices. Mechanisms for promoting perceived efficacy –voters' belief that their action might effect a change [29] – was considered a key design parameter for decision making and voting systems.

A number of interfaces and input methods have been trialled for situated voting, aiming to increase citizen engagement by making the voting systems more accessible and playful. In [182], the authors use two tangible buttons and a public display allowing citizens to vote on questions by stepping on situated buttons. The prototype was deployed publicly next to a bus stop allowing bystanders to observe the voters preferences, which initiated interesting discussions about the privacy of the vote. The vast majority of participants were not concerned about people watching, especially for questions where their opinion mattered or had an ethical implication. The "whole body" interaction that was required to cast a vote was appreciated by participants, as it was perceived as an indication of commitment. The device engaged pedestrians in social interactions and debates about community matters. In [192], the authors use hand gestures as the interaction mechanism for citizens to cast votes. To increase the visibility of the voting system, mirror images of passer-by were displayed on a screen, a strategy previously proven effective in communicating interactivity [137]. Even though the prototype was mainly designed to attract attention, field experiment yielded conversations between bystanders with the voters stating that they voted honestly about their opinions. Participants were interacting less with

the system when their identity (in this case a picture) was associated with a vote, which indicates the privacy implications at play.

In addition to the various situated input methods, research in HCI has also been focusing on the utilisation of the collected data for raising awareness about the polled issues and the voting interfaces. In the majority of cases this entails innovative and in some cases real time visualisations of the data in urban public spaces. Most of these field studies use digital displays [23,24,74,93,112,118,173,182,183,189,195] or projections [18,70,176,192] of the gathered data. However glare and display blindness [138] have been cited as reasons for limiting citizen engagement. In [108], low technology voting devices were placed in local shops, allowing community members to vote on local issues. The results were stencilled on the pavements on alternating days by using brightly coloured chalk spray to provide a more accessible visualisation of the results to a broader range of community members. The study identified several types of citizen engagement with the project, and questions were raised in respect of levels of curiosity, contemplation about citizen views in relation to others, conversations initiated in-situ, comparison between the results of different shops and areas and competition between different shops.

Media façades have been used for visualising the data gathered from voting devices. The *Smart Citizen Sentiment Dashboard* (SCSD) [18] introduces the concept of media architectural interfaces, a design approach in which a tangible interface mediates the interaction between citizens and a media façade. A system consisting of a console with a knob for selecting questions, a button for changing the visualisation of the media façade, and three sensors for smartcards each labelled with a different mood was deployed at the centre of Sao Paulo in Brazil. The results were projected as colourful chart displaying visualisations within a 3700 square meter media façade on a tall building. According to the authors the small scale interface, which contrasts with the large visualisation of the results, made most citizens unaware of the interaction involved or the interpretation of the visualisation on the façade. Even though most of the participants perceived the visualisation as a piece of art, the majority of those who interacted with it expressed meaningful opinions, while a smaller percentage enjoyed exploring the system.

In [89] the authors developed two situated interfaces for polling. The first was developed on a tablet device installed on a stand with a series of yes/no survey questions. When a participant answered a question, a chart with the result for this question was shown and

the next question was displayed. The second interface was a full body voting application running on an urban display. A camera mounted below the display provided the display with live footage of a section of the precinct. The display showing the footage was split into two parts with one part assigned to “yes” and the other to “no”. As in the case of [192], participants could vote by physically moving into the equivalent side of the display and wait for a bar to become filled. In comparison with the tablet application the full body interface allowed additional voting dynamics such as multiple voting, group voting for the same option or simultaneous voting for opposing options. The authors, after deploying these two voting interfaces concluded that the embedding of polling technologies in the built environment is necessary to increase their accessibility but is not sufficient to increase their awareness. Live screening is a successful method of raising awareness, and compared with public full-body applications, more private interfaces such as tablets allow citizens to reflect more on their answers.

Finally, voting systems like VoxBox [78], are designed to invite more playful interactions mainly for collecting the opinions of a crowd at events and festivals. The authors use physical tangible objects such as buttons, levers, spinners etc. to make the affordances of the system more obvious in order to increase its awareness and avoid possible impediments of participation such as display blindness [138]. The authors argue that such an approach might be more representative than conventional surveys or touch screen displays at events, and might simultaneously preserve the experience of a given event. After an initial deployment at a one-day conference, VoxBox was very well received by the attendees, with the design of the system encouraging participation, completion and a clear connection between answers and results.

3.3.3 Concluding Remarks

HCI research is very active in exploring various interfaces and input modalities for community engagement through voting. Playful and creative interfaces are able to motivate participation and engage citizens in discussions. However, if these advances are seen from the viewpoint of engaging the political, the majority of them either do not reflect the type of participation achieved and how it contributes to democracy, or presume the existence of a specific hierarchical structure which these systems serve. The type of participation that this interaction results in is rarely explored, with the majority of these interfaces contributing towards a model of direct democracy where a representative structure (i.e. local

councils, large organisations etc.) is presumed. As a result, these prototypes serve mostly as tools for consultation and doing politics rather than engaging citizens in the political with only large organizations and councils having the power to drive agendas. Even though such systems succeed in providing tools for top-down citizen consultation and information dissemination, the cost of expansion and the followed hierarchical approach makes them inappropriate for citizen-led initiatives.

In [89], one of the case study outcomes was that between the two provided voting interfaces, the tablet interface allowed participants to reflect on their opinions before they cast a vote. Such results indicate the importance of the interface design not only for motivational factors but also for the political participation that it results in . The design of voting interfaces such as in [78], is without question engaging and invites a playful interaction. The assumption behind the design of these systems is that providing an engaging interaction mechanism will also result in citizen engagement in the case of polling. I argue that even though this is indeed one avenue towards increasing voter turnout, it doesn't resolve the key problem of citizen apathy, which relates to the political assumptions embedded in the design of these systems. Such playful interaction methods [78,182,192] can be viewed as crucial for increasing the visibility of consultation exercises initiated by local councils. However, they only allow citizen participation to be enacted through answering previously defined questions with a particular consensual focus. As a result, citizens' participation depends on the will of the organization or political body running the poll, with citizens unable to be fully involved in a meaningful political debate with the poll organiser. In many cases these consultation exercises are seen with great scepticism as they seek confirmation of already affirmed decisions rather than allowing political debate and providing feasible alternative options. This results in citizens' indifference, as they don't see any purpose in participating in a 'democratic theatre' where it seems like they are given options when they are not. In Netville [83], new residents of the housing block used the online platform to organise against the developers in order to resolve some of the housing problems. Unfortunately the residents were unsuccessful, with the developers stating that: "*they would never build another wired neighbourhood*" [83]. This exemplifies the need for designing decentralised systems that not only motivate participation but also enable questioning of power relations.

In this thesis I explore avenues that political participation can be achieved through extending the capacities of voting systems and configuring them according to contextual parameters. Just as in HCI research reported here, this also involves the configuration of the system's interface. However, instead of taking a technological deterministic approach, I start out from the need to invent systems designed to enable the political, which in addition to increasing the mere number of people using them, also involves their participation in political processes of setting up polls, driving agendas, debating issues and being part of a truly participatory data collection process. As in [14] and [45] in which the authors develop methods and processes, which can be sustained in the community for grassroots driven political participation, I attempt to reconsider voting for engaging the political through a bottom-up, sustainable means of participation in a vibrant model of agonistic democracy.

3.4. Summary

In this chapter I reviewed work in three seemingly different areas of research: computer security; usability, accessibility and trust; and civic engagement through voting in communities. Whilst acknowledging the variance of the work in these areas, by reporting state of the art developments in each one of them, I attempted to highlight the politics embedded in certain methodologies and practices within the fields most active in e-voting research.

All three areas of research share common characteristics that drive the majority of the development in equivalent areas: they facilitate the methods, structures and mechanisms that enable governing and as a result, according to Mouffe, they serve 'politics'. This results in essentially accelerating a hierarchical top-down model of representative democracy by making voting more secure, more usable, and more accessible through multiple channels of participation or playful interfaces. This does not imply that this is not vital for modern democracies, and a prerequisite for their democratic operation. However, in this thesis I am particularly interested in investigating the political design of e-voting systems, ones that are able to create vibrant public spaces of contestation in which different opinions and political projects can be democratically confronted. Following political theorists and particularly the call by A. Giddens for enlarging the domain of politics in contexts traditionally considered irrelevant to politics, I explore the effect that politically

designed voting systems may have on main institutions of society such as the workplace, the family and the local community.

Chapter 4.

Designing the Vote for Participation

After highlighting in the previous chapters the politics and political assumptions embedded in the design of technology to support democracy and after reviewing the latest research in e-voting, in this chapter I attempt to propose a design framework for instantiating voting systems for political participation[17].

Here I attempt to synthesize the conceptual and practical work that I have discussed so far with example instantiations of voting systems being found in a variety of contexts and consisting of divergent features and affordances. Ultimately, I attempt to propose a design space and framework of voting for participation, allowing for both the instantiation of voting systems according to contextual and other parameters and also for their assessment according to how they configure participation in the deployed context.

Instantiations of digital and also conventional voting can be found in a wide variety of forms and designs, including social media polls, online scheduling, idea management systems, shareholder meetings, family decision making and national and local binding elections. These can be characterised as binding/non-binding, reoccurring/spontaneous, deliberative/direct, off-situ/on-situ etc. and are designed to be appropriate for specific contexts, but also to support different types of user participation. For example, for social

[17] Published version of this framework: Vlachokyriakos, V., Dunphy, P., Taylor, N., Comber, R., & Olivier, P. (2014). *BallotShare: An exploration of the design space for digital voting in the workplace*. Computers in Human Behavior, 41, 433-443.

media polls, ‘liking’ stories online and online petitioning realize the direct collection of opinions, whereas forums for policy making or consultation try to mediate a more deliberative form of participation. Voting by raising hands in contexts such as workplace meetings is used to highlight the individual choices of members of the group, whereas voting in modern day local and national elections involves more private voting formats to avoid coercion of voters.

In this chapter, I first explore a range of instantiations of voting systems across a wide spectrum of decision-making contexts, from institutional (such as elections) to mundane (social media polls, idea management systems, etc.). Taking into account the assumptions for doing ‘politics’ embedded in the design of conventional voting systems and their traditional requirements originating from security and participatory boundaries of representative democracy, I unpick a design space of voting that serves as a toolkit for the design of voting systems for political participation.

4.1. The Design Space of Voting

There appears to be a rich space of possibilities to enable voting organizers to configure and affect participation according to contextual and participatory parameters. However the various design features and affordances able to configure and achieve political participation are largely underexplored.

Throughout the years of the evolution of democratic decision-making, many configurations of voting have been proposed, adopted and discarded on the basis of contextual considerations that have reflected the changing needs of stakeholders. In recent times, digital technology has been applied to voting in order to realize benefits that primarily relate to convenience (of access) and efficiency (of deployments). Whether technology is fulfilling its potential to support voting practices is still a matter of debate, with political theorists arguing that simply using it to remove barriers to participation will not increase the quality of the resulting decision-making process [196]. This suggests that encouraging participation in voting cannot be achieved simply through provision of convenient access to a digital interface.

The need to reach some form of consensus is a common requirement of the everyday lives of people in groups. This consensual focus is also reflected in the affordances of the majority of voting systems, which are mainly designed to enable the quantification of

opinions that will lead to convergent decision-making. In addition to consensus, the configuration of a vote amongst a group reflects the specific values of the group, and the challenges they face. Decisions regarding who can vote, and how they can vote, are fundamental to the resulting participation and the acceptance of decisions made. These needs and values are revealed through trade-offs in the design of voting processes, including the way voters are able to express their preferences, which can range from a direct collection of opinions to a more deliberative discussion of the issues at stake.

The application of technology in everyday decision-making can be found in scenarios ranging from political debate, television talent shows, to the agreement of meeting times between collaborators. In such cases, digital technologies have in general served to increase the spatial and temporal reach of conventional votes (i.e. amongst spatially distributed groups of individuals) and the facilitation of the methods and mechanisms for converging viewpoints. However, I identify that the potential of digital technology to enhance participation through voting is relatively untapped, with technology enabling us to re-envision voting as a socio-political tool that can better serve democracy by exploiting the context-specific stimuli of participation. Despite the diversity of the voting systems being used for various contexts and practices and diverse ways of reaching consensus, there is currently little research into how system's affordances influence participation and how voting can be re-envisioned for participation in the political.

A driving factor affecting the affordances of voting and e-democracy systems is computer security, informed by the requirements of voting systems for representative democracy. Computer security research, committed to the idea that systems should be simple, has systematically unpicked through threat models the possible avenues for someone to participate. One of many examples can be found in [80], which provides a definition of the constitutional requirements and design principles of e-voting systems. This identified the design principles of generality, freedom, equality, secrecy, directness and democracy as the security and institutional requirements of voting systems. In order to achieve these requirements and minimise the possible threats, example secure voting systems allow minimum user interactions and have limited affordances. They are therefore based on rigorous modelling, which is the first step towards developing encryption-based algorithms to ensure the correct operation of these systems with a high level of trust. It is my contention that this focus on encryption-based security limits the possibility of engaging

people in political participation, which is already bounded by the explicit emphasis primarily on the 'representative democracy' model and the consensual focus that this entails.

Based on our novel conceptual understanding of voting, described in Chapter 2, and the review of related work in a number of fields, from usability and security to trust and HCI (Chapter 3), I propose an extensible design framework that will enable us to instantiate systems that question some of the participatory assumptions and intended outcomes of voting. This framework (see Figure 3 for a graphical account of my envisioned design space of voting, and Table 1 for a more descriptive representation) represents only one way to capture this design space and I hope this will be extended by other researchers. Each one of the design categories in the framework consists of a set of attributes of digital voting systems that can be found today across a broad spectrum of contexts and democratic practices. These design categories are highly informed by previous research in computer security (e.g. see [80]), which I use as starting points to unpick how traditionally assumed design features and affordances can be reconsidered to enable additional means of political participation. I consider the important decisions to be made in the configuration of any vote to be based upon contextual parameters and the design categories of *eligibility*, *fairness*, *secrecy* and the method of *expression* given to voters.

4.2. Context

The context in which polling takes place is one of the most significant determinants of participation. As Figure 1 depicts, the context differs from the rest of the design categories as it relates to parameters external from the actual technology or features of the system. This entails characteristics of the social and physical geography of a community or group, the issues that are topical and able to affect change, ownership of data collection methods and collected data, further use of data for influencing change (and others). As a result, most of the context's features are not open to configuration at the system's level. Nevertheless the deployments of the voting systems I will later introduce in various contexts allow for the exploration of the impact of contextual parameters on participation and thus facilitate our inquiry of designing for political participation.

It is without question that the content of the question asked can significantly affect people's engagement with the polling system. For example, citizen participation in a vote that will result in a substantial socio-political change is expected to be much higher and

more political compared to an opinion collection exercise with no real implications. Even though this is predominantly independent from the affordances of the voting system's technology, design can underline the implications of the vote or provide alternative stimuli for participation – for example participating for social visibility, and for the formation of collectives.

The ownership of the system and the initiator of the voting process are additional contextual parameters able to affect participation. Even though voting is predominately understood as an unbiased process, the neutrality of the involved stakeholders and especially the vote initiators can be questioned. Most voting processes relate to political agendas and as a result the framing of the question and the means of opinion collection might be chosen specifically to affirm these underlined agendas. For some contexts this might be acceptable and in some cases essential, for example petitions and campaign surveys designed to collect only votes that support a particular cause, or at least bias people positively. The implication of this for the design of voting systems for political participation is significant, as a system designed for the materialisation of political engagement should allow everyone with a cause to initiate and own a voting process. As a result, the democratization of various contexts through the application of technology in voting also requires the democratization of voting technology itself.

In particular contexts and socio-political environments, everyday practices and rhythms might require the utilisation of various disparate channels of participation with adequate affordances. An apparent example of this is the recent proposal of implementing multiple channels of participation in national elections (by using remote voting, mobile voting etc. as complementary to traditional polling methods). Preliminary applications of such methods haven't resulted in a significant increase in voter turnout, especially for politically indifferent citizens [8,106]. This might relate to the affordances of the voting systems, as different channels of participation to support different populations might require rethinking how these groups participate. For example some groups might prefer to cast a more deliberative opinion or participate by being involved in the organization of the vote rather than voting themselves. Even though this opens up debates about the fairness of participation and how the various participation methods will be weighted, this multi-channel and multi-method approach of participation might be more appropriate depending on the context.

In later chapters (see 5.1, 6.1, 7.1) I reflect on how some of the contextual factors discussed relate to the case studies and contexts that I have engaged with, which in turn stimulates discussion about the correlation of voting system's affordances with other socio-political parameters.

4.3. Eligibility

Eligibility refers to the qualification of specific groups of people to participate in a voting or decision-making process. By participation, I refer to not only the casting of a ballot, but also the citizen's eligibility and involvement in the political process around the vote: organizing the voting process, participation in the setup of political agendas and alternative options, tallying and tabulation of the results etc. In this section I discuss three aspects of eligibility: who is eligible to participate (suffrage); for how long (closing-poll condition); who decides the alternative options (nomination).

The criteria by which someone is judged eligible or not to participate in a poll are significant determinants of the credibility of a result. In national elections the principle of universal *suffrage* is applied, which with country-specific variations, allows all adult citizens to vote. The choice of who is eligible to vote can significantly impact participation where there is a concern that the voters are not representative of those upon whom the result would have the most impact. Participation can also vary according to context and hierarchy, for example, in a workplace setting where only members of the board of directors might have a say on significant decisions. Digital voting systems can be designed to facilitate this hierarchy or question it.

Nomination refers to the way participants nominate candidate options in a poll. In most Western democracies, voters have no mechanism of adding and managing further options to the ballot slip spontaneously, although they may choose to spoil the ballot paper to register a protest or may be permitted to vote in favour of reopening nominations. Contrastingly, candidate nomination in less significant polling contexts is much more dynamic as candidate options can be added at almost any time. Examples of this include social media polls and doodle scheduling. Allowing the dynamic nomination of alternative options might result in the political engagement of marginalised groups that do not feel represented by the available alternatives. Even so, the mere act of nominating new

options is an act of political participation and as a result such a system extends the channels with which stakeholders can participate.

The *closing poll condition* is traditionally time-based and fixed. In many political elections remote voting, such as voting by mail or in some cases internet voting can extend this polling duration. In other voting contexts an event such as reaching a set number of votes can in itself be used as a termination condition. In general, contextual parameters have a significant impact on when the voting process ends. In the majority of cases the poll organizer is responsible for its termination, however exceptions exist in which termination can also be decided by the participants – for example by using a 'veto vote'. Eligibility also relates to system ownership, access control and systems' permissions that were discussed more thoroughly in the previous section. Who is eligible to perform certain actions, the type of actions and the delegated permissions depend not only on the affordances of the system itself but also on the environment and context.

Whether universal suffrage and open nominations are truly implemented in modern Western democracies under the current socio-political and socioeconomic systems is a matter of debate [126,154]. It is not in the purpose of this thesis to go deeply into philosophical remarks about the interplay between the economic and political systems, nonetheless highlighting the struggle for achieving universal suffrage gives additional weight to exploring how voting systems themselves can be designed to be more politically inclusive.

4.4. Fairness

Considerations of fairness are based upon the perception that those eligible to vote have a proportional impact upon the result. If a voter does not feel their vote is having this impact the imperative to participate will be reduced. This is widely known as a reduction of perceived and actual self-efficacy [16]. Self and collective efficacy have been proved to be important determinants of participation in political contexts [189], with efficacy being defined as the user's or citizen's belief that they are able to effect a change through their actions (in other words participating in the political). We discuss four design parameters relating to fairness: vote weighting and equality; accessibility; 'situatedness'; verifiability.

The one-person one-vote principle is characteristic of modern day political votes in Western societies, yet there are many occasions where it might be inadequate to assign all

votes equal weight. The use of *weighted votes* is common where there exists a hierarchy of stakeholders with different levels of investment in a decision. For instance, voting within the council of the European Union is weighted so that the votes of countries with larger populations are worth more than votes from the smaller countries. At local level weighted voting may be appropriate in communities in which decisions have a proportional impact on various stakeholders. The various rhythms and everyday practices of these disparate groups may require weighting not only by assigning different weights on each vote, but also by the appropriation of a system that will value alternative, more explicit participation methods – e.g. a particular way of traveling in a neighbourhood might imply a preference on a planning proposal.

Accessibility seeks to ensure that eligible voters are able to cast a vote. Methods to maximize accessibility include proxy voting (where a delegated person can vote on the behalf of another person under extenuating circumstances) and remote voting (voting can take place away from a central voting location). Attacks on accessibility, such as voter suppression, attempt to influence a poll result by lowering participation. Typical suppression techniques include making it difficult for voters deemed "undesirable" to exercise their vote, e.g. by introducing specific barriers to registration for voters from certain socio-economic groups. There is an assumption that digital voting technology inherently promotes accessibility to voting material, although in practice it risks disenfranchising members of digitally excluded communities. In the last few years, steps towards designing more inclusive systems have been made, with a lot of work exploring and providing solutions for a variety of issues ranging from usability to accessibility for citizens with special needs and multi-language support.

Remote voting, and more specifically internet voting, is a particularly salient example of using technology to increase turnout as it is generally considered to have the potential to greatly reduce participation costs and increase the reach of the voting process (for a review of remote e-voting see [111]). The impact of remote voting (non-situated and in most cases internet based) on levels of participation is a topic of debate, with studies showing a negative effect due to the loss of rituality and locality [142]. Closely related to the accessibility of the ballot is the actual location of the voting system, with most conventional systems being located in specially designated polling stations to prevent illegal actions such as ballot stuffing and fraud. By the *situatedness* of the voting apparatus I

refer to the location at which the voting system is placed and accessed, and to the socio-political appropriation of the voting system in its respective environment. In a local community or situated group context, the placement of the voting system in the locality is in itself a political action, and as a result it extends the political action repertoire.

Interest in e-voting has led researchers to explore mechanisms to electronically verify the correctness of polls and allow voters to check that their vote was indeed counted, hence *verifiability* (see [80] for security requirements of e-voting systems). In most cases these verification techniques involve the use of mathematically strong proofs to verify the vote outcome. In most conventional voting systems (i.e. paper ballots), and in everyday decision-making, such mechanisms are rarely found, most likely because of the difficulty of performing a wholesale attack and the trust mechanisms that are in place. Instead, conventional voting systems use other socially acceptable mechanisms to verify the correctness of the outcome (e.g. party representatives or random citizens participating in vote counts). It is of particular interest to explore how verifiability is understood locally in everydaylife, and how verifiability is materialised through socio-political processes that are already in place.

4.5. Secrecy

Secrecy refers to the configuration of the system with regard to the transparency or opacity of user actions and produced data. More specifically in this section I discuss the capacities of systems in relation to: the secrecy or publicity of voting results; the configuration of participants' privacy; the system's level of coercion resistance.

Secret ballots are widely used to alleviate social effects (such as peer pressure) and avoid repercussions that may later face voters who have voted in a manner that is unfavourable to some institutions, groups or individual. In politically sensitive votes, secret ballots also have implications for *coercion* resistance; when voters sell their votes, no documents are provided to verify that the vote has been cast a certain way. In other contexts being able to prove the way a vote had been cast may be beneficial in gaining support for future polls, to show interest in a particular topic, or to give the result additional credibility. For example in small decision making panels, the casting of votes by experts about an issue of their expertise, even without having higher numerical value gives the result additional reliability. In local community contexts, the visualisation of some of the voting metadata

such as the ‘election roll’ might increase the social pressure for participation as non-participation might be interpreted as indifference. An online example of this can be found in social media polls, in which participants’ actions are made visible to increase social pressure for participation. Sociological studies have indicated that such social stimuli can positively affect the quality of decisions made [190]. A social media study found that banner messages on a social network site about friends who had voted in government elections drove 340,000 more people to vote [22]. The study highlights the importance of social influence and more specifically close ties, as they exerted about four times more influence than the banner message by itself. The banner messages also influenced political information seeking and political self-expression [22]. Studies like this underline the importance of social influence and political pressure for participation (already known in offline settings) and also open up the discussion of designing online political tools with these socio-political characteristics in the forefront.

Another aspect of secrecy involves features relating to the *publication of interim results* prior to the end of a poll and reviewing these results before voting. Studies have demonstrated [171] that by publishing articles about the strength of leading contenders or opinion polls, a bandwagon effect [130] can be stimulated that leads voters to choose one of the ‘apparent’ winners. Strategic voting by reviewing the interim results before casting a ballot can, under special conditions, increase citizens’ perceived self-efficacy and ultimately reflect on their participation [7,29]. Finally different methods of visualising and making the voting data public can play a pivotal role in the political engagement that the voting process results in. For example, in polls that relate to a geographically bounded community, situating the voting results in place raises visibility about the voting process. It also draws attention to possible subsequent actions which might enable other methods of participation in the political, for example by starting conversations about the matter of concern or by initiating a campaign against the decision.

4.6. Expression

Expression refers to the ways in which voters are permitted to express their preferences or opposition. Even though this is a key element of user interaction with a voting system and an important driver of perceptions of efficacy, only a small number of studies have explored the impact of different forms of expression [158,193]. In this section I discuss

five design aspects of expression: vote delegation (otherwise called liquid democracy); vote revocability (known in representative democracies as 'recall'); type of voting (referring to casting a vote for or against a decision); number of votes per person; argumentation in terms of how deliberative a vote is required to be.

Vote delegation (or vote transferring) is a method of self-expression where participants delegate their votes to a close or weak tie that they perceive as more knowledgeable for the particular decision. In the last few years initiatives such as LiquidFeedback [38] used by the Pirate Party ('Piraten') in Germany and the Five Star Movement in Italy show the potential of vote delegation as an alternative or complement of representative democracy. It is without question that delegation extends the affordances of voting systems and allows politically disenfranchised individuals to participate by delegating their voting power to someone they trust. The further visualisation of the voting power transfers might stimulate additional political debate and as a result serve as another channel of participation in the political. Another relevant expression method is vote *revocability*. Revocable votes have lately been proposed to cope with some of the security concerns of remote internet voting (e.g. voting under the threat of an interested party). As vote revocability allows voters to revisit their choices before the closing of the poll, voting can be transformed to a decision-making process rather than an instantaneous action. This can motivate discussion, argumentation or contestation amongst participants as they explore ways to support or confront the various political projects.

Most of the voting systems today are approval-voting systems (the participants vote for instead of against a candidate option) that may lead to a plurality win or a proportional representation. Alternative options include disapproval voting or ranked voting; indeed, in ancient Greece one of the first forms of voting was disapproval voting - once a year citizens voted to decide who would be exiled for ten years. In technology mediated decision-making systems, negative voting can increase perceived self-efficacy by allowing individuals to demonstrate their objection to (or disagreement with) a candidate option. Indeed, preliminary studies on 'like' and 'dislike' buttons on social media have shown the impact that a negative vote (i.e. dislike) can have on users' further engagement with the matter of debate [73]. Actions such as spoiling votes emerge due to the need for voters to express themselves in a manner the voting system does not afford [139]. In addition to

adding alternative options dynamically, negative voting can open a dialogue of possible alternatives which may even lead to a new nomination phase.

In most decision making contexts the one-person one-vote principle applies, which ensures the equity of the participants. Depending on context, more flexible systems could afford results that better represent the political engagement of the participants. One example can be found in [189], where voting system users suggested that allowing multiple votes per person was an effective way of capturing how strongly individuals felt about a community related issue. Multiple voting, in addition to other suggested interactions such as vote revocation, introduces game mechanics into the voting process (see gamification [48]) and this has been proved to have a positive impact on user engagement with a number of non-game related activities [49].

Finally, whether a poll is designed to allow *argumentation* around the issues of debate and how this argumentation or contestation is made visible is pivotal for the type of participation that the system achieves, from a direct model of democracy to a deliberative and contestational one. For example by requiring a certain level of political debate or contest to be performed before casting a vote, or utilising the political engagement itself as a vote instead of distilling a rich political process to a ballot selection, we achieve a more meaningful political process and more politically challenged feedback.

4.7. Concluding Remarks

In this chapter, I have engaged with a belief that the application of technology in voting gives the opportunity to re-evaluate the design and affordances of voting systems for political engagement and participation, and this has been explored within contextual, socio-political parameters. Taking conventional voting practices as a starting point and pairing these with the conceptual and practical work reported in the previous chapters, I classified the possible affordances of systems in the design categories of eligibility, fairness, secrecy and expression. This provides us with a design ‘toolbox’ that can be used for both the assessment of conventional voting systems and as a repository for the instantiation of novel ones responding to contextual and participatory requirements. This design framework can be instantiated according to the model of democracy and participation that the poll initiator attempts to achieve. For example in a deliberative polling system the focus should be put on enhancing methods of expression and argumentation that will possibly

result in reaching consensus successfully. This ‘toolbox’ can also be used for the assessment of the participatory elements of voting systems: in the same way that the various security models are used to assess the level of security of a voting system, a framework such as the one reported in this chapter can be used for the evaluation of voting participation achieved.

Table 1. Design Framework of Voting for Participation

Design Category	Related Design Decisions
Context	Ownership of the voting system; Context of deployment; Origin of the questions asked; Efficacy of the collected data; Content of the question; Number of stakeholders affected by the decision.
Eligibility	Who is eligible to vote; Who is eligible to nominate alternative options; Who is eligible to initiate the voting process; What is the condition of closing the vote.
Fairness	How much power does each vote carry and power distribution amongst the electorate; Access of the voting apparatus and multiple channels of participation; Physical or virtual setting in which the voting system is situated; Means of verifying the correctness of the tally, the individual votes and the voting system.
Secrecy	Visibility of collected data; Dynamic/real-time publication of interim results; Individual ballot visibility; Measures for voter coercion and vote selling.
Expression	Level of argumentation and deliberation required before the vote; Enabling or disallowing vote revocation; Methods for vote delegation (liquid democracy); Number of votes available per participant and vote distribution; Positive or negative voting.

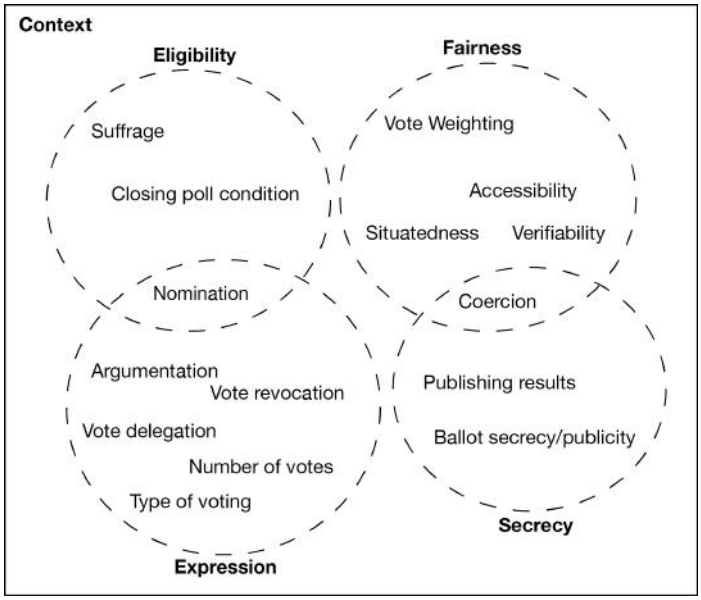


Figure 3. The design space of voting for participation

Although the effect of technology on participation and communication is an area of research well studied in psychology and sociology, the political implications and potentials of the application of technology in voting have yet to be explored. In the next three chapters, I design and develop novel e-voting systems by instantiating this design framework according to contextual factors, to better understand how the capacities of particular systems may support political engagement. By political engagement I refer to the participation of citizens (or users) in a process where different political viewpoints can be confronted. This involves not only casting a vote, but includes engaging in political debates, setting up polls, political canvassing and raising visibility about a poll's results. Consequently, I explore what C. Mouffe refers to as the political in the design of our novel voting systems, rather than the facilitation of doing politics through voting technology. I deploy these voting systems in local and everyday contexts to explore how the political can be extended and harnessed in institutions that are traditionally considered as unrelated to politics [76]: the workplace environment, the home and the local neighbourhood.

In Chapter 5 I introduce BallotShare, an online voting system to be used as a technology probe [95] and designed to act as a configurable voting platform to support different contexts and requirements. Later in the same chapter, BallotShare is instantiated to support the mundane everyday decisions of the workplace environment. In Chapter 6 I describe PosterVote, a situated voting system also serving as a technology probe, configured to

reflect on a different set of design options. PosterVote is deployed in a number of situated contexts, from activism practices in local communities to local city planning and local community regeneration. Finally in Chapter 7, a third voting system called Bullfrog is introduced. It is deployed in local community households whilst being run in parallel with a reconfigured version of BallotShare and PosterVote in the streets of a neighbourhood, providing multiple channels of participation with variant capacities. Through qualitative analysis of the data collected from these contexts, I attempt to better understand how the capacities of the voting systems and contextual parameters enable or hinder citizen engagement in the political.

Chapter 5.

BallotShare: An Exploration of Digital Voting in the Workplace

In this chapter I introduce *BallotShare*[18], an online voting platform designed to enable the exploration of the design framework for participation introduced in the previous chapter. This voting platform allows for the creation of polls with a variety of configurations, which enables us to use it as a technology probe [95] in order to gain a better understanding of how the affordances of a voting system and contextual parameters enable participation. In this chapter, I describe and deploy BallotShare 1.0 (see Figure 4) configured for the particularities of a workplace environment, and aimed at enabling social interactions and discussions in the group. Later in Chapter 7, I describe how BallotShare 2.0 (see Appendix A) with a new interface, comprising additional features that support community pages and an API that enables its use as a backend system (see Appendix G), was used in a community engagement project.

In this case study, as my first exploration of our design framework for participation, I report on a five-week deployment during which I collected 578 user interactions within polls of differing purpose, ranging from organizing periodical social activities to more spontaneous decisions. My findings highlight drivers and limitations of individual and

[18] Published version of this study: Vlachokyriakos, V., Dunphy, P., Taylor, N., Comber, R., & Olivier, P. (2014). *BallotShare: An exploration of the design space for digital voting in the workplace*. Computers in Human Behavior, 41, 433-443.

collective participation grounded in the themes of: social visibility and inclusion; commitment and accountability; influence and privacy.

5.1. Configuring e-Voting for the Workplace

As a first exploration of the proposed design framework, I configured BallotShare to reflect on the decision-making practices of a workplace environment. Our research lab was chosen as a first context of inquiry for a number of reasons: (i) as my first exploration of the design framework, the workplace in which I am situated allows to closely examine the social and political effects of the voting system in the voting system in the workplace; (ii) already being part of the group facilitates a more accurate interpretation of observations as I comprehend the internal power and social dynamics at play; (iii) the workplace is of particular interest in political science literature, with A. Giddens suggesting it as one of the main institutions in which we need to extend the application of politics; other authors (e.g. [146]) note the importance of the workplace for the educational function of participation.

Figure 4. BallotShare 1.0: An open poll showing current results and options

The familiarity of group members in the workplace and their act of gathering together for at least some hours within each workday drove us to configure BallotShare in order to enable social and situated interactions (more details on the method is given in 5.2). Our workplace context in particular consists of a vivid open working space in which group

members regularly have discussions about mostly work related topics. I intended, through the design of BallotShare, to exploit these social and situated characteristics and enable participation in previously non-existent or opaque decision-making processes. Traditionally, most innocuous decisions are openly made by the group, but in most cases are driven by the more senior members. As a result, BallotShare was configured to both support these decision-making practices, but also to provide the affordances for questioning them, aiming to democratize and enable political participation as a result.

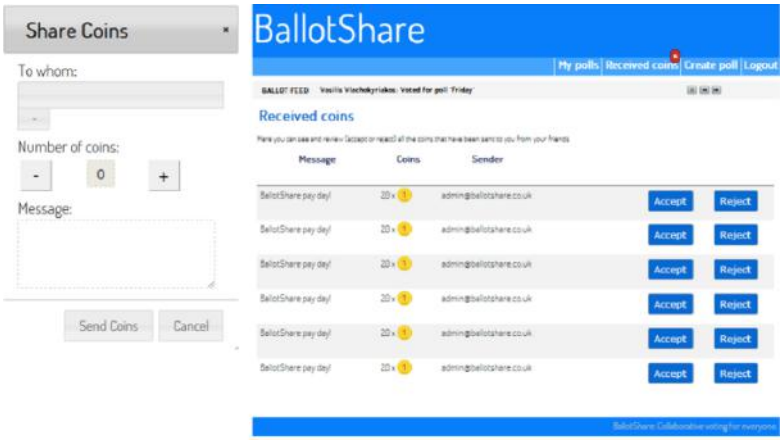


Figure 5. BallotShare 1.0: Interface for vote delegation (sharing coins on the left, accepting & rejecting coins on the right)

A number of features are implemented in acknowledgement of the social and collaborative characteristics of this workplace environment. As Table 2 depicts, I chose to implement design features that allow supplementary interactions and provide the transparency necessary to stimulate situated participation. By publicly showing user actions I intended to provoke social pressure for participation, as even though the content of the vote was private, all other actions and vote timestamps were available to the entire group. Multiple voting, vote delegation and vote revocability were implemented in anticipation of creating a gamification process between group members. I expected the familiarity of the group to facilitate the creation of tactics and open up new spaces of engagement in the workplace. Other implemented features, such as having open and dynamic nominations and negative voting were also implemented in anticipation of increasing self-efficacy.

To support vote delegation, users were provided with a number of tokens that could be used for voting in different polls, where each vote was assigned a particular cost. These tokens could either be distributed evenly or unevenly as desired, to reflect the level of

authority and influence related to the specific context. Users were also able to send tokens to other participants, potentially opening a new space for engagement. Finally, snippets of participants' actions, such as voting, commenting, and revoking were displayed publicly in a list of 'recent activity' to apply social pressure for participation.

Contextual factors such as ownership of a voting system, and the organisation of question and content can play a significant role in how a group participates. In this regard, participants were briefed about the following aspects of the voting project: its duration and the content of the weekly reoccurring polls; the fact that the decisions would not be binding for the group but open to negotiation; the possilibility for them to submit their own polls and questions by contacting one of the project members. The reoccurring questions asked were typically innocuous, relating to actionable decisions that were already common to the group (e.g. weekly social events). It was clear that the seemingly apolitical content of the questions influenced participation; however defining the significance of the questions is problematic as they were widely subjective. Even though political elections are assumed to be of increased importance, the majority of the electorate are unlikely to be more interested in national politics than politics of the everyday life [146]. This also applies to the workplace environment, as one decision may have greater implications for an individual when compared with the rest of the group. As a result, by deploying BallotShare in the workplace environment, I probed the effect of the various systems' capacities on the participation of different stakeholders with diverse investments in the voting process and the decision that it resulted in.

5.2. Deployment

BallotShare was deployed amongst staff and postgraduate students in our research institute, an environment that I could observe closely in order to explore how participants interacted with the system and what social interactions the system provoked. This approach has obvious limitations (see 5.5), however considering the paucity of work in this area I wanted to gain an initial understanding of the design possibilities of digital voting and identify issues that would inform our subsequent case studies.

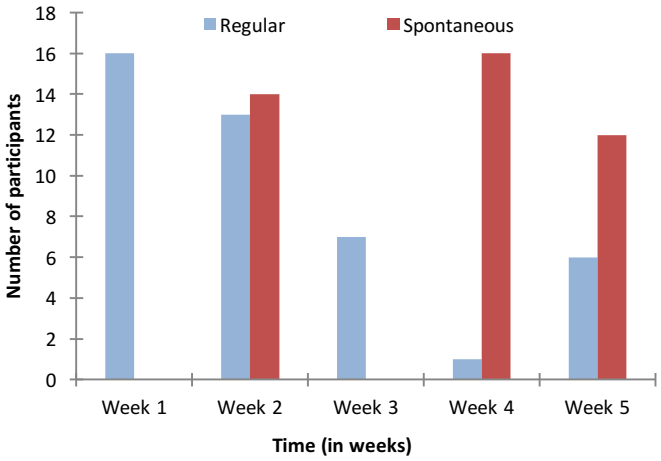
Table 2. BallotShare configuration for a workplace environment: implemented features, reflection of features on design framework, description

Features	Framework	Description
Voting coins	Expression; Fairness; Eligibility	Each user has a number of coins in their virtual wallet, which can be used to vote (negatively or positively) across polls. Each vote cast costs one coin for every user for all the polls of this case study. A fixed number of coins is given to all participants at the beginning of the study which must be managed across the five weeks of the deployment.
Positive voting	Expression	Users can vote positively on the candidate options of each poll. Voting positively increases the total number of votes of the candidate option while decreasing the personal wallet of the user by one coin.
Negative voting	Expression	Users can vote negatively on the candidate options of each poll. Voting negatively reduces the total number of votes of the candidate option while decreasing the personal wallet of the user by one coin.
Vote revocation	Expression	Vote revocation allows users to revoke their vote(s) before the end of the polling period. Voters are also reimbursed the coins that they spent to cast the vote(s). Users after revoking their vote(s) are able to reassign their vote(s) or keep their coins for future polls.
Open nomination	Eligibility; Expression	Users are able to add candidate options to the polls during the polling period. For regular and spontaneous polls users can add additional candidate options.
Intermediate results	Secrecy	The intermediate results are publicly visible and live during the polling period.
Vote delegation	Expression	Users can send coins – and thus delegate their votes – to other participants.
Multiple voting	Fairness; Expression	Users can vote multiple times for a candidate option or multiple candidate options. Users are free to cast as many votes as their coins allow them to.
Public actions	Secrecy	All the above-mentioned actions are visible to all other study participants. An “actions feed” page provides a list of actions of other participants.
Commenting	Expression	Commenting on poll’s pages is enabled.
Situatedness	Fairness; Expression	The system can be used online by using any personal computer or mobile device.

Staff and postgraduate students in our research institute (N=18) used BallotShare to vote on polls ranging from social activities to other spontaneous decisions that were required (eight polls in total). As inventing abstract decisions would add biases, over a period of five weeks five weekly scheduled polls about common social activities were created (e.g. “Choose a place to go out on Friday after work”). In addition three polls were created by request (naming a research project, choosing a colleague’s birthday gift, and deciding the type of cake being made by another colleague). Notification messages were sent to participants via email and an online messaging system, notifying them when they were invited to take part in a poll and reminding them again during the week, as well as shortly before the poll closed.

E-mail invitations were sent to a total of 12 people via a group’s mailing list. The system was introduced as a research prototype to facilitate decision-making in the group. A further six people asked if they could be included after noticing that they were not registered in the system (as their emails were not in the mailing list), leading to a total of 18 participants. From those 18 invitations, 16 of them participated at least once in a poll. The mean participation for the weekly scheduled polls was 8.6, with the highest participation being 16 and the lowest being one. In general, participation in the weekly social activity polls decreased over time (see Figure 6). The mean participation for all polls, including polls created by participants, was 11.

As shown in Figure 6, turnout was relatively high at the beginning of the study. This could be attributed to the novelty of the system. After the first two weeks, participants seemed to disengage from the regular polls. By the third week a decision to take part was not being made by some participants and active participants dropped from 16 to seven. By the fourth week participation was even lower with just one active participant. By comparison, participation in the spontaneous polls remained high (14, 16 and 12 active participants), even when being run in parallel with the less popular social activity polls.



	Week 1		Week 2		Week 3		Week 4		Week 5	
Poll type (Regular, Spontaneous)	R	S	R	S	R	S	R	S	R	S
Num. of participants	16	N/A	13	14	7	N/A	1	16	6	12

Figure 6. Active participants for regular (weekly) and spontaneous (by request) polls.

Even though the system could be used remotely, the gathering together of participants in the working environment appeared to be the main stimulus for participants to visit the website. Usage logs show that the participants used the system only during office hours and the majority of activity occurred within two hours after the invitation had been sent. The duration of the poll did not affect participation. Users tended to vote shortly after the creation of the polls and then reconsidered their vote shortly before voting closed. Other than voting, the most popular features of the system were vote revocation, negative voting and adding alternative options. Commenting on polls and vote delegation were less popular than expected (see Table 3).

5.3. Findings

In order to gain greater insight into behaviours and attitudes regarding the system, I distributed questionnaires to all users regarding usability, features and engagement with the polls. I received 13 responses to this questionnaire. This was followed by 10 semi-structured interviews, each lasting approximately 30 minutes to one hour in order to gain a richer understanding of user engagement with the voting process.

To analyse the interview data I carried out a hybrid thematic analysis [65]. Hybrid thematic analysis incorporates theoretical deductive analysis with an inductive coding process to refine codes and themes. Core psychological theories which underpin decision-making (such as self-efficacy and collective efficacy) and aspects closely related to voting (such as privacy) were identified as the initial coding themes. A thematic analysis was then applied to the collected data taking into consideration these predefined theoretical concepts.

Table 3. Usage of BallotShare's features.

Usage of features (%)	**Regular**	**Regular**	**Spontaneous**	**Regular**	**Regular**	**Spontaneous**	**Regular**	**Spontaneous**	**Total (%)**
Votes cast (negative & positive)	77 (45)	46 (74)	85 (77)	24 (80)	8 (88)	68 (94)	34 (93)	74 (86)	**416 (72)**
Vote revocation	62 (36)	13 (21)	10 (9)	4 (14)	1 (12)	4 (5)	2 (6)	7 (8)	**103 (18)**
Comments	17 (10)	1 (1)	12 (11)	0 (0)	0 (0)	0 (0)	0 (0)	3 (4)	**33 (6)**
Vote delegation	7 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	**8 (1)**
Added candidate options	9 (5)	2 (4)	3 (3)	2 (6)	0 (0)	1 (1)	1 (1)	1 (1)	**19 (3)**
Total	**172**	**62**	**110**	**30**	**9**	**73**	**36**	**86**	

When asked whether they felt that their votes mattered in the decisions, 62% of participants agreed or strongly agreed, with 23% being neutral and 15% disagreeing. Participants were also asked to what extent they agreed that their votes changed the outcome of the poll, with the majority of responses following the same pattern (54% agreed or strongly agreed, 31% were neutral and 15% disagreed). Thus participants felt both the value and influence of their actions. However, when asked whether they felt that decisions they had made were affected by the system, participants' responses were more evenly distributed between 'agree' and 'disagree' (30% agreed, 38% were neutral and 23% disagreed). There appeared to be a higher level of self-efficacy (i.e. the perceived ability of

an individual to succeed in their goals [16]), with lower levels of collective efficacy being noted (i.e. the belief that users are able to effect a change through their actions as a group [29]).

In this section, I explore the discrepancy between individual and collective efficacy through the thematic analysis of our interview data. Based on this analysis, I identify significant drivers and limitations of individual and collective participation in the voting process. All names used in the results are aliases.

5.3.1 Social Visibility and Inclusion

The design of BallotShare promotes the visibility of voting actions. However, more than this, the presence of the system within the voting context reinforces the decision-making process. Consequently, a reciprocal relationship exists between BallotShare and the social context. As Jack comments: *"a lot of the times that I went and voted was because I had a conversation with someone* [in the lab]*"*.

The visibility of the actions conducted on BallotShare and the possibility of revisiting votes and monitoring the voting process drove engagement. For one participant the ability to observe others fostered participation: *"when I heard about it* [a poll] *I was like, I have to get into this vote, to have a look of how is going see what people are voted so far"* George [M, 23]. The opportunity to observe the polling process also drove those who would not directly benefit from the decision. Participants who were not motivated to vote enjoyed monitoring the results: *"I may not go to the pub certain weeks* […] *although I wasn't voting I would check who is winning* […] *I found that interesting"* [Jack, M, 30].

Social interaction during working hours was widely cited as a stimulus of participation, with quantitative data indicating that the majority of the activity (with just two exceptions) occurred during working hours. One participant suggested that this happened because of *"conversation(s) that I had with people about things that we are voting on, inspired me to look at the website and then mess around and fiddle with the vote* […] *I guess being around the people that are involved in the decision makes a big difference on how you engage with it and when"*.

Operating within a social context, BallotShare was seen as a way of empowering group members, especially those new to the group, to voice their opinions about certain topics. For example James, a relatively new member of the group, stated:

> *"I think it's a nice way for people voicing their opinions, especially for people that are quite new* […] *nicer than necessarily voicing out to the group"*.

The potential for the system to support social inclusion, however, also contributed to social exclusion. In addition to the empowerment of new group members, a contrasting feeling of disempowerment was observed for group members who had normally had a say about social activities but had not initially been invited to use the system. Sophia commented:

> *"I wasn't one of the people invited and* […] *I was like, I want to be involved* […] *I felt left out and I wanted to be involved so I asked for an account"*.

In this regard, BallotShare could be viewed as having the potential to destabilize existing social hierarchies. Another new member suggested that although social activities *"might usually be decided by a few* […] *by having this polling system* […] *it gives more opportunity for other people have a say for a new* [activity]*"*. However, some participants reported that they did not believe the polls were effective. As Jack clearly identified: "[…] *people were saying we will not go to the place that wins anyway"*.

5.3.2 Commitment and Accountability

Participants regularly cited a reduced sense of efficacy as one of the main reasons for their decreased participation in the recurring social activity polls. At times polls were completed with uncertainty about whether the outcomes would be followed: *"the Friday one* [reoccurring poll] *was a bit annoying in a way, because we made these votes without knowing if we will actually go"* Jack, M, 30.

Furthermore, Dennis believed that the dynamics of the group did not allow the decisions to be implemented. For him, a leading voice that could enforce the implementation of decisions and drive action, was required: "*we need a leading voice* […] *I don't remember if somebody looked at the poll when we went on a Friday"*.

Aspects of the system that allowed game mechanics to be introduced in the voting process were appreciated but seen with scepticism if more politically charged questions were asked. When commenting on limitations of the polls, Albert reported: *"I think negative voting is a bad thing* [in more important decisions], *but I think more important than that is your vote has to be definitive"*.

Features of the poll might have contributed to the lack of finalized votes. Multiple voting led participants to question the fairness of the final decision with one participant noting that: *"when I see a lot of votes for one option I don't know if a lot of people voted for that or it was just one person who thinks that this is a very good option"*. Although the system is capable of revealing individual user actions, the final poll does not map the total tallies to particular demographics. As a result, the final decision is not attributable to due process. This due process was also understood to necessitate open discussion. Some participants viewed BallotShare as opening up discussion*: "it* [BallotShare] *is a process and voting - usually at least in my head - isn't a process* [it] *is something I do once"*.

Feelings of dishonesty kept some of the users from employing BallotShare's features to influence decisions. However these feelings would probably be diminished if the actions were completely private. James stated: *"having it more anonymous would probably tempt me even more and be more inclined to* […] *put coins to different things, rearrange stuff"*. In addition, Alexia believed that *"if it was more anonymous people would be more adventurous with it"* even though *"in this circumstance nobody would be embarrassed to put anything in because we know each other"*.

Whilst discussing one of his tactics to save votes for later decisions, one participant suggested: *"I seemed to have an unfair advantage. I think I would prefer if I had certain amount of coins for each poll. I think the equality aspect appeals to me more"*.

After saving some votes from previous polls, participants felt that they had the voting power to skew the final result (even though they chose not to). This contradicts previous findings and literature regarding the negative impact that low self-efficacy of participants can have on participation. It seems that increasing self-efficacy is fundamental when attempting to encourage participation, but simultaneously an opposite effect might be possible if some individuals are given too much power to influence the final decision.

5.3.3 Contextual Privacy and Exerting Influence

Participants had diverse opinions about the privacy of the system, with 46% disagreeing or strongly disagreeing that the system was private, 31% agreeing or strongly agreeing, and the final 23% being neutral. Although on questionnaires participants tended to agree that the system violated the privacy of individuals (because most of the users' actions

were publicly displayed and the content of someone's vote could be disclosed by combining actions of users and preliminary results), this point of view was not reported in the interviews.

According to the data, participants did not feel their privacy had been violated. However, participants cited a correlation of privacy with the context and content of the vote. These observations can be summarized in Jack's comment:

> *"I didn't really have a problem, I knew that someone could figure out by seeing the ridiculous amount of votes I put in one go sometimes but I didn't really feel any privacy concerns; that might be different if the votes were a lot more sensitive or they had wider implications"*.

Most of the participants agreed that the context of the polls and the social dynamics of the group were tightly related to the appropriation of measures to ensure privacy. There was a feeling that even for more important decisions, familiarity of participants in the group would make strict privacy measures somewhat unnecessary—as situated discussions about the issues at stake would reveal individual preferences. For example, when asked about possible privacy issues, Albert said: *"because we know each other that's not an issue* […] *even for more important decisions"*.

The lack of features to ensure the privacy of the participants and the secrecy of the actions on the platform led to the social manipulation of the poll. In most cases participants tried to influence others by using multiple voting and resetting which in combination with the visible actions and live results allowed voting strategies to emerge. For example, Jack explained how he used multiple voting and vote revocations to influence others and save votes for other polls:

> *"I was introducing new options to the poll and voting heavily for them and waiting to see if someone would actually go with it* […] *I was just thinking if whatever it is that I am voting for has a chance to win* […] *another thing I did one time was just before the vote got sealed I reset my votes and just added back the least amount needed to make it win"*.

Being able to see the results before the end of the poll generally influenced participants to vote tactically, for example, by taking back votes that would not influence the final result or redistributing votes in order to have an effect. It was common for votes to be

distributed evenly amongst options throughout the voting period only to be revoked before its end.

Many features of BallotShare promoted tactical voting and participants used various strategies to change the outcome of the polls, including coalitions with other participants and attempts to influence others through voting and commenting. Coalitions were the less common tactic and took place either through agreements to vote for the same options or attempts to convince participants to send their votes to others. One of the participants reported that another voter *"emailed me saying 'I really want to go to this pub can you send me your votes', so it was like an insider externalized trading"*.

Although users enjoyed voting tactically, they were reticent about applying these strategies to more important voting contexts and more political polls. For example, Albert mentioned: *"it depends what the vote is for. If it's something that as a group we want to agree on, seeing the results and being able to negate votes is useful but if it is something you want to know the individuals opinion then it won't be so useful"*. In addition, Jack, who was one of the most 'strategic players' of the game, said: *"I wouldn't do the same* [for a more politically important poll] *because it has a different kind of consequence"*.

Although during the interviews most of the participants mentioned issues that would probably arise in more political contexts, when asked how much they agreed that the system could be used for more important decisions 69% "agreed" or "strongly agreed", with only 14% disagreeing.

5.4. Reflection on Design Framework

In this case study the exploration of the proposed design framework was initiated by carefully configuring an online voting system for the contextual particularities of a workplace environment. A number of features were implemented in anticipation of expanding the methods and affordances for participation. BallotShare allowed participants to complete the following actions: revoke their votes; vote multiple times both positively and negatively; add candidate options dynamically; delegate votes to other members of the group; check intermediate results and the actions of other participants.

As anticipated, contextual parameters also played a significant role in the engagement of participants with the voting process, with the type of questions asked having the most

significant influence. No senior members of the group were involved in running the voting system. Also, allowing our participants to ask their own questions reduced the polls' efficacy, as some decisions could not be implemented. Finally, all our findings underline the importance of the joint gathering of our participants in the same open working environment, since the system was only used during working hours (even though it could have been accessed at any time. This suggests that a situated device to support and make the online activity visible in place might be appropriate. In the remainder of this section I reflect on how the findings relate to the design categories of eligibility, fairness, secrecy and expression discussed in Chapter 4.

5.4.1 Eligibility

Within the whole workplace group a small number of users initially raised objections, as they felt socially excluded from the decisions being made. The initial allocation of voting power to a random set of people (by using a mailing list) and the discussions that followed in the workplace revealed hierarchical structures that were not visible. Since the system was not designed to explicitly support hierarchy – every participant had the same number of coins to use across the polls – decisions were not followed by the subgroup, either because the subgroup members opposed those decisions or because of a reduction of their decision-making power.

In contrast, new members of the research lab perceived the system as a socially non-invasive way to have their opinions assimilated into the group and were more active in the decision-making and subsequently the social activities. Thus the democratic and non-hierarchical configuration of the voting system served to further democratize the context in which it was applied. Even though I acknowledge that in some contexts poll organizers might require the hierarchical structures to be reflected in the voting system (e.g. share-holder voting), in other contexts such horizontal and bottom-up configurations can be used to question hierarchical structures and power relations (e.g. activism in local communities). Thus, configuration of voting systems for participation is not only dependent on context but also on its governance and ownership. Future work is needed to further explore the impact that specially configured voting systems can have on hierarchical structures within an organization.

The closing poll condition, which in this case was time based, didn't have any impact on participation as nearly all the activity happened during working hours where the participants were gathered.

5.4.2 Fairness

The ability to own and cast multiple votes both positively and negatively, in combination with the publicity of the results during the voting period, resulted in undermining the perceived fairness of the system for participants that were directly affected by the outcome of a poll. Even though multiple and negative voting increased the levels of perceived self-efficacy, our findings suggest that if the voting system provides too much power over the final decision, participation is negatively impacted. This is due to the perception that an individual might be able to use their power to undermine the result. In the case of more important spontaneous decisions that were polled, a conventional configuration (one vote per person) was perceived as more appropriate. A better configuration for future deployments would be to impose an 'upper custom barrier'on the number of votes that a user may cast per poll. This could be configured to either one vote per person for more important decisions, or multiple votes per person for a more interactive voting process.

Finally, even though encryption-based verifiability might be necessary for critical decisions and contexts (e.g. national elections), in the case of BallotShare (due to the publicity of the actions, intermediate results and close grouping of participants), unscrupulous acts become quickly visible to the group and therefore appear less likely. Consequently, the social context in combination with the transparency of the system and data, allowed for alternative social verification methods to arise. Even so, the visibility of some more sensitive actions such as vote delegation was cited as less appropriate.

5.4.3 Secrecy

Intermediate results affected perceptions of the fairness of the voting process. In combination with other characteristics such as vote revocation and offline discussions, the publication of intermediate results contributed to voting being perceived as a political process rather than an instantaneous act. Privacy concerns were not prominent in the study, even though users' actions were visible. Clearly such concerns are contingent upon the context and familiarity of the group members. Overall, inconsistent attitudes towards

privacy were uncovered, with more senior members claiming that the partial violation of privacy was an engaging factor, while more recently affiliated members saying that total anonymity would have been more appropriate. These findings reflect on the power structures within the group and further support the notion that the application of specially designed technology results in the further democratization of its context. Further research is required to understand how manipulation of the design might provide privacy in the poll (according to the context's hierarchy) and could support participation.

5.4.4 Expression

Multiple voting and voting both positively and negatively was widely used and was one of the most important determinants of an increased self-efficacy. As mentioned earlier, putting an upper limit on the number of vote casts per poll and per voter would have contributed in increasing the perceived fairness of the system. Voting against candidate options was used for tactical reasons (i.e. lowering an opposing candidate's total) or for publicly showing dissent from the rest of the group. Consequently, negative voting is particularly relevant for contestation when designing voting systems as it materialises dissent while contributing towards achieving a decision. Even though negative voting was one of the successful features of the system and made the voting process more politically engaging, the cost associated with voting (the coins spent per vote cast) contributed to limiting the number of negative votes cast. A better configuration could be to reduce the 'cost' of negative voting or use alternative 'voting currencies' for negation. Dynamically adding new nominations was used less than expected but when used had a significant affect over the outcome of the poll. Finally it is apparent that the use of open nominations is contingent upon the type of question being asked.

Some qualities of BallotShare, such as commenting and vote delegation, were included with the intention of motivating discussions online, but failed to support this process. The interviews highlighted the need for better supporting online argumentation, even though the collective gathering of participants in the same workplace setting motivated offline discussions. In future work, a more adequate online commenting and argumentation system should be considered that allows the various viewpoints to be stated and challenged. However, such a system should be designed to complement rather than replace offline discussions. Combining unlimited vote casts with equal distribution of coins made vote delegation irrelevant and as a result it was not used as much as expected. Introducing

user-specific upper limits in multiple voting and explicitly requesting coins from poll participants might be more pertinent in vote delegation systems.

Vote revocation in combination with offline discussions enabled participants to engage in a political process, as conversations led people to revisit the polls, revoke their votes and recast them accordingly. Some participants noted that the high number of vote revocations that occurred per poll diminished the purpose of visible preliminary results as the results were shifting regularly. Adding a cost to vote revocations (i.e. withholding a percentage of the coins instead of giving the full amount of cast votes back) could limit the number of revocations thus contributing in more balanced voting results.

I perceive that a number of expression features contributed to creating the experience that voting was a political process, thus participants were involved in a more meaningful politically engaging democratic process rather than in instantaneous voting action.

5.5. Limitations

This first case study serves as a first instantiation of the design framework proposed in Chapter 4 and the results are context specific. The configuration of the voting system reflects the particularities of the workplace environment that the system was deployed into and as a result this configuration is not generalizable to any other contexts. Nonetheless, some of the gained design framework's understandings can be applied in similar social and situated decision-making contexts.

Selecting my current research lab as the context of this initial case study carries obvious limitations and introduces biases in the data collected. Taking into account that the case study reported here serves as a preliminary exploration of the design framework, I believe that this was a methodologically valid decision as it allowed for the close observation of the effects of the technology probe on the decision making context and informed the later redevelopment of BallotShare for larger scale and less controlled contexts.

5.6. Conclusion

Digital technologies are currently not fulfilling their potential to engage political participation. In this chapter, after designing and developing a voting system that acts as a technology probe to explore the affordances and contextual parameters affecting 'the political' in voting, I instantiated it to reflect on the physiognomies of a workplace

environment. After five weeks of deployment, I uncovered several aspects in its configuration that supported participation. I considered how multiple voting, voting negatively, and vote revocation supported the expression of the participants and allowed voting to be perceived as more of a political process than a transient action. Publicity of actions and intermediate results motivated discussion, supported by the collaboration of participants within an open workplace environment.

After highlighting the importance of the situatedness for participation, in the next chapter I introduce a novel situated voting device, designed to support the collection of local opinions. Later, in Chapter 7, I re-instantiate BallotShare in a community engagement context, where it serves as the online platform supporting a number of situated and online channels of voting participation.

Chapter 6.

PosterVote: Situated Digital Polling for Community Activism

One pivotal characteristic of the design of any voting system and one of the main arguments for the introduction of technology in voting is its 'situatedness', i.e. whether the voters need to be physically present at a designated polling place to vote or the voting apparatus can be accessed remotely. In the previous case study the exploratory voting system deployed in the research lab had no physical presence in the working environment. However, as indicated by the interviews, the physical gathering of participants, the relevance of the decisions to the context and the presence of some of the authors in the working environment, played an important role in raising awareness about the existence of such a voting system and in motivating people to participate. Consequently, extrinsic motivational factors played a significant role in why and how participants performed certain actions. In other contexts, some of these contextual parameters might not be present and as a result other means of raising awareness and motivating participation would need to be put in place.

In this chapter, I introduce the design concept and development of PosterVote[19], a new instantiation of the design space of voting for participation, which allows the situated

[19] Published version of the design concept and case study: Vlachokyriakos, V., Comber, R., Ladha, K., Taylor, N., Dunphy, P., McCorry, P., & Olivier, P. (2014, June). *PosterVote: expanding the action repertoire for local political activism*. In Proceedings of the 2014 conference on Designing Interactive Systems (pp. 795-804). ACM.

collection of local community opinions. Instead of taking a conventional hierarchical and top-down approach to designing for planning (as in city council consultations and conventional situated e-voting methods discussed in 3.3), I design situated voting technology able to expand the action repertoire of local communities and create radically new forms of bottom-up political participation. This involves reflecting on the sustainability of voting devices as well as their capacity to be deployed in diverse localities.

6.1. Configuring e-Voting for Community Activism

In this second case study I designed and developed a situated voting system to reflect on the needs of local community opinion polling. Instead of taking a conventional approach to community e-voting, which assumes the involvement of a third party to sustain the devices in the community, I endeavoured to create a design concept that can be integrated with local community practices and run by local activists themselves. I contend that the community activism context is appropriate for the second case study for a number of reasons: (i) it complements the voting prototype described in Chapter 5 as it relates with situated technology for opinion collection able to run in parallel with online systems; (ii) by designing e-voting for community activists, I reflect on the difficulties introduced when shifting the ownership model of voting from local councils and organizations to individuals; (iii) I bypass biases introduced when the voting system and questions are managed by the research team; (iv) it allows for the exploration of the effect of perceived data efficacy on participating in the political as data collected by individuals will most possibly serve for campaigning purposes rather than consensual decisions; (v) it enables contemplation of the use of voting for engaging local communities in the political, contrasting traditional applications of voting that only serve to manage local politics.

Online and digital technologies support and extend the action repertoires of local social activist movements [129], including extending the reach and awareness of the local context to the global scale. For years activists and campaigners use door-to-door surveying to collect data and apply pressure on councils and local governments. Tools such as online surveys, online petition websites, SMS voting etc. are added to the action repertoire of activists. Even though the cost of managing and initiating a campaign online is significantly lower, additional barriers of participation are added (digital divide, accessibility etc.). More specifically, even though the Internet allows for broadcasting local political

debates, it also disconnects activists from their locale and attracts a more viewpoint-oriented sample compared with face-to-face surveys [58]. Even though research in developing voting systems for consultation in a top-down approach is extensive, the development of sustainable, low cost systems for the collection of opinions and raising awareness is widely underexplored.

The application of technology in local communities for establishing additional channels of communication between local councils and citizens has become common in the last few decades in local consultation and HCI. Example systems include situated displays [131,149,160,170], tablets [189], media façades [18] and others (see 3.3 for a more thorough review). These developments have been driven both by advancements in computing, and by the increasing gap between citizens and their representatives. For example, with Viewpoint, Taylor et al. [189] found that the deployment of situated voting technologies was capable of collecting large quantities of feedback, but struggled to address the low sense of efficacy in the community. As questions posted on the device were determined by representatives from local government and other organizations, there was no provision for members of the community to drive the agenda themselves. In this regard, it can be argued that the deployed system ultimately acted as a data collection tool in a top-down consultation process. What the system did not take into account was the need for the community itself to push topics that mattered to them.

Whilst deployed voting devices are simple and mostly easy to use by citizens, effort is required from researchers to build and maintain them. Most activists do not have access to these resources, making it more difficult for them to use instead of traditional survey methods. Expertise required for the correct operation of systems affects their ownership and this can be a detrimental factor for the pursuit of the democratization of technology. Cheaply available tools—such as online surveys, SMS voting etc.—can have limited local reach and only attract a small number of responses compared to situated devices.

Conventional situated voting devices and their aforementioned associated cost and maintainance does not facilitate their deployment in non-controlled environments. In some cases, the opinions that an activist needs to collect are dependent on a situated area in a community, which might be located in a non-supervised environment. The mere presence of an activist action in the location with which it is attributed, increases the credibility of the act. For example, one of the uses of graffiti is to support local activism as in most

cases it refers to the area in which it is situated. Moreover, it is common for activists to collect opinions in-situ by using conventional surveys and to promote social action by distributing leaflets and putting up posters. These conventional practices have to be considered and inform the design of technology to support action. The simplicity and sustainability of such conventional activism methods makes them resilient and effective over time.

Another prerequisite for activism is supporting diverse viewpoints of stakeholders. Whilst a goal is to provide those who are politically active with the ability to drive the political agenda, stakeholders with different views might want to collect their own data (e.g. if they are in opposition to those conducting the polls) or verify the data being collected. In agonistic contexts verifiability and integrity of the voting system are necessary for the reliability of the data being collected. Opening up the ownership of such tools for action may entail putting security measures in place to prevent anybody from jeopardising the voting process.

Table 4 depicts how this discussion on the requirements of voting for local, situated political participation is materialised with the design of PosterVote, and how PosterVote's features reflect on the design framework.

Table 4. PosterVote features and reflection on design framework

Features	Framework	Description
Explicit closing poll condition	Eligibility	The polls are explicitly closed (by design) when the poll organiser collects the devices from their locations.
Explicit electoral roll	Eligibility	Participants eligible to participate are set by the physical access to the locations were the posters are located.
Situated arguments	Expression	Argumentation is feasible by both placing contradicting voting systems (posters) up and by discussing the polled issues in place.
Positive voting	Expression	Each button press on the device is translated to a positive vote for the equivalent candidate option.

Open nomination	Eligibility; Expression	Nominations are open as everyone with a cause can create their own voting systems (in this case voting posters), with their own alternative options.
Hidden intermediate results	Secrecy	Even though a vote download feature is incorporated in the voting system, the poll result is hidden to the voter.
Multiple voting	Fairness; Expression	Each voter can press as many buttons they like and as many times as they like so multiple voting is possible (and invited).
Public actions	Secrecy	Voters do not need to register before voting, however placing the posters in socially visible locations makes casting a vote public.
Situated devices	Fairness	Connecting the data collection process with their locale by placing the devices in any supervised or non-supervised environment.
Situated devices	Fairness	More accessible voting systems by placing them in the context of interest; technical expertise is lowered to the minimum to enable someone to participate and run their own poll.
Multiple poll (poster) initiators	Expression	Any community member can initiate their own poll by making their own voting system (poster).
Social verifiability	Secrecy	The integrity of the collected data can be (anecdotally and not mathematically) verified by multiple uploads of the results by multiple participants. The integrity of each voting device and the results can be questioned by placing alternative devices (posters) at the same location.

6.2. PosterVote: Design Rationale and Technology

PosterVote, in this line of research, serves as a methodological artefact that allows the exploration of situated voting for political participation. Nonetheless, I contend that its design concept can also be used in practice to expand the political action repertoire of local community activists. PosterVote is the incorporation of conventional posters with low-tech hardware to allow the collection of opinions that can serve as evidence to apply

pressure on local authorities. It is an artefact that enables sustainable electronic voting by dropping the development and maintenance costs (to approximately £3-£5 per piece), whilst increasing the potential for social movements to engage in action.

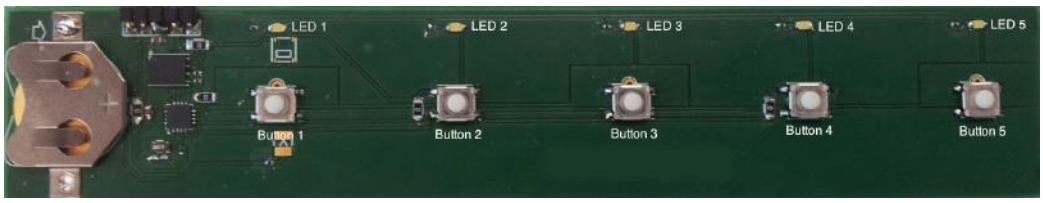


Figure 7. First exploratory prototype of PosterVote: PCB with five buttons, five white LEDs, a metallic battery holder, a memory and a microprocessor

PosterVote consists of two parts: a conventional paper poster to be put on walls and lamp-posts, and a piece of lightweight hardware. The hardware device is attached to a paper poster, creating an augmented tool for dissemination and feedback of political discourse. Throughout the course of this PhD research, three hardware versions of PosterVote were designed and developed[20]; Figure 7 depicts the first exploratory version of the device, while Figure 8 and Figure 10, versions 1.0 and 2.0 respectively. All hardware versions consist of: five buttons, five white LEDs, a microprocessor (PIC16F1824), two separate non-volatile memories (internal and external EEPROM) and a battery holder. When a button is pressed one vote is registered and stored, and the corresponding LED is turned on to indicate the button pressed and the recording of the vote. Hardware specifications change only slightly with different PosterVote versions with the main differences being the flexible circuit board used after the first exploratory prototype. This creates a much thinner poster profile which allows laminating the device with paper posters. The addition of a piezo speaker in version 2.0 enables the audio download of the votes.

One of our main design goals was to maintain the sustainability of the voting devices, which entails the development of innovative ways of downloading the data from the devices without the need of special technical skills. In version 1.0, I utilised the LEDs as a sustainable method to calculate the device tallies without the need of wired or wireless connectivity. Pressing a specific combination of keys causes the LEDs to transmit the

[20] The hardware design and firmware development of the devices was implemented by Dr. K. Ladha and Dr. D. Jackson from Open Lab, Newcastle University.

results by flashing a series of on-off tones. This can be captured by a phone's video camera and analysed either on the spot by using the phone's processor or on a server by uploading the video footage. The footage is processed by identifying the on/off states of the LEDs and by decoding the captured digital signal. Finally, the footage is converted to the results of a specific poll and sent either back to the device or uploaded to a result's website. The submitted footage may also serve as visual proof of the data's origins and the filming of the surroundings may increase confidence about legitimacy. Even though an algorithm was developed that calculates device tallies from the on/off states of the LEDs, the algorithm had varying success rates depending on environmental and brightness conditions. As a result, in version 2.0 an audio module was included on the circuit board (adding an extra £0.50 cost to each device), which enabled the audio download of the data. Individuals can use any phone to call a number, while pressing a combination of buttons on the voting device that enables the device to transmit the data via an audio encoded message engineered to pass over the GSM networks of mobile phones. An SMS message is sent to the user as a result, containing the number of votes per option and the content of the vote if this information is registered with the device's harware ID.

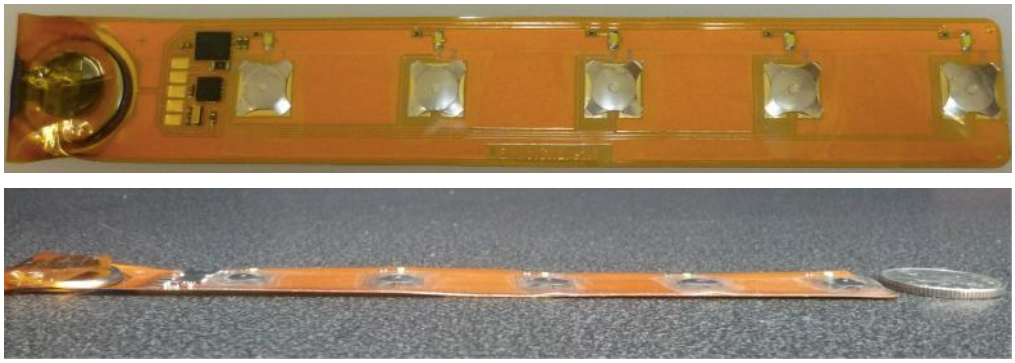


Figure 8. PosterVote 1.0: Flexible hardware to be placed at the back of each poster (the five buttons and the LEDs on top).

Although individuals can create their own custom-made paper posters to attach the devices on, an online website was developed that allows the creation of specially designed posters with visual elements corresponding to device dimensions and information about the system's use. Figure 9 shows website's version 1.0 (which corresponds to hardware's version 1.0) with visual elements to facilitate the detection of the LEDs by the vision algorithm, while Figure 11 shows version 2.0, including information about the number that the user needs to call and visual elements for the correct positioning of the phone

next to the poster. Version 2.0 of the website also enables the registration of a hardware device ID with a particular question. A five digit code is generated when the user prints a poster through the website that can be used for registering the printed poster with a device ID. This results in having tailored messages sent to users after the data download.

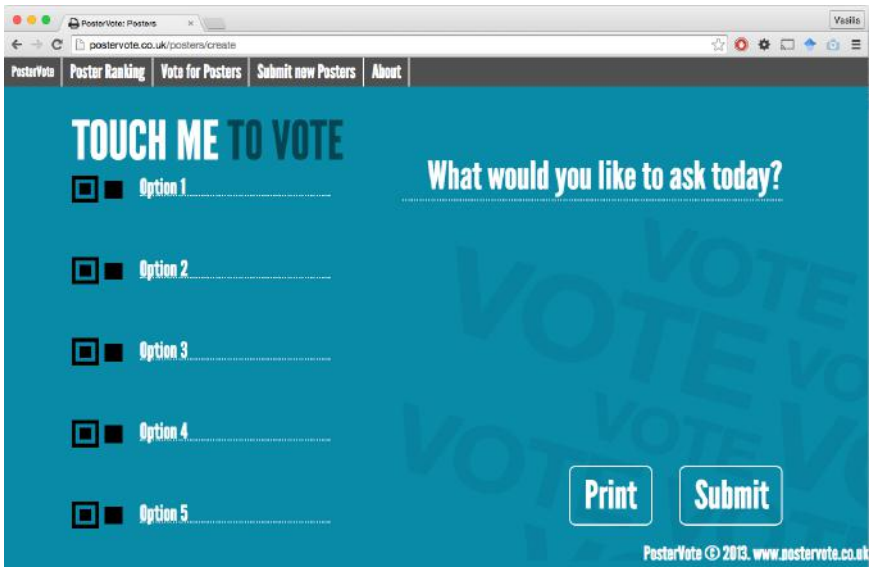


Figure 9. PosterVote 1.0 website that allows the creation of .pdf posters with visual elements for enabling the vision algorithm to detect the visual pattern with which the data is transmitted.

The two methods of collecting the votes (visual and audio download) are designed to be sustainable by lowering the cost of deployment and requiring the active involvement of the community. Even though it is not compulsory, residents of a community can be involved in either the initialization of a campaign or the collection of the data from the posters. Politically apathetic residents of a community can participate by simply voting whereas more active residents can be involved in setting agendas and collecting and uploading the results. Consequently this design concept allows for the creation of a participatory ladder with different levels of investment. Uploading the results on the server (every time a community member calls or uploads video footage) allows the creation of an online space where further political engagement can occur, for example by sharing the voting results online, sharing voting metadata, or debating about the legitimacy of results.

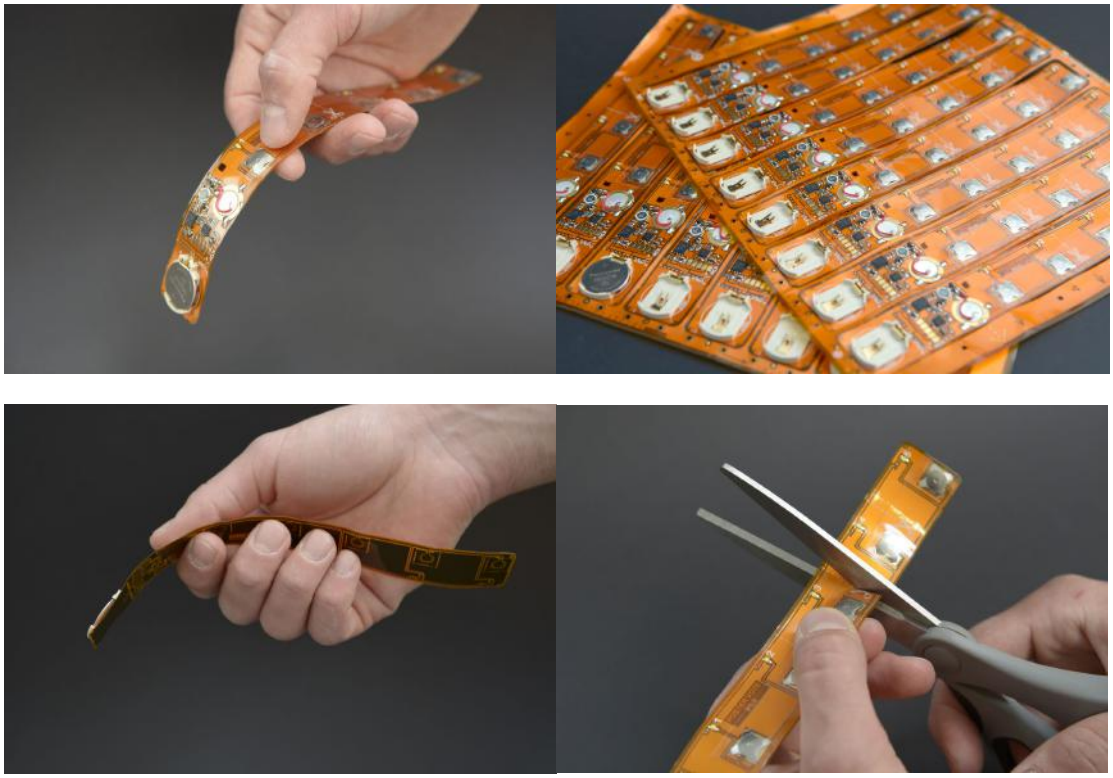


Figure 10. PosterVote 2.0: Top left: Flexibility and audio module on the circuit board; Top right: wholesale production of voting devices at low cost; Bottom left: low profile of devices and flexibility; Bottom right: flexibility of the circuit board and hardware design allowing for unnecessary buttons to be cut off

The use of the voting posters by activist groups supports the questioning of existing power hierarchies in a community by collecting supplementary evidence about an issue, or by opening up the agenda of community issues to less engaged citizens. The design of the technology allows and motivates participation of the wider public regardless of their digital literacy. In other words, PosterVote can be adopted by any typical or non-typical socio-political movement and appropriated into conventional and unconventional social and political action.

The location in which the posters are placed enables both the configuration of participation levels and the collections of information about who is participating. As a result, by placing multiple electronic posters in strategic locations an interested party can collect the opinions of specific citizen groups and gain a deeper understanding of the needs of the community. The use of its simple interfaces drops the costs of participation for less computer literate and digitally excluded groups, something that is not readily achievable by electronic means of voting or surveying. Many large-scale collaborative projects depend upon a very small number of participants (less than 2%) for the bulk of the

contributions made, yet PosterVote has the capability to create profound value for millions of users [175]. Expecting the same level of investment from every member of a local community is unreasonable and as a result inequality of participation should be expected, harnessed. PosterVote is designed to manage such inequalities as activists and more engaged individuals can contribute by setting up polls and collecting data whereas other community members can be involved simply by voting or by making use of the collected tallies.

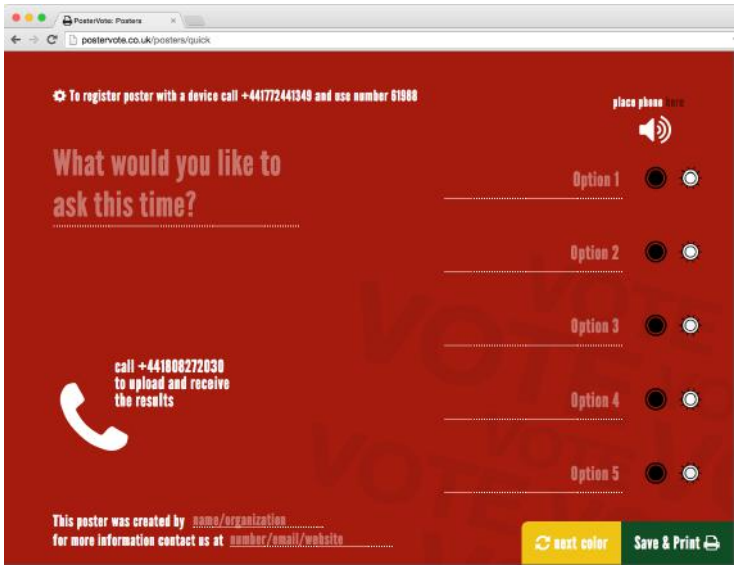


Figure 11. PosterVote 2.0 website that allows the creation of .pdf posters containing basic poll information and instructions about data download

Multiple voting can be an important determinant of how citizens use the system. In [189], residents suggested that multiple voting reflected how strongly someone felt about an issue. However, the use of electronic voting tools for the grassroots collection of evidence poses additional trust considerations as contextual parameters such as the ownership of the voting system may affect the perceived reliability of the collected data. Even though positioning the devices in visible and social locations may prevent such acts, the effect of multiple voting in these configurations and contexts still remains a matter of debate. Being aware of the issues that arise from multiple voting, I chose not to implement any averting measures (e.g. biometrics) to ensure the sustainability of the prototype (monetary and technical). I acknowledge that multiple voting is possibly a shortcoming of PosterVote, compared with conventional methods which do not allow for this, such as face-to-face surveying. This first iteration, however, is useful as a probe to further explore the

understanding and requirements of local communities with regard to voting and how multiple voting can serve as a stimulus for engaging the political.

6.3. Deployments

To collect feedback about the concept, version 1.0 of the prototype was deployed in two local communities in the UK. The first deployment was in collaboration with the local strand of an international movement for sustainable communities. Another case study was conducted in a different local community setting, with a regeneration planning group who were working on a local annual festival at the time of the study.

6.3.1 Case study 1: Road planning group

The first case study was conducted in collaboration with an activist group interested in collecting opinions and mobilizing the community for pedestrianizing and changing parking regulations of a central area of the community (from now on called *road planning group*). The group wanted to raise awareness about parking regulations and traffic in their community. The questions that the group put on the posters were related to managing car traffic on the central street of the community, and altering the parking regulations of a neighbouring street to reduce the number of cars parked on the more central street.

Table 5. Votes cast for each one of the deployments. Deployment 1: 2 posters for 8 days; Deployment 2: 2 posters for 14 days; Deployment 3: 2 posters for 14 days

	1st deployment (8 days)	2nd deployment (14 days)	3rd deployment (14 days)
Poster 1 (votes)	62	281	219
Poster 2 (votes)	81	22	137
Total Votes	143	303	356
Votes/Day	**17.8**	**21.6**	**25.4**

I met with two group activists who highlighted the difficulty in reaching residents in the community by using alternative to conventional door-knocking survey methods. After presenting the technology and the prototype, they indicated the street where they were planning to put up posters for the first deployment (relating to the street affected by the proposed changes in parking regulations) and provided questions to be printed on two posters. The posters were printed and handed over to the activists who put them up on lampposts across the street as can be seen in Figure 12. The posters (which were printed

on normal A4 paper) were stuck on cardboard by one of the activists to prevent them from rolling around the posts. Thick transparent tape was used in order to protect the paper posters from adverse weather conditions.

The posters were deployed for a period of eight days (deployment 1) and then collected to download the results (see Figure 12). Uploading the results by filming the LEDs was not used, as the activists expressed a preference for being provided with a computation of results at the end of the deployment. Subsequently, two additional deployments were conducted (deployment 2 and 3): the first on the same road as the first deployment with a question related to parking regulation but with a wider range of possible answers instead of simply yes/no; and the second on a different street of the community with the topic of polling being rerouted traffic. In both cases the posters were deployed for two weeks during a busy period, with the two activists involved in setting up the posters and collecting the results.

Figure 12. PosterVote stuck on a lamppost during the first deployment

Table 5 shows the number of votes for each of the posters for all three deployments with the road-planning group. The majority of the participants were in favour of changing the parking regulation in the street (as asked on posters of deployments 1 and 2) while keeping the same traffic regulations (as asked on posters of deployment 3). Further analysis of the collected votes for all three deployments indicate that approximately half of the

votes recorded were cast within two seconds of each other. This indicated that either multiple voting occurred widely, or participants were casting votes in groups.

Figure 13. PosterVote on a lamppost during third deployment

As can be seen in Table 5, participation in the second and third deployment was higher than in the first. This could be attributed to the period of time over which the posters were deployed as the first deployment was conducted on a student-based street during summer vacations. The large discrepancy in votes between Poster 1 and Poster 2 during the second deployment can be accredited to the location where the posters were positioned (the first being placed next to a metro station and the second on a lamppost in a quieter part of the street). In general, comparisons across posters and deployments are not appropriate due to the differences in time of deployment and precise location of posters, and the numbers of votes counted are used to roughly indicate participation levels.

6.3.1.1 Interview data

Following the deployment, I sent the results to the two community activists and conducted an interview lasting approximately one hour about their reflections on the results and their experiences with the voting devices.

According to the community activists, one of the main problems of the design (when compared with conventional surveys) was the ambiguity of the collected data. More specifically, the prototype did not allow for the collection of demographics and there was no way to identify voters. Multiple voting added more ambiguity to the interpretation of results due to the inability to map the number of cast votes to a fixed number of residents. The activists suggested that submitting demographic information before voting might have possibly prevented multiple voting and generated additional data. The main advantage of PosterVote over other electronic means of collecting opinions is related to the location where the prototypes can be deployed. More specifically, PosterVote allows the configuration of participation according to the region that the system is deployed in:

> *"*[…] *the thing about having it on a lamp post is its directly relevant to that particular position.* [in a supermarket] *the sample population is too broad, we wanted to be people who used Coniston* [street]".

Although the activists perceived PosterVote as better than electronic polling systems placed in shops, believed that putting posters indoors might increase the trustworthiness of the results, as in comparison a polling device on a lamppost raises more doubts about the reliability of the collected data.

Even though PosterVote was perceived as having potential for democratizing local communities, its affordances are not yet entirely clear due to users' lack of previous experience with relative devices: *"loads of shops and museums have* [computer-based] *devices like this so its more in the range of peoples experiences; this* [PosterVote] *is not at the moment"*. The subtle affordances of PosterVote were one of the most important reasons for scepticism about the collected results as *"it is like we build our own tool to prove something"*. Thus it seems that even though the prototype was designed to be as simple as possible, PosterVote's innovative qualities lowered trust in the collected data.

Limitations of PosterVote included the inability to display results and limited interactivity: *"if the democracies are about to work, they* [citizens] *have to get feedback and feel that they have influenced something I made a difference I will do it again"*.

When asked whether visual downloads of the results would make the poster more interactive one of the activists replied that: *"taking videos of the poster is not very simple; definitely for the* [neighbourhood name] *population"*. Filming the posters and uploading

the results was perceived as too complicated for the road planning group activists. Instead putting up paper posters with the results was suggested as an effective way to give feedback to the residents.

Governance of the voting systems and whether ownership by local governments can foster increased participation was one of the main issues discussed. Actions of local governments were seen with scepticism. Civic participation and consultation projects were considered to have been conducted largely to meet governmental civic participation goals:

> *"I think people are sceptical about local government collecting information because it tends to be this word "consultation"* […] *people are very cynical about these consultations it's a lip service being paid and I think if the local council did this* [putting posters up] *then people would feel, well what they are going to do about it".*

Generally, apathy in society was perceived as the main motivation for inventing and testing new tools to support democratic practices:

> *"I think the trouble at the moment is that people are switched off from the standard political system,* […] *and that's because of peoples ignorance but also disaffection they are disquiet about the political process and anxiety about politicians not representing them adequately. I think our democracies isn't working and different ways are needed which needs to be interactive; this is a start I think that you need to start by having a system to get peoples views more validly".*

6.3.2 Case study 2: Regeneration group

The second deployment was conducted in a local area after being contacted by the community's regeneration planning group (from now on referred to as *regeneration group*). This local voluntary organization has recently taken on the responsibility for the regeneration plan of the community. According to new legislation in the UK [47], local communities have been given new rights and powers for neighbourhood planning. Under the act, local communities can apply to establish neighbourhood forums for the "purpose of promoting or improving the social, economic and environmental well-being of the area" [47].

Following introductory meetings with the group, the voting prototype was presented to them as part of a wider engagement, in order to probe how it might help them promote their work and simultaneously collect opinions in the community. A local summer festival was suggested as a good opportunity to collect some of the visitors' opinions about the local area. The festival is an annual showcase event organized by the local community, which attracts visitors from the local city and surrounding areas. Any interested parties can set up table stalls at the festival to promote their work or sell products. The regeneration group proposed asking visitors three questions, with five possible answers for each question. All three questions were related to what people liked about the area and possible future initiatives for the community.

Figure 14. Posters on Regeneration group's table stall

The regeneration group's stall was located in a central location at the festival. I designed, printed and set the hardware on the posters with the suggested questions and answers. One poster per question was created.

Although the posters were designed to be placed in highly visible and public locations, such as on lampposts or walls, the group was not specifically instructed to follow this through. The group decided instead to place the posters on a white sheet of paper on their table stall with the prompt "Push our buttons" (see Figure 14). According to the group this would reduce disturbance to other participants visiting the festival and would allow group members to be close to people interacting with the posters. Feedback could also be gathered about the issues being voted on. Posters were deployed for a total of five hours during the festival. Following the deployment an interview was conducted with the person

responsible for the group's stall and the posters were returned to calculate the results. The number of votes per poster was very similar for all three posters (221, 234, and 259 votes for first second and third poster respectively).

6.3.2.1 Interview data

I conducted a semi-structured interview with the community member (from now referred as Clare) who was managing the community's stall during the festival. The interview lasted for one hour and the participant described her experiences during the day and responses from the visitors.

The first impression of visitors was generally positive with the community member commenting: *"their reaction in terms of seeing their expressions and gestures were very positive, they didn't comment very much on the form of doing it. Which was good because it meant that actually it appeared to them to be low-tech way to doing things"*.

After mentioning a comment from one of the visitors (who was looking for a pen to tick the boxes as an alternative to pressing the buttons) the conversation moved to comparing e-voting solutions such as the poster with more traditional forms of collecting data such as surveys. The organizer highlighted the simplicity of downloading the results when using an electronic means of collecting opinions. More specifically she said: "[…] *I felt that this offered a simpler way of doing things, for my point of view it is much better because then you don't have to transfer the information into a database."*

According to Clare people expect tick boxes and pens because these are conventionally used when filling in questionnaires, but PosterVote was more user-friendly for visitors in terms of facilitating interaction. The discussions motivated by the posters represented one of the most significant outcomes of the deployment. She stated:

> *"What I found that was interesting was that people weren't just pushing the buttons, they were actually talking to us about what they have chosen. We felt very strongly that having the questionnaires there, having them in the form that they were in helped us to interact with the people."*

In addition, Clare mentioned that she tried to find a notebook so that she could take some notes about what people were saying to her while voting. One possibility of designing to facilitate this in future could be to have blank spaces for making notes on the posters,

however this could also result in hindering visitor participation as: *"people might feel more uncomfortable if they have been recorded in some way* […] *One of the things that I think worked well was the fact that we were not gathering any demographic information and the fact that we weren't asking for any personal information whatsoever I think encouraged people greatly"*.

Sitting next to the table stall with the posters provoked discussion with visitors about things in the area they were dissatisfied with, or options that they wanted to vote against. More specifically, when asked how visitors showed their negative thoughts about specific options Clare mentioned:

> *"Yes, they voted for the things that they liked and they told me about the things they didn't like"*.

The posters served as a way of initiating a discussion between the community activist and the public. One of Clare's suggestions in relation to designing a poster that would allow negative feedback was to have special posters for negative options, for example having a red background colour for negative voting polls and green for positive.

One of the most prominent topics of discussion was the ownership of the voting devices. Who should in the future ask questions and suggest possible options for people to choose from? Even though the prototype was well received by the festival visitors, the community member was sceptical about giving the prototype out to any interested members of the community. She explained this by saying: *"inevitably there would be some that would put up rude or abusive things and I am a bit concerned about that because it happens with graffiti all the time"*.

So even though she agreed that the prototype facilitated community engagement, she also believed that it should be used in a restricted environment and the ownership of the posters should be controlled to avoid misuse. Additional meetings with the regeneration group further revealed that the group, having gained some authority over the regeneration of the area, were acting more as a local committee than as an active group of local residents. The posters were perceived as a valuable tool for the group to further influence and support the development of the community, but the group considered that their use should be controlled. This discretion was also reflected in the content of the questions asked

through the posters: *"I was very careful about putting positive options rather than having negative options"*.

Visitors to the annual festival vary each year, but it is usually very popular amongst families with children, who wanted to stop at the community's stall to respond to the questions by voting. The community representative commented on the way in which parents were instructing their children regarding the pressing of buttons:

> *"Parents were saying to them* [children] *don't press more than once; we didn't say that to anybody. We actually had to encourage people to press more than one button per sheet quite a few people at first thought that they could only choose one thing out of each sheet"*.

In general, voting only once (opposed repeatedly) seemed to be the unconscious understanding visitors had concerning the process of voting. One common practice was also for groups of visitors 'to elect' one group member as eligible to vote for the whole group.

> *"What we had more problem with was trying to get more than one person in a group to vote, couples, families they were electing one member of the group to press the buttons and the one member of the group seemed to think that they were doing it for all of them". Clare tried to explain this as happening because "having the same views united them more and perhaps because being seen in public"*.

6.4. Findings

The two case studies conducted and the subsequent interviews with the community activists brought a number of interesting insights to the surface about the deployment of grassroots led e-voting and the affordances that make voting an adequate tool for political campaigning. Although the findings of our deployments are contingent upon contextual factors of the local communities, and as a result the findings of the two case studies diverge, the themes of representativeness, interactivity, governance and social norms can be identified as pertinent in both contexts.

6.4.1 Representativeness

In both case studies the representativeness of the collected results was one of the most discussed issues, with different perspectives applying to each of them. The road-planning

group that deployed the prototype as a situated voting tool indicated that the lack of demographics from the collected votes, the inability of mapping a number of votes to number of residents, and the possibility of multiple voting undermined the trustworthiness of the results and their representativeness.

On the other hand, the regeneration group that used the system as a replacement for conventional surveys on table stalls did not raise such issues. For this group the face-to-face interactions with visitors enabled the supervision of the voting process and further discussion with visitors who came to vote. The collection of demographics, in contrast with the road-planning group, was perceived as inappropriate by the regeneration group as something which might introduce barriers of participation between the community activists and the residents.

6.4.2 Interactivity

According to the regeneration group, the electronic posters were as intuitive to participants as a more conventional non-electronic means of conducting surveys but at the same time had the advantages of online surveys. On the other hand, the road-planning group perceived the lack of interactivity to be prohibitive for participation and as something which hindered the affordances of PosterVote.

In the road-planning case, the lack of feedback was recognized as one of the main limitations of the prototype and the need for the provision of additional feedback to increase the perceived efficacy of the voters was suggested. Whilst PosterVote motivated discussion between community members and the public in the regeneration context, using the prototype as a voting device on lampposts prevented these discussions to emerge. As a result, ways to capture situated feedback might need to be considered in future redeployments. I anticipate that for contexts where the visual or audio download of results is used, the preliminary voting data can facilitate the creation of online spaces for political discussions and consequently some of the discussions that occurred at the festival table stalls could also be captured in cases where posters are left unsupervised.

6.4.3 Governance

The most prevalent theme that emerged throughout the deployments was the governance over the electronic posters as their low cost and sustainable design enables any community stakeholder to initiate a poll. The road-planning group boldly supported the bottom-

up approach of collecting opinions and then using them to support action, contrasting such movements with council led e-participation projects that are viewed with great scepticism. Contrastingly, the regeneration group was more sceptical about opening the ownership of the prototype to everyone in the community, wanting to act themselves as a committee which would represent the community interests.

Although these observations might be only be relevant for our specific community contexts, the different attitude of these community groups regarding governance was dependent on different political beliefs, organizational characteristics and the hierarchical structures of the group. The road-planning group did not distinguish themselves from the rest of the community, acting more as members of the community that they want to democratize. The regeneration group, perhaps due to the power newly assigned to them by the local council (i.e. the regeneration of the area through neighbourhood planning), was very doubtful about delegating the ownership of the system to other members of the community. Although members of the group were inclined to further democratize the community, according to the regeneration group the issue of 'who asks the questions and what questions are asked' is one that should be censored. Taking this into account, it is the low-cost, openness and self-preserving characteristics of the technology itself, which acts as a democratizing agent.

6.4.4 Social norms

The way that the communities deployed the prototype affected how the residents used the system. In the regeneration case, the supervision of the voting process from the community group enabled social norms that prevented multiple voting from occurring. The visitors to the community's table stall mostly voted only once per poster (as the conventional norms of voting indicate). The road-planning group, by not supervising the voting process, allowed participants to vote in 'private' and thus the social pressure for voting only once was eliminated.

According to these findings, placing the posters in more visible locations and making the act of casting a vote more visible to the social surroundings will possibly decrease multiple voting as it enables social norms of participating in a democratic voting process.

6.5. Reflection on Design Framework

The findings and the emerging themes of representativeness, interactivity, governance and social norms also have implications for the design framework. In this section I attempt to relate these observations to the characteristics of the design framework that either facilitate or hinder the collection of local opinions for community change. The contextual parameters that influence the perceived efficacy of the data and devices will also be discussed.

6.5.1 Eligibility

Although I expected that placing the voting posters in explicit locations in the communities they related to would foster a higher level of trust, other features such as multiple voting led to the data being seen as ambiguous. This was mainly attributed to the lack of representativeness of the data in terms of mapping the number of votes to particular demographics.

For the first set of deployments (road planning group), the activists positioned the posters on lampposts, with one of the researchers observing to deal with any technical difficulties. The two community members asked for help from local shop owners when setting up the devices (by requesting spare cardboard or some tape to stick the posters up) and in the process of doing this they entered into discussion with the shop owners about the proposed traffic changes. They tried to gain support from the shop owners for the campaign, explaining how PosterVote could help to collect community opinions. As a result, in addition to the visibility that was raised about the traffic plans through the actual deployment of the posters, the setup of the devices by activists enabled further political engagement with local residents. This indicates that the development of sustainable voting technology, is able to shift 'ownership model' from the local council or HCI researcher to community campaigners, and can support increased political engagement of the involved stakeholders.

The capacity of PosterVote to be used by anyone with a cause and the possibility of democratizing local decision-making through such initiatives were perceived differently by the two groups. The road planning group raised concerns about participatory democracy initiatives led by local councils and praised initiatives such as PosterVote, while the regeneration group interpreted the openness of the ownership of the system as a possible

limitation. These contradictions highlight the subjectivity of the 'democratization of technology' and the methodological difficulty of assessing the capacities of systems like PosterVote for political participation within conflicting contextual parameters.

6.5.2 Fairness

Social norms, in terms of participants' and voters' beliefs about the voting process and democratic representation of opinions, were important determinants of the way participants interacted with the voting system. The inconsistency between the two case study contexts and ways that PosterVote was appropriated raised interesting contradictions. For the regeneration group multiple voting wasn't perceived as a problem, and was invited by the community activists as it provoked visitors to discuss issues. This was mainly due to the appropriation of PosterVote (as an alternative to conducting surveys on table stalls) being supervised by at least one of the community members. However, when the voting posters were placed in an unsupervised environment, the possibility of multiple voting and potential tampering with the devices raised questions about the data representativeness and accuracy. These findings highlight the importance of contextual factors on how open technologies are appropriated and their possible effect on perceptions of fairness.

The situatedness of the voting devices was unanimously seen as the device's main advantage over alternative methods of digital opinion polling. For the road-planning group this was reflected in collecting opinions about issues directly relevant to the communities in which the posters were located. For the regeneration group on the other hand, the devices situatedness permitted their supervision and control via the opportunity to overlook the voting process during the festival and being able to initiate discussions with visitors.

6.5.3 Secrecy

For the road-planning group, the collection of demographics has an impact on collecting community opinions when campaigning and can be effective in increasing the efficacy of the data. In this regard, the representativeness, accuracy and perceived objectivity of the data can play an important role in affecting change. This was something that was not supported by PosterVote as there was no voter identification method in place. Contrarily, using the posters as substitutes for conducting conventional surveys on table stalls raised different requirements: collecting demographics was seen as inappropriate and possibly intimidating. This discrepancy can be justified by the different ways the posters were

appropriated by the two groups, however it also highlights that differing drives for data collection demand diverse requirements. A tool designed to support multiple data collection contexts and motives should be flexible to allow its adaptation according to the stakeholders' needs.

Whilst PosterVote enabled the association of the questions with their corresponding locations, leaving the voting systems unattended on the street reduced the perceived accuracy of the data. The novel form and design of PosterVote also contributed to a distrust that the data was a valid representation of community responses. This has implications for the perceived integrity of novel voting systems as security mechanisms (or the complete absence of them) might motivate different perceptions of integrity according to contextual parameters. Finally, the extraction of votes from the voting posters, by recording the LEDs transmitting the results, was not done as the process was considered to be too complicated when taking into account the neighbourhood profile. I believe the new hardware version of PosterVote that allows the audio transmission of the device's data through GSM will facilitate the involvement of more community residents in downloading and using the data for political purposes.

6.5.4 Expression

The devices were perceived as easy to use and a *"low-tech way to doing things"*. Compared with other traditional means of information collection, PosterVote was currently perceived to be more fun, with its novelty being one motivating factor for participation. However, having innovative voting devices at extraordinary locations may increase accessibility but can result in decreased confidence levels regarding data collection. This raises interesting concerns (thoroughly reported in [151]) about the impact of new voting technology on perceived and actual security and trust.

Informed by findings reported in our previous case study (see Chapter 5), PosterVote was designed to enable situated debate. For the road planning case, discussions with the community members occurred even before posters had been placed in the streets. The activists walked into local shops to ask owners for help, and took the opportunity to talk to them about the polling system and seek support for the campaign. Leaving the poster devices unattended on community streets, prohibited additional political discussions from emerging. Systems which are intended to not only collect quantitative data but also raise

visibility and engage the community in political discussions about the issues at stake, face methodological and practical problems of measuring this engagement (quantitatively or qualitatively), which in most cases comes as a by-product of the system's deployment. For the regeneration case, the physical presence of the community activist next to the table stalls motivated discussion about the polled issues with festival visitors. This was more specifically driven by the publicity of the vote casts. The visibility of the voters' actions also minimised multiple voting. According to the regeneration group, voting 'once only' was the default interaction of visitors with the system, so the group encouraged visitors to vote multiple times to engage them in further discussion. As a result qualitative feedback was perceived as more significant than the representativeness of the quantifiable votes, which was not the case for the road-planning group where ambiguity of the collected quantitative data and the lack of associated demographics was seen as a limitation. This distinction can be attributed to the lack of qualitative data to support the vote tallies (which affected the interpretation of them). Quantitative data alone raise questions about when and why voters voted multiple times; these concerns are lessened by qualitative feedback.

The ambiguity of quantitative data can be exemplified by social media 'likes' [73]. The success of the 'like' button rests on the different interpretations that it might have depending on the context. It may indicate sympathy, respect, recognition, irony or acknowledgement. Where necessary, users might feel the need to explain their 'likes' by leaving comments and thus supporting their quantitative action with qualitative 'arguments'. This ambiguity is invited in social media networks as they drive user engagement. It is interesting, however, to question whether this ambiguity also exists in other voting contexts and whether this ambiguity (or the lack of it) supports democracy and democratic representation. For example, casting a vote might have many interpretations: aligning oneself with the ideology of a party; selecting the option that is more likely to cope with political problems of everyday life; choosing the best out of the given options; casting a protest vote, etc. Is this aggregation of the different types of vote casts beneficial for democratic representation?

Almost all road planning group's posters included both negative and positive options, giving voters the option to express their negative views or opposition to the campaign. The regeneration group chose to ask 'apolitical' questions with most of them having a

positive interpretation. This was informed by both the nature of the event (i.e. summer festival) and regeneration group's desire to avoid antagonistic encounters. Nonetheless, festival visitors' expressed their negation by talking to the community members at the table stalls.

6.6. Methodological Note

With PosterVote I attempted to underline how we can design innovative but also sustainable voting technologies. This refers to whether the designed artefacts afford their use when the research project ends and the technical support by HCI researchers is no longer possible. In this case study we designed PosterVote to support local democratic practices at grassroots level by creating additional methods of political participation. I believe that it is important for this type of research to clearly define the purpose of the data collection through voting, and map out the possible avenues where data might bring about change – either through collaboration with local councils and their agreement to implement suggested changes or through clearly defined methods of campaigning.

PosterVote was designed on the basis of supporting local activists, however the openness and flexibility of our design allowed our participants to appropriate it in different ways. On the one hand the systems were used exactly as expected and designed for (street activism) and on the other hand they were used as a user-friendly replacement for paper-based forms on table stalls. This can be thought as an advantage, as the democratisation of technology comprises its appropriation in unexpected ways. Even though the contrasting use of our prototype revealed unexpected interactions with the technology for the participants, this variation (which depends not only on the participants' needs but more importantly on political standpoints and values) raises methodological questions about the interpretation of data collected by such methods [95]. Political values and the perspectives of participants around the use of the technology to facilitate their political needs might vary greatly, resulting in biasing research findings according to contextual parameters. As a result, the inevitable biases of participants (and researchers) trialling community engagement prototypes should be taken into account when reporting the research findings of community engagement projects. This will result in a clearer representation of the research findings and their contribution to HCI.

6.7. Limitations

In the case studies reported in this chapter although I provided the technology that enabled local community activists to expand their action repertoire for local opinion collection, I did not clearly design for possible avenues of bringing change either through collaborations with the councils or through effective campaigning. This has obvious limitations, as otherwise the participants might have seen greater value in the data collected. However, I wanted to allow local residents to use the data in the way they would usually do (i.e. if conducting surveys via conventional methods). Indeed, one of the community activists from the road-planning group confirmed that data collected (charts of community opinions) had been sent by the group to local councillors in order to influence decisions regarding the proposed changes on streets. Approximately one year on from the deployment of PosterVote, the changes are about to be implemented with the road planning group saying that the data from the poster devices played a role (amongst other considerations) in the decision-making process.

Another limitation is lack of evidence on whether the interactivity of the devices contributes to the further engagement of the community with the issues at stake. It is true that even without the interactive element (the use of the PosterVote devices at the back of the posters) the mere existence of posters about road planning issues on the street would have raised visibility and would have motivated community discussions. I do not claim that the voting devices contributed significantly in raising awareness. The proposed design combines two local activism practices: raising awareness through putting posters on lampposts and door-to-door knocking for information gathering purposes, with the interactive element of PosterVote mainly supporting the latter. However I believe that the invention of new methods to complement existing non-technological practices add value to them not only by giving them additional affordances but also by reinventing their traditional capacities.

6.8. Conclusion

This chapter builds on existing situated e-voting and activism literature in HCI (e.g. [117,120,128,189]) by repositioning technology for data collection in the hands of grassroots campaigners instead of local councils. I believe that PosterVote is a step towards

expanding the repertoire for local political participation with sustainable tools with potential to reinvigorate local democracies. Lightweight and low-cost technologies for on-the-ground activism show promise for the purpose of supporting sustainable and deeply democratic processes of data collection and public political discussion. As a more accessible tool for political activism, PosterVote opens avenues to increase reach to existing social movements. Openly available devices for opinion polling have the capacities to foster citizen political engagement where members of the public can openly question the political. However, as we have seen in one of our case studies, open technology can also be used to reinforce existing power structures, and the importance of governance, transparency and fairness in the design of democratic technologies cannot be understated.

PosterVote limitations when compared with well established e-surveying and e-voting systems are of course significant. If used as a survey tool, the lack of demographics makes it inappropriate for accurate collection of data whereas if it is used as a voting tool it is open to manipulation, as multiple voting cannot be prohibited. Nonetheless, the prototype as a first iteration of such a system, initiated and managed by community campaigners, acted as a probe and brought to light interesting insights about both the design space of voting and the participatory security framework introduced earlier in this chapter.

The use of PosterVote to expand the collective action repertoires of social movements also brings with it an ethical consideration of 'unconventional' political methods. The use of fly posters for political action can be considered conventional, though the precise legality, even within democratic societies, is questionable. The response of social movements to this possibility can mirror the values of that group – for instance, the regeneration group chose to implement the poster as a more conventional survey device to support face-to-face interaction. There are many alternative and imaginative possible use scenarios, including those that could be considered as unethical and illegal. It is unlikely that any open design in a political space can avoid such possibilities, however, it can be noted that the expansion of the action repertoire for social movements, particularly through introducing new means to engage in political action can increase the potential for unconventional political action. It is also important to recognise that the willingness of social and political movements to be open to all discourses might sometimes work in contradiction to their own values.

Chapter 7.

Voting-in-Place: Exploring Multiple Channels of Community Participation

In this chapter, I continue the inquiry towards designing voting systems for political participation through the deployment of various voting systems and data representation technologies in a local community[21]. The research reported here is part of a year-long community engagement project led by Microsoft Research Cambridge.

In the initial stages of the project, a series of monthly evening meetings took place with local residents to explore what mattered to them and how data might be used to play a role in supporting the community's everyday practices (see [186] for more detail). Following on from this, a number of voting systems to collect, aggregate and share meaningful data were built and brought together. In the last phase of the research, residents were offered access to this group of data technologies to investigate how they experienced the different systems and made sense of data. Elsewhere [119], findings of

[21] The conceptual framing of this chapter and preliminary data can also be found at: Taylor, A. S., Lindley, S., Regan, T., Sweeney, D., Vlachokyriakos, V., Grainger, L., & Lingel, J. (2015, April). *Data-in-Place: Thinking through the Relations Between Data and Community*. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (pp. 2863-2872). ACM.

The empirical data reported in this chapter is currently peer-reviewed.

this deployment are presented by drawing on Marres' [125] work on material participation and Massey's conceptualization of space as dynamic [127].

In the case study reported here, following a more holistic approach to research that acknowledges the complexity of the social, political and cultural context in which voting is situated [55,167], I present insights into how the context of the deployment and the affordances of the different systems impacted peoples' participation in the project and their engagement with, and understandings of, the technologies and data. Specifically, I highlight how the presence and involvement of Microsoft Research in the project, while being located in the community, came to play a significant role in perceptions of community, data, and affordances of the voting systems deployed. Despite its evident importance, a closer consideration of such contextual factors is rarely included in presentations of similar HCI research. I frame this case study by using the design framework for participation in voting introduced in Chapter 4, with a particular focus on the impact of contextual parameters on participation.

7.1. Research Context

This case study involved engaging with a community of local residents, who were living on, or in close proximity to a particular road called Tenison Road in Cambridge, UK. The initial stages of this project were designed to explore how the production and use of data is bound up with physical and social notions of place (findings of this initial engagement can be found at [186]).

In the last phase of this research, a group of voting technologies for data input and data representation methods was deployed to provide feedback. During the five-week period of deployment I explored how residents experienced the different voting mechanisms and made sense of the data collected, and how this related to community participation. In this chapter, I am particularly interested in how the context and affordances of voting and data representation methods affect citizen participation within a community. This involves questioning some of the assumptions of voting as a tool to primarily support the collection of actionable, consensual data. I begin by presenting descriptions of the three voting technologies used (two of which were described in Chapters 5 and 6), which in total provided six voting channels, and five voting data representation methods for feedback. In this later research phase BallotShare, PosterVote and an additional household voting device called

BullFrog are deployed in tandem, in order to explore through their affordances, the community's interpretation of voting, its context and collected data. In the following sections these technologies are described in more detail and the way in which they are configured to leverage different types of community participation is explained.

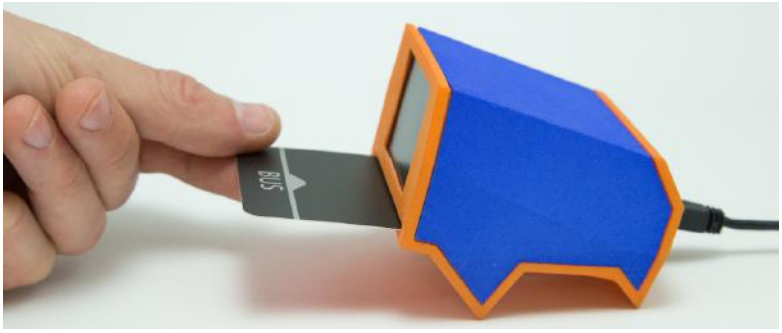


Figure 15. BullFrog device with a voting card inserted

Figure 16. Storage box and weekly results envelope with new voting cards and a wild card

7.2. Voting and data representation methods

The voting and data representation technologies that were deployed collectively over the five-week period encompassed: 33 *BullFrog* devices, 6 weekly *PosterVote* posters, the online voting system *Ballotshare*, and a set of interactive *Physical Charts*. Online (BallotShare) participants were able to vote through four channels: the online interface (see Figure 17), Twitter voting, SMS voting and voting through a plugin on the community's website. Consequently in addition to PosterVote devices on the street and BullFrogs in households the community had six channels of participation in total. To provide feedback five methods were used: physical charts placed on the display of the Microsoft Research lab (see Figure 20), cards with printed results posted to BullFrog users (see Figure 16),

the online BallotShare interface showing live results, the posting of results on the community's website, and the printing of latest poll results on PosterVote posters on the streets.

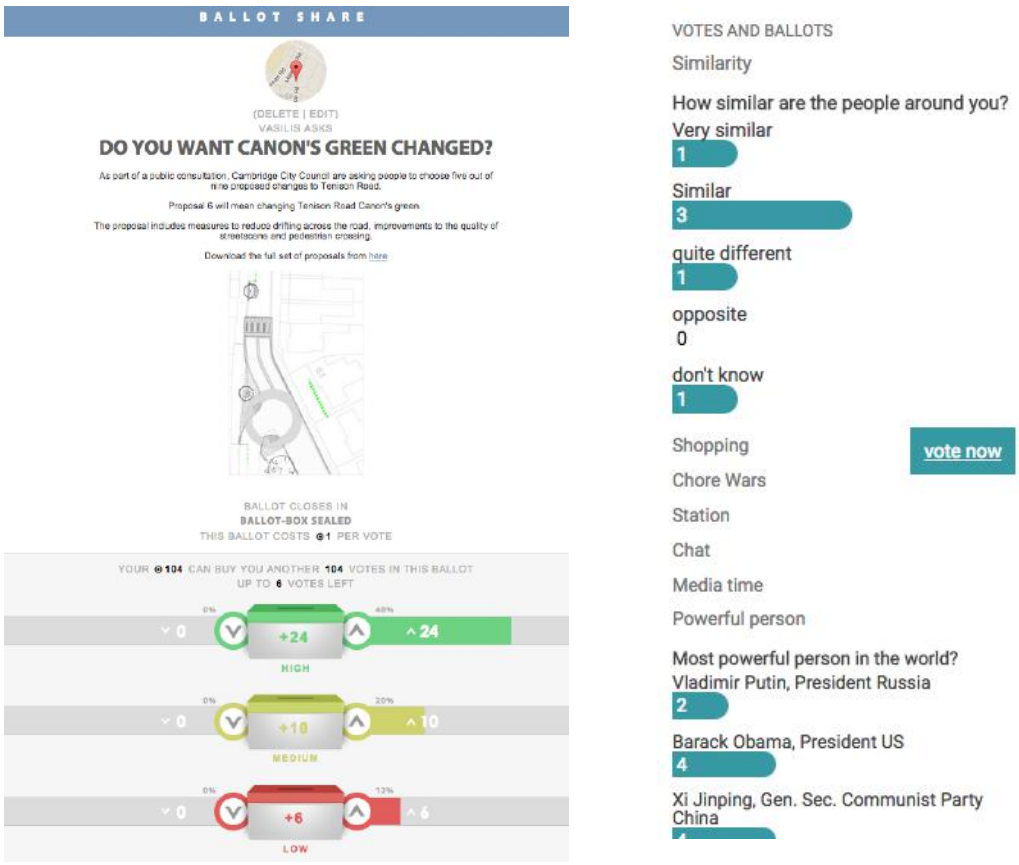


Figure 17. BallotShare 2.0 (also see Appendix A

BallotShare Screenshots): BallotShare appropriated for the community engagement context. BallotShare community poll (left); BallotShare Wordpress widget with list of community polls and results (right)

BullFrogs, designed and developed by Microsoft Research Cambridge (for details see [157]) are small voting devices that are situated in peoples' homes and display questions on a screen. Voting responses can be made by inserting a machine-readable paper card into the device (see Figure 15). Participants are able to check the results of the vote on cards which are posted out to them every Monday (see Figure 16).

PosterVote [193], introduced in Chapter 6, is a laminated paper poster that is strategically placed on a street for passers-by to vote on. It is augmented by push-button functionality that allows users to indicate a choice between up to five response items (see Figure 19). I placed six PosterVotes (version 1.0 – see Figure 8 in Chapter 6) along Tenison Road.

The posters were brightly coloured, A3 in size, and mounted on an acrylic board, then attached to lampposts at locations where people might be likely to stop or linger. The posters were designed to be self-explanatory and included a link and reference to the project, the poll question and mechanism to vote, and information as to where and when the results would become available. Results of the previous week's question were printed on the posters to give back feedback.

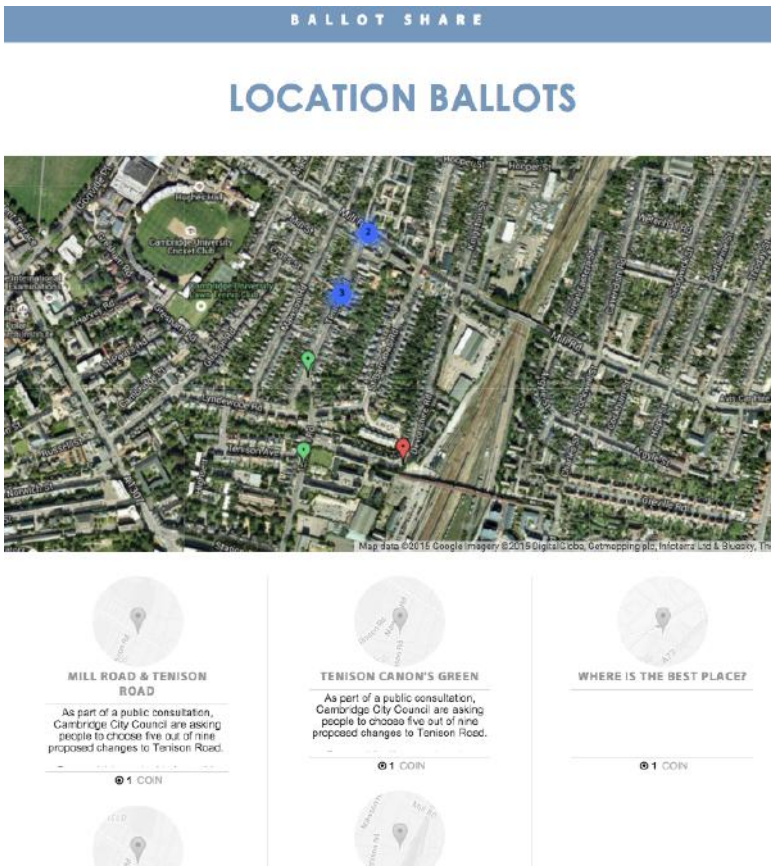


Figure 18. BallotShare page mapping PosterVote devices on the neighborhood's streets

BallotShare [194], as described in Chapter 5, is an online voting system that offers a lot of flexibility as to how polls can be configured. For this study, I adapted the system so that it could work as an independent online system as well as being able to work in conjunction with the Physical Charts for data visualization purposes [157]. The system was also extended to accommodate twitter voting – voting by tweeting a hashtag followed by one of the options (tweet's format: @tenisonroad #vote #{answer_number} {optional_comment}), SMS voting – voting by sending a text message at a five digit shortcode (SMS content with the format: {answer_number} {optional_comment}), and

voting with live results through a wordpress plugin on the community's website (see Figure 17 right).

Figure 19. Examples of PosterVote posters offering push-button functionality to vote and the poll result of the previous week (left), or how local residents (BullFrog users) had voted (right).

Figure 20. The Physical Charts on display in the windows of the research building, presenting poll results of the deployed voting technologies & different ways for passers-by to vote.

Physical Charts are an assembly of two easily readable mechanical pie charts and a bar graph (Figure 20) for a 'material' visualization of different data sets (designed and developed by MSR, for details see [157]). The Physical Charts, whose design attracted the

attention of passers-by, had information printed on banners that invited others to get involved in the voting process. These charts were put on display in the ground floor windows of Microsoft's research building (located on one end of Tenison Road). This local advertisement included an online link (URL and QR code) to BallotShare as well as instructions on how to vote via SMS or Twitter.

7.3. Participants and Recruitment

The deployments and findings presented in this chapter are the outcome of a longer engagement with the neighbourhood, this local knowledge played a significant role in the recruitment of participants. During the preliminary engagements with the local community we presented the various voting and data representation devices (i.e. Bullfrogs, PosterVote and Physical Charts) at weekly residents' meetings and at a summer street party. PosterVote devices had also been deployed on the street in relation to a local traffic consultation led by the council, and as a result some of the residents might have already become familiar with the device.

Through regular planned meetings participants were recruited who were willing to take Bullfrogs for the study. Others were recruited through a street party and through 250 flyers delivered to the neighbourhood, every household on the central street and on the side streets coming off it. This area included parts of the community where residents had reported feeling 'less connected', and aimed to include people that had not engaged strongly within the earlier phases of the project. We managed to build and distribute 33 Bullfrogs to the community. The households deciding to take a Bullfrog included both regular attendees and people that had not previously been involved in the project. The latter included students, couples and families who rented and owned properties in the neighbourhood and areas associated with rental properties. Participants covered a range of categories, and those identified by residents in earlier phases of the research as being more difficult to engage in community matters. Participating households had from 1 to 6 members (average 3.06), and in total there were 54 females and 48 males ranging in age from 8 months to 74 years.

7.4. Configuring e-voting for community engagement

In this chapter I attempt to explore the effect of the context and the design of the voting and data representation methods on how participation is perceived and enabled in the

community. In this regard, I adopt the framework of participatory voting [194] described in Chapter 4. The framework consists of five spaces: *the context*, which refers to the setting in which the voting system is deployed, including the ownership of the voting system and data efficacy; *eligibility*, which refers to eligibility of participation in both voting and setting agendas, in addition to suggesting alternative options and deciding when polling should stop; *fairness*, related to accessibility of the voting location and multiple channels of participation, vote weighting and coercion; *secrecy*, which involves the publication of interim results, and privacy of the voter and secrecy of the vote; and *expression* containing all possible interactions that a user might have with the voting interface, for example, the number of votes allowed, vote delegation, vote revocation or overwriting, argumentation and discussion as reinforcing the vote etc.

In the remainder of this section I revisit each one of these design categories to describe how they relate to the particularities of the community and context, and the affordances of the numerous input and output channels.

7.4.1 Context: Place and local interest

The context in which polling takes place is one of the most significant determinants of participation. This entails characteristics of the social and physical geography of a community, the issues that are topical and able to affect change, ownership of data collection methods and collected data, and further use of data for influencing change. In [186], drawing from preliminary meetings with the community, the focus was on how data can be conceptualized as bound to place, and how data is capable of enriching understanding of communities. The relationship of communities with data was also considered, and how it is shaped by temporal and spatial boundaries which inherently exist in a particular location.

In this one year project, a community's perceptions of data were explored from the inside, without losing awareness of the everyday difficulties faced by the community. The motivational focus was centred around the community that Microsoft Research Cambridge is physically located in - Tenison Road. The community is very diverse and comprises a variety of residents, from families to students and tenants. The main road of the community was part of a major redevelopment program, Microsoft's move into the community being in the early stages of this. At the time of the project, the building works and the

final redevelopment plan were considered to have the potential to severely impact the established community and rhythms of the neighbourhood.

In addition to appreciating the varied demographics of the community, we were particularly interested in questioning how Microsoft Research's involvement in the community, as a research department located within it, might further complicate the community's interpretation of data when put in place. I anticipated that Microsoft, as a big organisation leading a community engagement project, will influence residents interactions with the voting systems. As a result in this case study I was particularly interested in exploring the neutrality of various stakeholders involved in such community engagement projects.

In [186], early reactions of residents to the project were briefly discussed and the role of researchers in the data collection process, with residents noting that as people with no stated agenda (i.e. not living on the street) the researchers brought neutrality to the data collection process. This was seen to be in contrast with events run by the residents' association, which was believed to serve particular political interests. Speaking at one of the initial meetings, a resident highlighted the distinction between "data coming from us and data being done to us", raising concerns about the potentially non-representative and biased nature of data collected by the local council.

In respect of the voting context, this chapter describes my attempt to build on Taylor et al. [186] work and explore the relationship between the community and data when data is related specifically to polling. This involves shedding light on the effect that different stakeholders might have on how data is perceived and enabled,, particularly in relation to organizations running participatory projects. One specific assumption that I attempt to challenge is the premise that researchers running the participatory projects are 'the experts' in participation, with the rest of the public having lower value as participants in a community engagement experiment.

7.4.2 Eligibility: Multiplicity and fixity of place

The choice as to who is considered eligible to vote can significantly impact participation and the credibility of results, especially where there is a concern that the results may not reflect the views of those whom they most impact. In the deployments described in this chapter, local residency and interest in local matters can be regarded as the key criteria for someone to be considered eligible to participate. As a result, through the deployment

of multiple voting systems attempts were made to reach the various participatory bodies in different ways.

The re-association of data with physical and social geographies poses interesting difficulties when considered under the lens of collecting opinion data to democratically represent the community. Who is eligible to participate and what does collecting "representative data" entail? Who is eligible to ask the questions and how are these questions framed? Our initial understanding of eligibility was associated with residency in the neighbourhood. However, the temporal, spatial and social boundaries of a community in addition to the emergence of a multiplicity of 'small worlds' [127] requires us to rethink how we design voting technology to capture community opinion data. In this project the existence of multiple small worlds is accepted rather than viewing a community simply as 'homogenous'. In addition, the ways in which material and situated qualities of devices can mediate participation are explored. By using different technologies, designed to encompass the various and fixed community rhythms, attempts are made to harness a dynamic space and create additional opportunities for community involvement. Multiple voting devices for data collection, designed to address the uneven demographic distribution of the community and different levels of investment in the research project (or in community life in general), might enable a more democratically valid collection of opinions by questioning what a local representative democratic practice entails. In order to explore participatory eligibility BullFrogs were deployed in houses for the collection of residents' opinions (i.e. physical and exclusive voting), PosterVotes on the main and neighbouring streets (i.e. physical and open voting), and BallotShare was used for off site access (i.e. online and open voting).

7.4.3 Fairness: Accuracy and weighting small worlds

Fairness is based upon the perception that those eligible to vote have a proportional impact upon the result [194]. This requires voters to be able to access the voting apparatus through different channels of participation or by decreasing the transactional costs of participation.

Multiple voting devices with varying affordances form a collection of methods for capturing opinions of disparate user groups. BullFrogs were designed to allow easy access

to voting. Its material form is inviting and designed to engage users in community discussion and negotiation. BullFrogs in households, PosterVotes on the street and BallotShare online provide a multiplicity of channels for participation, with the expectation that participation costs will be reduced, whilst allowing fruitful involvement in community engagement.

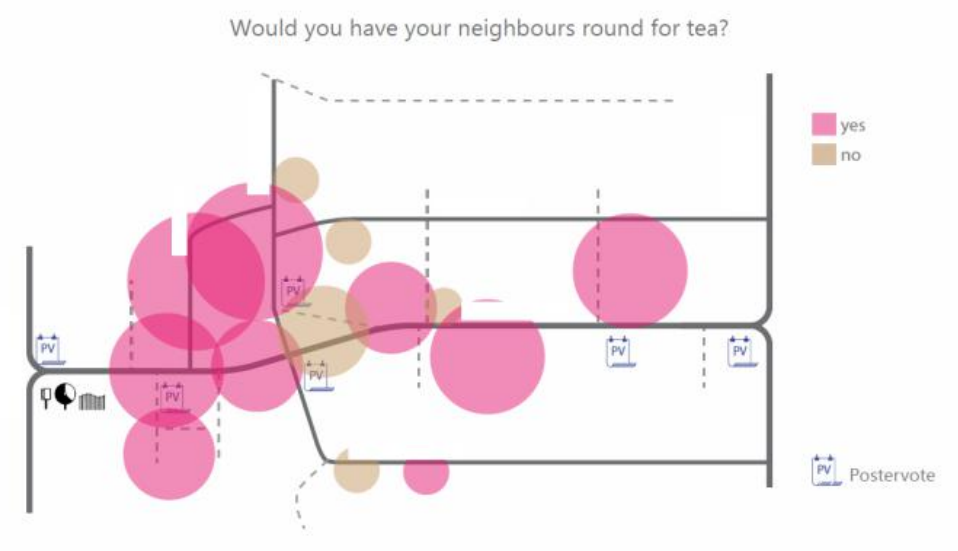


Figure 21. Example of an Analytics Card showing responses to the question 'Would you have your neighbours round for tea?'

Accuracy of the data is essential for maintaining the fairness of the vote. In many cases accuracy is seen as an easily quantifiable property, measured as a function of the technical characteristics of data collection systems. Accuracy, however, can relate to a number of factors, from the initiator of the process to spatial and temporal characteristics of the community. For example, some of the residents in the first stages of the project noted the inability of the community to collect their own data (causing reliance on the council's seemingly more accurate data collection methods). In this regard, accuracy relates to ownership and publication of the data. By handing over voting technologies to the community and allowing them to ask their own questions, a toolkit was provided which enabled residents to collect their own 'evidence' in dialogues with the council.

Vote weighting refers to the use of weighted votes to allow participants to have different investment and power in a decision. It allows voting to conform to an abstract and displaced sense of participation by tying results to the specific contexts in which they were produced. As a result, the data extracted from the voting process also includes the characteristics of how the vote was made. In this project all devices and voting channels had

an equal weight, independently of where they were located or participation level achieved. Whether this is an optimal configuration regarding fairness in such a context is questionable, as different channels and methods of voting afford different levels of engagement with the issue of concern. As discussed in [119], the multiplicity of small worlds inherently existing in communities requires the reconsideration of the technology design for capturing an illustrative sample of a community. When data relates specifically to polling, is a weighted system that delegates power disproportionately more or less appropriate for the diverse levels of investment and desires in these "multiple worlds"?

Table 6. Example BullFrog questions of each category.

(*) indicates questions and answers generated by BullFrog users

Category	Example question	Response cards
Daily mood	What is the mood in this house today?	Excited; angry; energetic; happy; tired; grumpy; quiet
Household characteristics	What colour characterises this household?	Blue; red; green; yellow; white; black; orange; purple
	The youngest person in this house is?	Baby; toddler; child; teenager; adult; pensioner
Neighbourhood characteristics	Do you want a crossing on Station Road? *(*)*	Yes, pelican; yes, zebra; no; don't care
	How open to change is this neighbourhood? (**)*	Very; somewhat; not a lot; not at all
Flows & contours	When did you last chat on the street? (**)*	Today; this week; this month; distant past; never
	Where do you buy your milk?	by the station; on Mill Road; on Hills Road; milkman delivery; large supermarket
Playful, imaginative	Have you given your BullFrog a name? (**)*	yes; no
	Would you like snow this Christmas?	a blanket of snow; a light frost; a few flakes; no snow

7.4.4 Expression: Asking questions and engineering responses

Expression refers to the ways in which one can articulate preferences or oppositions, and nominate options in a poll. An important determinant of individual expression is the content of the question being asked. For the BullFrogs, a set of questions was generated that and grouped into four categories: household-related; neighbourhood-related; relevant to

temporal flows or spatial contours; or simply playful questions (see Table 6). In addition to these topical questions, the BullFrogs displayed a daily question asking ‘What is the mood in this house today?’ During the five-week deployment, residents were invited to submit their own questions and responses, and as a result providing additional channels of participation (in addition to voting). This enabled the impact that the origin and content of the question was having on community participation to be explored. PosterVote was designed to be particularly effective in providing this additional channel, as questions were posed on multiple posters on the street, with the result of raising the visibility of the issues at stake.

BullFrog was designed to allow participants to overwrite their vote. By way of example: once a response card was recognized by a BullFrog device its screen displayed a ‘Thank you for your vote’ message and, where multiple questions were available then rotated to the next question. For each question answered, the text ‘You voted! Revote?’ was displayed underneath to indicate that a previous vote could be overridden by entering a different response card. It was made clear to participants that only their last vote would count. This was an attempt to stimulate debate in households where more than one member was engaged with the decision making process in answering the questions. Moreover, participants were invited to attend community meetings that were specifically set-up throughout the five-week deployment period. These took place twice a week and were scheduled as drop-in sessions on Wednesday mornings at our research lab and Thursday evenings at a local pub in the street, with a view to engaging participants in discussions with each other and around the data voting technologies. Participants were also given the opportunity to suggest and discuss their own ideas for questions. The physicality of the BullFrog results envelope and the visual presence of the PosterVotes and the Physical Charts on the street were also intended to attract people’s attention and to become potential points for discussion with others. Discussions were also facilitated on BallotShare through the use of the comments section on the online interface, or via posting a specially crafted tweet on Twitter.

Both PosterVote and BallotShare for practical and exploratory purposes were configured to deviate from a one-vote-per-voter model towards a more flexible model that would allow a person to vote multiple times, for example in the event of somebody wanting to express strong feelings about an issue (cf. also found in [189]). Practical reasons for this

include reducing the transactional costs of participation, as people do not need to authenticate the devices to vote. Our exploratory purposes include our endeavour to harness and explore, through specially configured systems, the heterogeneity and rhythm of the community.

7.4.5 Secrecy: Mapping and intersecting results

To find a balance between protecting the confidentiality of our BullFrog participants and the presentation of their votes on more personal (e.g. household specific) questions, a decision was made to restrict feedback results solely to the community of BullFrog users rather than to publish them online. To this end, every Monday the research team would analyse the BullFrog data of the previous week, which was then printed and included inside a carefully crafted paper envelope together with a Wild Card and a set of new voting cards for the forthcoming week (see Figure 16), delivered to participants' houses on Tuesday mornings. In keeping with the design of the Physical Charts, Bullfrog results for topical questions were visualized as pie charts, whereas day-by-day trends relating to the mood of participating households were plotted as a bar graph.

Within this closed community of BullFrog users, however, attempts were made to highlight certain voting patterns and raise awareness of the different contributors to the process. During the five week period, therefore, Analytics Cards were delivered on two occasions, which showed how BullFrog users had voted, categorised by (i) their physical location on Tenison Road, and (ii) temporal data as to when and at what exact times during the day or night they had voted. The geographical plotting of voting patterns across a neighbourhood (see Figure 21) allows some participants to recognize their own vote in the data as well as some of their neighbours' responses, which can serve to verify results (but may also be regarded as a breach of privacy).

The results of the BullFrog votes were published only within the community of BullFrog users with the exception of their votes on the community question, also presented and responded to by PosterVote and BallotShare users and therefore enabling potential comparisons between data sets. For example, the physical bar chart in the windows of the research office contrasted the community voting results of local residents in their homes (BullFrog users) with those of passers-by voting on the street (PosterVote and BallotShare results). The intention was to attract different members of the community to take a

look at the Physical Charts and thereby invite conversations about the data and the different voter demographics that had informed it.

The research team was motivated to intersect data results from BullFrog votes with PosterVote. In other words, while the results of PosterVote from the previous week were typically printed on the poster for the forthcoming week, at times the results were replaced with those of the BullFrog vote to inform participants how people in their homes had previously voted on the question that was now posed via PosterVote (e.g. “Last week we asked local residents voting from their homes: [question], Have your say: [voting options]”). Similarly, from time to time the results from the PosterVote were included in the BullFrog results envelope (e.g. “Last week, people of the street voted…”) to raise awareness of the other voting technologies available and introduce new ways of engaging with the data.

7.5. Deployment

To invite local residents to consider taking a BullFrog into their homes, the research team drew on interest that some of the residents had expressed during previous community meetings, and also distributed flyers to the neighbourhood. In addition, the project was advertised on a Facebook page and website to include people who had not previously engaged with the project. Residents of 33 local households choose to accept and use a BullFrog device in their home. This included regular project attendees and also people who had not been involved up to this point. BullFrog participants presented a diverse group, ranging from single household occupiers to couples, student flat shares and families of up to six members. In total, these households comprised 54 females and 48 males, with an age range from 8 months to 74 years. Six PosterVote posters were used on the street, with participation invited from passers-by who were presented with a single question per week for the five weeks of the deployment. Finally, 1 to 5 questions were posted per week on BallotShare allowing online voting through multiple channels of participation. Figure 22 depicts a map of the relative locations of the data technologies we deployed in the neighbourhood.

Towards the end of the deployments 14 interviews were conducted with members of the participating households, of which 10 were individual interviews and the remaining 4 interviews with multiple household members (in total 5 males and 15 females, ranging

from 10 to 69 years of age). The interviews were then transcribed in full and I conducted a thematic analysis with a particular focus on questioning how the context and affordances of voting (and resulting data) affect how participation is perceived and enabled.

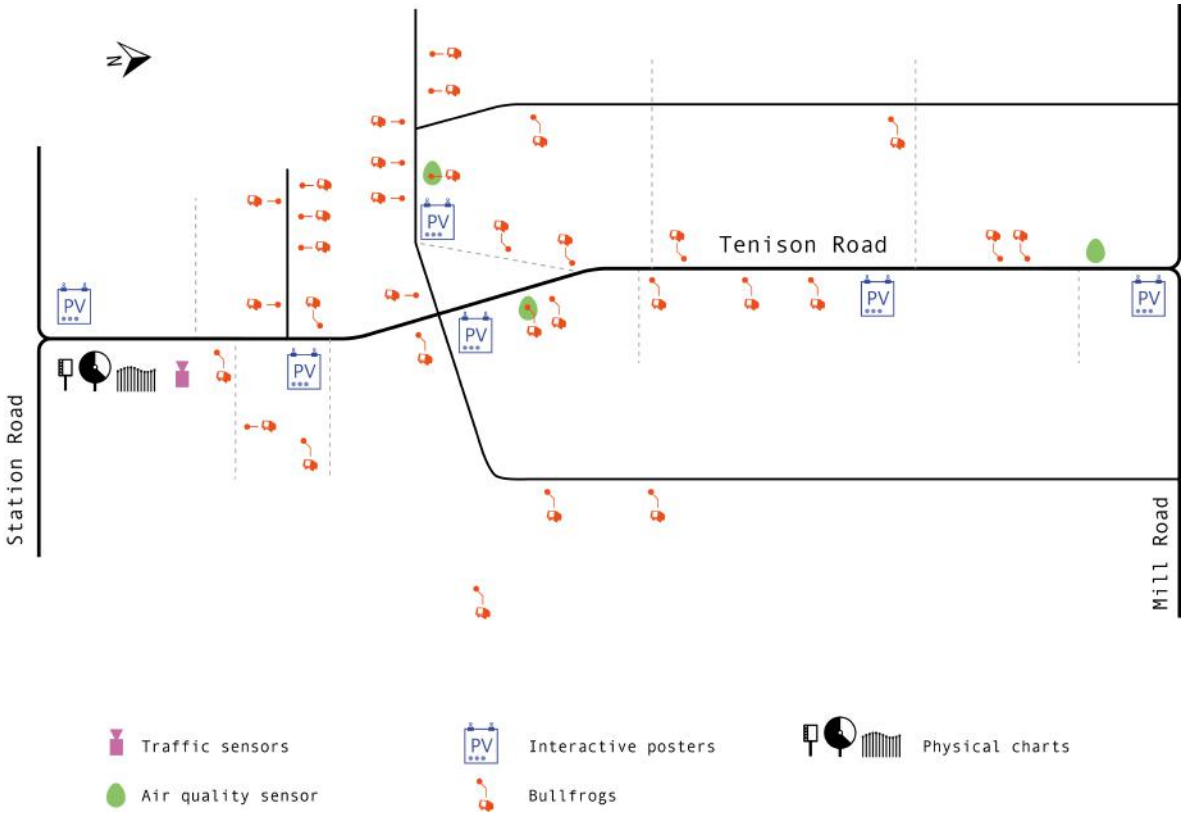


Figure 22. Map of various voting technologies in the neighborhood

7.6. Findings

In total, participants received 60 questions via their BullFrogs over the course of the deployment that comprised 35 mood questions and 25 topical questions. 15 questions were generated by the research team and 10 were proposed by BullFrog users. Over the five-week period, 810 votes were cast via BullFrogs (on average 13 votes per question, *min* = 4, *max* = 27). In general, participants responded more frequently to the topical questions (9 votes on average) than to the daily mood questions (20 votes on average). The number of votes decreased slightly over time, especially during the last voting week which ran into Christmas holidays.

On the online voting platform BallotShare, 348 votes were registered in total, of which only 2,8% (10 votes) were cast by SMS and none by Twitter. In addition to voting, users posted 21 comments in total, 7 of which were received via SMS and 14 entered using the

BallotShare online interface. Finally, 791 votes were collected from all PosterVote posters that ranged from 127 to 178 votes per week. Posters remained on the specified lampposts for a week. Every Monday morning they were taken down for data analysis and replaced with new ones. Even though passers-by were able to vote multiple times, post-voting time-based filtering of the results indicated no significant differences in the actual poll results.

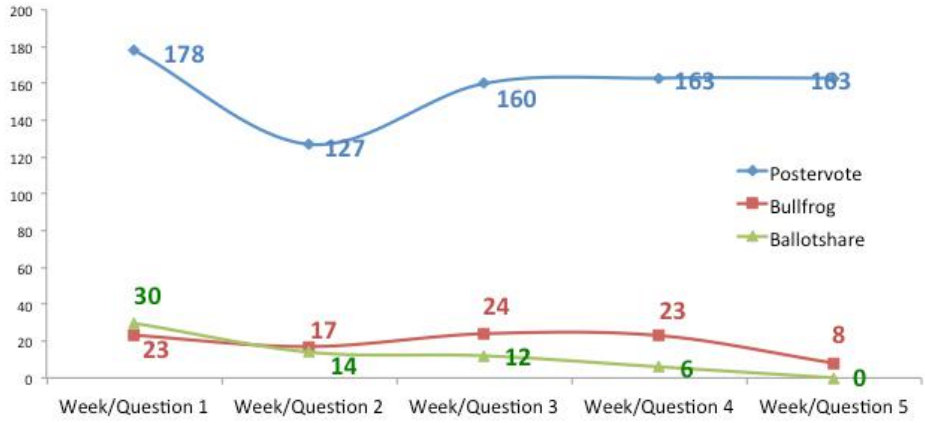


Figure 23. Votes cast for each of the five community questions (one community question per week) across the different voting technologies.

Since the study was not designed as a quantitative cross-device experiment that would allow for scientifically valid comparisons between them, Figure 23 presents a descriptive account of the total number of votes that were cast for each technology on the five community questions they had in common. It shows how vote counts via the BullFrogs were relatively low compared to those of PosterVote (which was expected considering the limited availability of BullFrogs to 33 households). Interestingly however, while one might expect more participation and a higher number of votes for an online voting system, engagement with BallotShare was generally low and decreased steadily over time.

In addition to quantitative measures of the neighbourhood's engagement with the devices, in the remainder of this section I report on main themes that emerged from the thematic analysis: the research lab's influence on participation; community perceptions on voting data; and expression through voting.

7.6.1 Research lab's effect on participation

7.6.1.1 Doing community politics with Microsoft as the facilitator

Whilst carrying consensual connotations, voting also has alternative interpretations depending on who initiates the voting process and what their motivations are: "[…] *But of course the real answer is it depends on who designed the method of collecting the data; what motivations they have, what outcome wishes they have and how fully they give you access to it because most people don't." JP*. Voting on a local or small-scale level can be seen as a political process which mainly seeks affirmation rather than consensus through representative sampling. As a result this puts restraints on the use of voting when support is uncertain: *"But some people are very invested in things, and the idea of invalidation is a big deal to them, I guess. And it's almost kind of, "I'd prefer not to know rather than have my dream shattered". SB.*

For this research the importance of the role of an independent mediator was recognised, to ensure the unbiased operation of the data collection process. This role was assigned to the research team by the community, as Microsoft Research was recognised as the independent third party with no vested political interest in the area (even though the research lab is located in the community). This, however, was not the unconscious understanding that the residents initially had regarding the research group but came after significant time and effort had been invested, both leading up to and over the course of the deployments. More specifically it was the efforts in designing and developing the data collection interventions that made a difference in how the research group was perceived and accepted.

The research team involved were seen to be enforcing the objectivity of the data collection process. This was contrary to the negative way in which local organisations were generally viewed in respect of their use of political data collection tools and processing of data. One of the participants in early stages of this project noted: *"you guys are obviously aliens you 're above and beyond Tenison Road* […], *trying not to be dictatorial* […] *makes you not of Tenison Road"*. It should be noted, however, that residents with a less favourable perspective on our motives (and possible hidden agendas) would most certainly not participate in such a project in the first place. Residents often described voting as a mechanism to mainly serve specific political agendas run by certain

organizations, rather than to collect unbiased data. In this regard, a third party not belonging to the community, and as a result having no political interest in it would have to be the overseers of the data collection process: *"An independent third party would have to be the overseers or the analysis would have to be automatic and much more careful about anonymity." FH.*

The process of voting as an affirmation tool for political agendas was seen as undemocratic, and as a result the fairness of the data collection process was interpreted as a function of ownership of voting systems: *"I suppose the one danger say if you hand it over to the Residents Association or whatever, it becomes then, it is not totally democratic in a way, or it is owned by someone who has vested interests in whatever.* […]" *RB.* In addition to affecting understanding of fair process, system ownership can also affect the way residents vote, as they might choose to vote strategically if a political agenda is involved: *"Yes, I don't mind how they vote at the moment* […] *but if it was for some sort of lobby, I would want to be quite strategic in it.* […]*" RB.* These comments highlighted the community's understanding of the role of the research group in this project as that of a neutral third party with no interest in interpreting or "grinding" the data in a particular way.

7.6.1.2 Community efficacy through Microsoft

The data collection process was perceived as able to bring change, even though most of the questions asked were not politically motivated. This can be justified by the significant and ongoing redevelopment program that might have been creating a sense of helplessness in the community at that time: *"It just gives you a voice I think, which on this road as well with big developments and a couple of big companies and stuff, it's not nice for – I think a lot of people do feel with the development that perhaps they weren't listened to" MM.* Residents cited implicitly and explicitly how our role in running this project contributed in increasing efficacy, with one participant saying that: *"It is sort of, I don't know, it feels like you are a part of something bigger that could change something" RB.*

In addition to our involvement contributing to an increase in perceptions of community efficacy, residents also referred to the deployed voting systems as capable of bringing change: "[…] *There was a really useful one, because I have some real safety concerns about the zebra crossing here. I have felt powerless to be able to gauge other people's*

reactions about it, even to the point of which I don't feel I can really ask my neighbours about it." MM. This quotation exemplifies how asking questions is not only restricted by the lack of technological tools but also affected by social boundaries. An independent third party, in addition to bringing neutrality to data collection, is not constrained by these social boundaries and consequently can act as a community mediator.

7.6.2 Participating for Data

7.6.2.1 (non) Representativeness & (in) Accuracy of data

Self-selection biases, both in participating in the project and in community events, contributed to making the collected data non-descriptive and also to a perceived lack of trust in the accuracy of the data: *"Of course, this is a self-selected group of people who proclaim themselves to be interested in this project by choosing to take the BullFrog." TO.* This was reinforced by the lack of visibility of the voting processes and negotiations in the home: "[…] *I wouldn't feel, to myself, that it was a reliable reflection of the neighbourhood* […] *because you don't know who in the house is answering the questions, either, do you" JP.*

Nonetheless, PosterVotes placed on the streets were perceived as giving voice to a different demographic in the community and thus, in aggregate, achieving a more representative sample. Multiple ways of data presentation allowed for making results more accessible to people with different needs:

> *"I can see the benefit of it is that you're opening up opportunity to people to contribute and understand in as many different ways as possible, so it's about widening dimensions of it so it is convenient to people in different ways.* […] *I think having the variety of means of both collecting it and communicating it is important." TD.*

Multiple voting channels also sparked discussions about the effect of the exact location of voting on data accuracy. Data collected in the streets was seen as less valid, not only because of the exposure of the devices but also because they can invite a more 'flippant' type of response: "*Yes, well I think people are much more flip aren't they? I wonder how much one could feel earnest about the data collected on the street like that. Whereas I think, you know, well I felt very earnest to the tea question* [posted on BullFrogs] *because,*

you know, it does feel like a commitment and I think that would be the difference is as if it's data collected on the street I wouldn't feel so strongly about it I don't think".

7.6.2.2 Factual and Opinion Data

There were different categories of data identified, with different levels of effectiveness to support or change local politics. One clear differentiation was made between *factual* and *opinion* data. *Factual* questions were seen as opportunities to engage with actual community problems; for example pedestrian crossings and traffic control: *"The stuff about asking questions about what we'd like, like the crossing one in particular. I was actually really pleased to see that question because then you can say to people, "Well actually, local representatives for example- there's a problem here and actually people do want a zebra crossing or whatever"*. As a result the devices were seen as possible levers of change if more factual questions were asked and put into a specific context: "[…] *it would be those kinds of things, the things that people think that the data provides the lever, if you like, which we may not be getting by other means, so there will be quite a few people who will be strongly motivated by that"*.

Some of the questions asked were innocuous, aimed at generating data for local consumption and self and community reflection. However, their lack of efficacy was critiqued. This is not to say that data collection for community reflection is meaningless, but rather perceived in this case as the collection of subjective information and "*opinions, as opposed to* […] *hard data"*. This assessment might have been driven largely by the outcomes of the data collection process, which in this case were not apparent: "[…] *At the moment it still feels like we have information but we're not doing anything with it. I'd like to see a positive outcome of it rather than just a purely academic sense of what's going on." RK*

7.6.3 Participating for Expression

7.6.3.1 Material voting in the home

In interviews, BullFrog users commented on how they had appreciated the physicality of the small standalone device and its paper card interaction, and on how it contrasted with other means of voting such as voting online. In this regard, giving the BullFrog a place in their home, continuously displaying and rotating through questions, was considered to

have increased the visibility of the polling process and drawn people into it . *RK* for example shared: *"I think just by making it different and making it physical makes it disruptive and makes it part of your home rather than just part of your internet life, which has all sorts of other things, there's Facebook and so on. It wouldn't necessarily stand out on the internet. It's nice being part of your furniture and being connected in a different way."*

It addition to acknowledging the visual presence of the BullFrog, looking back on the community project, participants also described the act of choosing and entering a response card into the device as a more deliberate process: "[…] *with a touch screen it's just like, tap – done, but looking through the cards, this is the answer I want, in out.* […] *It's not like, as I was saying earlier, a tap on the Smartphone, it's a vote." BM.*

Although the card interaction was valued for contributing a sense of commitment and permanence to the voting act, this was complicated in situations where participants felt that the fixed set of response options (maximum 124) did not reflect their opinion. In those cases, participants either entered a proxy response or abstained from voting. In the presentation of the voting results, however, a differentiation could not be made as to whether a household had deliberately abstained from voting or simply not taken part in it. Talking about one of the Analytics Cards, *JS* explained i.e.: "[…] *I don't think that properly represents the fact that I didn't vote.* […] *Just that I felt that the three options were not enough to – and that it's better to not vote. If there isn't an option that actually says what I mean to say, I'd rather not vote."*.

Participants expressed the fact that they had experienced difficulties at times in identifying a response card that would most appropriately express their position. They also believed their vote would be binding, and that scope for more fluid expressions or potential transitions was restricted. Regarding the daily question asking about general mood, ML described her difficulty in having to commit to one specific mood label as: "[…] *Because it's like writing something down, you know, then you've nailed it, then why just stay grumpy the rest of the day?* […]".

7.6.3.2 Whose vote? – Negotiations in the home

Participants, who were sharing their BullFrog devices with others in their home, highlighted the negotiations and discussions that occurred in order to, when possible, decide

on a vote that would reflect the opinions of the whole house. One participant further described how in their house they took straw polls to collectively decide which option to vote for. In another case, participants explained how voting can become territorial: "[…] *The older one was less engaged than I'd expected and there was a few fights about, you know, the last vote. Then I think it became territory a bit – well everything is territory isn't it? And so one person just gives up, abstains from, because he is not interested in that territory."* ML.

Descriptions such as the latter were particularly pertinent to family households. Here, parents would describe how the co-located BullFrog device was particularly empowering for children, as it gave them the chance to have their voice heard: "[…] *I think it's maybe about that as an adult you get to make all the decisions and they rarely do, and this was a possibility to own the response really and speak for everybody else and I thought it was very powerful for them." ML.* At the same time, however, it was important to the parents that the vote cast was representative of their household. This became particularly apparent in one household where a parent realised, by looking at a results card, that her child had voted for what she considered to be the 'wrong answer', *ML*: "*Well, yes. It wasn't about being judged myself, it really was just "That's the wrong answer". I hadn't really thought of it in those terms before, then that for me was just, "Oh my God we voted that" rather than worrying about what other people think".*

ML described how what she perceived as a misrepresentation of their household was less of a concern in terms of what other people in the community might think; instead it became a point of discussion within the family around values and the general upbringing of the children. As one of the participants noted, voting at home through BullFrogs *"becomes a much more kind of complicated human problem* […]*".*

7.6.3.3 Reflection and Dialogue

Both the nature of the 'innocuous' and not directly actionable poll questions, as well as presentations of the voting results, were described by participants to have invited reflection about the community. Describing her engagement with the BullFrog questions:

> *"I think what's positive about this were the questions about, you know, "Have you talked to anyone on the street?" "Do you feel there's a sense of community?" because then you reflect on it and then you think, "Oh, you know, I*

haven't talked to anyone for three days. Why would I, why is that?" The questions are more provocative in a sense than the data itself." ML

As described previously, participants engaged and made sense of the data differently. In this regard, some stated that they had identified trends in the voting patterns of others similar to their own, which they interpreted as an alignment with their own opinions and beliefs which was in turn perceived as nurturing a sense of community. Others highlighted differences in how they had voted, describing their 'dissent' as possibly detrimental to the community, and recognizing a need for more opportunities to debate. Yet, although the poll questions and findings were found to raise awareness of community and community matters, the design of the BullFrog device and result envelopes did not offer any functionality to support dialogue beyond the level of the individual or household. Participants acknowledged that face-to-face meetings were necessary to achieve more meaningful community participation, therefore evaluating the BullFrog device as a:

"[…] *vehicle into other ways that communities can engage with each other and participate in local issues and things. They're not meant to be the final – otherwise obviously the functional is pretty minimal. That was what was interesting to us: how does it, if at all, create other networks. Is that something you've found?"*

One of the participants proposed the creation of occasions for sporadic meetings that would require participants to call into the research team's office, viewing it as a central meeting point: *"Yes, and actually if you were doing it again, maybe run it over a longer period and do more firmware updates so people have to bring them in and then bump into each other"*. However, attendance at two weekly meetings planned for residents to come together was generally low.

7.7. Reflection on Design Framework

The findings I reported in the previous section related to three main themes: biases introduced by the research lab running this project; community perceptions of the data collected and whether participation was enabled or prohibited; channels through which the participants expressed their opinions. In addition the lack of affordances have been discussed, which in many cases prevented adequate participation to emerge. In this section I discuss main aspects of the findings while relating them to the design framework.

In this regard, I attempt to elaborate on some of the questions raised earlier (see section 7.3) and also revisit some of the decisions that informed the design.

7.7.1 Context

In this project I was particularly interested in the context in which we deployed our voting devices and data representation methods. It is without question that the context, referring to issues related to the ownership of the system, the initiator of the process, the social and physical geographies of the community etc., have a significant effect on whether and how people participate. This raises methodological questions on the validity of community engagement projects in HCI as typical motivators of participation. Self and collective efficacy might be a result of the biases introduced by the context rather than a result of the deployed prototypes.

The participants perceived the role of the research team as an independent third party to oversee the data collection process. In this regard, the team's initial assumption that their physical location in the community would provoke distinctive results was not materialised, as they were seen as a neutral party that enforces objectiveness. This was perceived as necessary, especially when data was intended for informing actual change in the social or physical geography of the community. More specifically, residents were sceptical about voting, as previous voting exercises in the neighbourhood, primarily led by the residents' association and local council, were not designed to collect a representative, democratic sample but for the affirmation of specific political agendas. It is possible that the abstention of Microsoft from the community's everyday practices, the apparent indifference of the research group (as a big organization) from the community's politics, as well as the time and effort invested in design interventions and meetings, all played a part in contributing to the community's perception of the research group as neutral and objective.

In addition to neutrality, participants' comments cited a sense of increased community efficacy and empowerment. In some cases these comments were specifically linked to the affordances of the devices – e.g. the posters on the street increasing the sense of the community being able to act collectively, and in other ways the project itself was cited as able to bring change. According to the interpretation of the data, the content of the questions in addition to the research team's involvement in the project were the main variables

affecting perceptions of efficacy and empowerment. Residents felt empowered mainly when inherently political questions were asked – questions relating to actionable changes in the community or council plans – which combined with the leading role of the research team in the project led to a sense of increased efficacy.

The lack of representative and accurate data, as reported by residents, possibly reduced the perception of data as actionable. Residents cited self-selection biases as one of the main problems of representativeness, as the participant sample included residents wanting to participate in the project and generally active in community matters. This posed problems not only for the representativeness of the community data but also for research data collected for HCI e-voting projects. For example, as discussed earlier, participants perceived Microsoft as independent and politically neutral and as a result were willing to participate in the project. However, this is also true for residents that abstained from participating: they chose not to participate either because they did not value the original motivations for the project or because they were sceptical about hidden agendas. This did not affect the view that an independent third party was needed for the collection of 'accurate' data; it highlights that Microsoft was not necessarily perceived as such, at least homogenously.

7.7.2 Eligibility

One of the main considerations from the outset was the re-association of data with place. In this last phase of the project I questioned how re-association could be materialised with regard to eligibility – who would be eligible to participate, own, and manage the data, and how? The intention was to bring together the multiple "small worlds" and question how people with different interests and practices could come together through data.

A tendency for community residents to interpret community as something homogenous and fixed was noted. Many of the result cards for BullFrog devices, and data collected from PosterVote, represented data analytics that varied geographically across the community. However, similarities were a feature more than differences, with similar viewpoints being interpreted as a sign of 'community'. On the contrary, where dissent and multiplicity were apparent and visible, participants tended to question the notion that a 'sense of community' existed.

Eligibility also relates to an entitlement to ask questions and to nominate options to polls. Innocuous and apolitical questions were initially selected, with residents then being asked to send their own to be posted on the various voting devices. Some of the participants using Bullfrog devices noted that the option cards did not necessarily reflect their opinion, and as a result the devices did not allow for effective expression. Amongst the objections raised was that abstaining from voting was visualised on results cards as non-participation and this was perceived as an ignorant assumption in respect of the community. According to one participant, not voting for a question does not necessarily mean indifference but can also relate to either making a political statement (by abstaining), or the fact that the affordances of the device do not facilitate appropriate participation.

7.7.3 Fairness

Data accuracy and possible disproportionate vote weighting are main determinants of fairness in voting. From the initial stages of the project, residents referred to data collected by the council (sensors counting traffic on the street, surveys about noise levels etc.) as "data being done to us" rather than "data coming from us". This was from the beginning an interesting distinction, especially due to the notion of subjectivity accompanying council's data collection methods. The accuracy of the BullFrog and PosterVote data was thoroughly discussed, with participants questioning their efficacy. Three main reasons affecting the community's perception of accuracy were identified: the type of question asked; the perceived representativeness of the sample; the locations of the voting devices.

With regard to the type of question, a distinction between "opinion data" and "hard data" was cited, with opinion data referring to data collected through innocuous questions and questions about household characteristics, and hard data as "objective data" relating to factual problems in the community (e.g. whether a pelican crossing should be installed). The former category of 'opinion' data did not provoke discussions about accuracy (possibly due to the need for change via participation in an actionable poll) whereas the latter did. Using a different lexicon, 'hard data relates' to the category of data "for doing politics" in the community, referring to data able to facilitate its governing.

Concerning the representativeness of the sample polled, participants cited the relatively low number of residents that chose to participate in the project by taking a BullFrog, thereby introducing significant self-selection biases. As a result, BullFrog data was not

seen as accurate enough for use to support a particular case. However, the additional voting channels used (i.e. PosterVote etc.) were appreciated and the combination of data from multiple devices was seen as a more accurate representation of the community. The representativeness of BullFrog devices was also questioned due to the vote overwriting feature. There was no feature to visualize the last vote counted in the house, even though this motivated discussions and interactions.

The exact location of voting devices also affected considerations of fairness. PosterVote on the street was associated with the collection of more "*flip responses*" compared with responses made via BullFrog devices in the home. Participants felt earnest about their votes at home, possibly due to a sense of commitment created by the visibility of the community's votes on the temporal and spatial analytics cards. Finally, BallotShare, due to its detachment from the community (being online), was not used by BullFrog users in order to gain any understanding of its effect on data accuracy.

7.7.4 Secrecy

One of the reasons for deploying multiple voting devices in parallel was to understand and support the multiple smaller community groups and interests by making them visible and allowing them to intersect. As a result, we increased the visibility of data in a number of ways, for example by printing data on posters on the street, using the Physical Charts, and sending Analytics Cards every week.

The visibility of the data resulted in participants interpreting community through data – by identifying homogeneity or dissent. The Analytics Cards were of particular interest as they mapped votes on a physical map allowing participants to compare how different areas had voted. In some cases the low number of residents having a BullFrog resulted in making the association of a vote with a house possible, and as a result there were violations of privacy. This highlighted a tension between maintaining privacy whilst participating in community, in other words some residents wanted to be part of the community but were uncomfortable about sharing their personal data. This might require a re-evaluation of community privacy and how a voting model might be implemented to maintain residents' privacy whilst allowing the interpretation of community through its data.

Finally, in some cases the lack of visibility of some of the processes underlying a vote was seen as limiting the representativeness and accuracy of the data. One characteristic example was family voting, which due to the lack of transparency of the internal processes and negotiations that resulted in a vote, was perceived as not accurately reflecting the will of the entire household.

7.7.5 Expression

Multiple channels were provided for people to participate, either through situated devices for increased access or through online voting, with anticipated coverage of a wide range of requirements for expression. Participants, however, cited a lack of affordances for dialogue and negotiation. The devices (BullFrogs and PosterVotes) supported the collection of votes but without allowing any further argumentation or affording the suggestion of additional poll options. BallotShare, which was the only system designed to allow discussion through its online interface, Twitter and SMS comments, was not used as much as expected.

Nonetheless, the voting devices were perceived as the first step towards more meaningful participation as in many cases they provided the stimuli for situated discussions. Face-to-face meetings were important (partially due to the inability of the devices to support dialogue) in order to create a sense of community and the materialization of more meaningful participation, e.g, by organizing an offline activity.

The physicality and materiality of BullFrogs provoked negotiations and in the home. A number of participants and especially families cited debates for the last vote (as vote overwriting allowed only the last vote to count), or took part in straw polls to decide who would be eligible to cast the last vote, creating an additional democratic practice in the home. Even though this was perceived as a positive interaction, participants also raised concerns about the lack of representativeness – as one vote did not represent accurately the aggregate opinion of the household, with multiple voting therefore being a suggested alternative. In general, due to the negotiations initiated by the physicality and location of the device, voting was perceived as a process rather than an instantaneous action.

As a result of the findings, the devices need to afford and capture additional channels of expression (rather than mere participation), with dialogue and methods for community self-organization being of particular significance. Negotiating the vote in the home was a

positive outcome of the BullFrog design, with democratic practices in households contributing to the educational function of participation [146].

7.8. Limitations

The case study reported in this chapter, as part of the bigger project led by Microsoft Research Cambridge, was not specifically designed to focus only on the affordances of e-voting systems and community perceptions of data. Rather, the project was far more generic, exploring the association of data with place (see [186] and [125]), data when viewed as polling data, data captured from air quality sensors, traffic data etc. As a result, due to the project's more abstract focus, it was not possible to control specific variables that would allow a valid quantitative comparison across voting devices.

In addition, a wider sample of participants, including pedestrians, or residents that decided not to participate by using a BullFrog, would have contributed to a deeper understanding of motivators of participation and the effect of Microsoft on participation. As previously mentioned, for this last phase of the project we attempted to include as many people as possible and specifically residents of neighbouring streets that were not involved in the earlier stages of the project. We achieved that to a certain degree by delivering 250 leaflets for Bullfrogs in areas that were not very well connected with the main street of the community. This resulted in the installation of devices in households of people with varying levels of engagement with the project. Interviews with BullFrog users revealed interesting insights into the way devices were used, and into perceptions around collected data. The effect of decisions made relating to design and context, and impact on neighbourhood participation, was also brought to light. It should be acknowledged that interviews with people who made a deliberate choice not to participate, and additional methods such as observations (e.g. for PosterVote use or misuse), would have further contributed to the findings of this study.

7.9. Conclusion

In this chapter, through the deployment of a series of e-voting technologies in a local community, covering a number of settings from situated to online, and from private to public, I explored the effects of the context and the affordances of voting systems on participation, and residents' understanding of the deployed technologies and data.

After a five-week deployment of six e-voting channels and five data representation methods in a local community in Cambridge, I identified three main variables that had an impact on participation: the research lab's involvement in the project, seen as a facilitator that increased perceived community efficacy; the distinction between "factual" and "opinion" data and the effect of these on doing politics; and the practice of voting as a method of expression.

Chapter 8.

Discussion

In this thesis, I introduced a novel conceptualisation of designing voting systems for the political, which in combination with a critical review of work being done in computing science and HCI, enabled me to work with a research team to materialise a design framework of voting for participation in the political. After thoroughly discussing the theoretical background in politics that influenced this inquiry, I described a novel and extensive framework that invites reconsideration of the affordances of voting systems for participation. I have understood participation here not necessarily as the simple quantification of ballots to reach consensus, but as the involvement of citizens in a condition of on-going contestation and 'dissensus' [136], what C. Mouffe calls participation in 'the political' and the creation of 'vibrant public spaces of contestation' [135,136]. Through the multiple configurations of voting systems being used in my empirical work, I have investigated the validity and fruition of this political concept for voting.

The last three chapters of this dissertation have documented the process of designing, developing and deploying voting systems for contexts ranging from workplace environments to local communities, and from voting for planning proposals to building a sense of community. These deployments have provided a number of insights into the role of the affordances of voting systems and other contextual parameters on the type and level of participation achieved. In this concluding chapter I revisit the research questions that I identified in the introduction, list my contributions and implications for designing voting systems for the political and propose possible avenues for future research.

8.1. Politics and the Political in Voting

At the beginning of this thesis, the relation between design and politics was extensively discussed. By taking L. Winner as a starting point, and by referring to physical objects such as bridges in New York that embed politics in order to configure social relations and infrastructures in cities, I highlighted the importance of design in configuring power relations. I argued that such assumptions of politics are also prevalent and embedded in the design of voting systems and highlighted the need for rethinking how voting systems can be designed to question accepted conventions by providing alternative, more fluid types of participation and democracy. Chantal Mouffe's theory of agonistic pluralism played a pivotal role in grounding this discussion and talking more concretely about how the features and affordances of voting systems serve the doing of politics rather than an increase in political participation.

This conceptual demarcation between politics and the political in voting allows for the questioning of traditional configurations of voting and the development of a design framework that enables the design of voting systems for various types of political participation. I define 'design for politics in voting' specifically as follows: (i) the efficiency of the voting process in terms of its cost and speed; (ii) increasing the availability of the voting apparatus by facilitating access through multiple communication channels; (iii) the focus on the quantitative accumulation of voters' opinions, with the ultimate aim of reaching a consensual decision; and (iv) the hierarchical, top-down approach of a system's use, including eligibility for asking questions and driving voting agendas.

Political design in voting can be defined as: (i) facilitating political participation instead of merely increasing turnout, which involves "qualitative voting" and the provision of spaces in which opposing political viewpoints can be envisaged and contested; (ii) highlighting the political process generated from the application of voting in a context rather than the consensual decision that results from it (which includes the constructive utilisation of dissent); and (iii) focusing on facilitating the bottom-up approach, which relates to the enablement of self-organization, the questioning of power relations and the openness of technology to allow anyone to drive their own political agendas (which involves coming up with sustainable e-voting designs in terms of their monetary cost, and the technical expertise needed).

BallotShare serves as the first platform that through acknowledging the politics of design in voting, enables the exploration of the effect of the affordances of voting systems on political participation. Through the configuration of BallotShare for a working environment my first case study revealed how the system's features allowed participants to question its inclusivity and representativeness through making power hierarchies more visible. I reflected on how design decisions which enable influence to be exerted affect the accountability of the voting process, and also considered how the notions of secrecy and privacy are contextual rather than fixed. In this regard, this initial case study exemplified how voting can be thought of as a political process rather than a tool for reaching consensus through the accumulation of votes.

Through the design, development and deployment of PosterVote I extended this inquiry to other contextual parameters such as the ownership of the voting system, and how this can affect political participation in voting. The case studies reported in chapter 6 exemplify how the design of flexible and sustainable e-voting systems can allow their appropriation in different ways in order to support various governance models and political structures. As a result, PosterVote is one of the first systems that demonstrate how the rhetoric of agonistic pluralism can inform the design of concrete digital systems. This requires the acknowledgement of the politics embedded in the design of sociotechnical systems, an area of design attracting increasing attention in the HCI community. The work presented in this thesis and specifically the systems described in Chapters 5 and 6 provide us with one of the first examples of how agonistic pluralism can be productively manifested in the context of voting.

Finally, through the parallel deployment of voting systems with varying affordances, in chapter 7 I explored how the various design assumptions embedded in these systems also affect how data is produced, understood in a specific location , and further utilised. As a result the politics of design (in this case of design in voting) impacts how various stakeholders perceive the collected data and consequently relate to the politics of data.

8.2. The Application of Technology in Voting: Civic-centered Security

In this thesis, in order to build the argument that current work in e-voting focuses on the 'politics' rather than 'the political' I reviewed work in three seemingly different areas of

research: computer security; usability, accessibility and trust; and civic engagement. Whilst acknowledging the variance of the work in these areas, by reporting the state of the art in each one of them I attempted to highlight the politics embedded in certain methodologies and practices in the fields most active in e-voting research. All three areas of research share common characteristics that drive the majority of the development in the equivalent areas: they facilitate the methods, structures and mechanisms that enable governing and as a result, according to Mouffe, they serve 'politics'. This results in essentially accelerating a hierarchical top-down model of representative democracy by making voting more secure, more usable, and more accessible through multiple channels of participation or user-friendly interfaces. In this thesis I investigated the political design of e-voting systems, recognising systems as capable of creating vibrant public spaces of contestation in which different opinions and political projects can be democratically confronted. For apparent reasons, a major driver of e-voting innovation is computer security and information encryption. In this section, I attempt to highlight the implications of this conceptualisation of politics, and also discuss 'political in voting' in terms of computer security research.

There are three main philosophies which come into play when considering democracy and digital technology [196]. The first is based on technological determinism [177] and embraces novel technologies as important steps in human progress. This philosophy assumes that the "retooling" of democracy [196] will by definition facilitate the negotiation of differences, lead the way towards collective action and problem solving and as a result serve democracy in the new world. This philosophy presupposes that amplifying the initiative and referendum processes to support a system of direct democracy will by definition upgrade our democracies. On the other hand, technology dystopians [86], who emerged from phenomenology, are sceptical about the impact of digital systems and communications as they can potentially disrupt socio-political life. Their main arguments lie in the qualities of contemporary society and politics such as situated deliberative workshops and face-to-face dialogues. Finally, technorealists [203] suggest that citizens need to think critically about the role that digital technology and designed tools play in their everyday life. From this point of view, technology should be assessed taking into account the impact of innovative tools on human values.

Computer security research mainly follows a technologically deterministic theory, uncritically supporting progress and assuming that the application of technology and security in any social or political practice will by definition lead to its advancement. As a research discipline that mainly originates from the military, there is a tendency towards perceiving users as adversaries and consequently limiting users interactions with the system to the minimum possible: *"Security is only as good as its weakest link, and people are the weakest link in the chain."* [172]. Even though steps towards usable and user-centered security have been made, we are still far from reaching a truly user-centered or experience-centered security [59].

In this thesis and through my deployments I have exemplified how such a user-centered understanding in security should be extended to a *civic-centered* one. Civic-centered design should also aim to empower citizens to question the state of a given system, its design as a whole and the contribution of the system's design for democracy. Issues such as ownership of the design and system, the representativeness of the data produced as a result of its use, and the mapping of paths leading from actions and system states to democratic action, should all be founding principles of a design to support citizen participation and democratic practice. This makes designing civic-centered security systems more challenging as instead of people being perceived as the weakest link, they have to be effectively transformed into the strongest ones- as they should be in any healthy functioning democracy. This transformation from a system-centric to civic-centric approach on security also requires questioning the assumption that security research is politics neutral.

'*Participatory security*' can be viewed as a property relevant to many other factors seemingly disconnected from the actual mathematical security of the system. Examples include levels of participation, how well informed the electorate is, citizen involvement in the election process, deliberation etc. When interpreted in this way, election security, in addition to traditional mathematical verifiability may depend on, for example, channels of citizen communication that empower them to voice their opinions even in cases where the prevailing political choices do not represent them, and new methods of analysing citizen input – e.g. qualitative voting as complementing the quantification of ballots, new ways of maintaining the integrity of a complex verifiable digital voting system by the

involvement of people in a transparent process, human-based computation [155] cryptography, and others.

Consequently, I contend that current research on e-voting is assessed against only a subset of the e-voting requirements, specifically the conventional information security ones. If we abstract ourselves from the technical peculiarities, it is clear that these systems fail to achieve a democratic society's goal: to provide a secure, participatory e-voting platform where integrity is assessed according to its contribution to democracy. This connection between voting systems and democracy is undermined by existing developed systems or at least only considered through the lens of the encryption-based security of systems.

8.3. Research Questions

8.3.1 How do we design for politics and the political in voting?

Designing voting systems that enable contestation and dissent is an endeavour that in many cases comes into conflict with an understanding of voting essentially as a consensual tool. This was something that I came across through my empirical work, where my participants' perceptions of voting were in many cases aligned with tangible decision-making processes that required viewpoint convergence. This was related to contextual factors. For example for questions with content linked to actionable decisions, consensus was seen as necessary and as a result some of the features that brought dissent to the fore were perceived as inappropriate.

BallotShare was successful in engaging colleagues in situated discussions and creating political processes around the vote. Even though participants' understanding of voting was primarily consensual, they were more interested in being part of the voting process and were less concerned about the voting result (see 5.3.1 Social Visibility and Inclusion). This may have been due to a lack of leadership and commitment from the poll organizers to materialize the voting data (see 5.3.2 Commitment and Accountability). Consequently the identified lack of efficacy of the vote, although lowering participants' interactions with the online system after the initial weeks of deployment, contributed towards participation in a political process with regards to the situated discussions, the questioning of decision-making hierarchies and the utilization of the system's capacities for strategic voting. In future work I intend to adapt and instantiate BallotShare for the particularities

of additional contexts in order to further explore how the affordances of voting affect participation in the political (also see 8.3.2).

PosterVote was designed specifically to support the practices of local activists and as a result mirrored some of their existing conventional ways of campaigning, which are inherently political. The various unsupervised locations where the devices were positioned and the delegation of the setting up and maintenance process (from researchers to community activists) enabled activists to perform political tasks (e.g. talking to shop owners on the street) which were unrelated to the actual collection of quantitative data (see 6.3.1 Case study 1: Road planning group). This also relates to the purpose of the data collection process, as campaigning is by definition political: for the campaign to be successful, the creation of a collective with shared goals and values must be created, which involves politically motivating residents and shop owners towards the campaign's goal. Contrastingly, the regeneration group, which acted more as a hierarchical organization (see 6.3.2 Case study 2: Regeneration group), used the devices more conventionally and as a result more as a device for facilitating the doing of politics in the community. This highlights the fact that the democratization of technology, in spite of having the potential to facilitate political participation, can also be used to reinforce existing power structures. In future work, I will consider how PosterVote can effectively and sustainably reach local communities through the utilisation of its open source hardware design and code. Finally, PosterVote will be considered in the context of supporting self-organised communities in order to make adjustments to and facilitate alternative methods of governance and decision-making.

One of the findings of the community engagement project in Cambridge (see Chapter 7), was that 'community' was perceived as a homogenous entity, bound with a broader sense of alignment with others, with dissent being perceived as an indication of a lack of community (section 7.6.3 Participating for Expression). This was stated by a number of residents even though for many questions diverse sets of answers were given, which were made visible in place through our multiple methods of data visualization. This implies that the contestational nature of agonistic democracy might come into conflict with the creation of 'community', in which homogeneity is perceived as necessary. However, this finding is contingent upon the lack of affordances of our voting devices to enable the

creation of vivid spaces where different viewpoints could be challenged. Alternative designs and more meaningful channels of communication could have created avenues through which dissent could have been constructively manifested and as a result been successful in facilitating community engagement through agonism.

Questions asked by the residents were related to palpable problems that demanded, or appeared to demand, a 'politics' approach to be resolved (section 7.6.2 Participating for Data). These perceptions originate in part from traditional connotations of voting, however, they might also be influenced by the demarcation of community problems themselves. For example, existing ways of doing politics locally results in matters of debate to be defined and framed in a very specific way, and leads to a need to quantify opinions that can only by mediated through conventional means of voting. In order to incorporate voting systems at the local level designed for the political, a change might also be necessary in how politics is practised .

8.3.2 How do systems' affordances affect participation in voting?

Each one of the novel voting systems described in Chapters 5, 6 and 7 were designed, through their capacities, to extend the repertoire of political participation. My empirical studies underlined the significant effect that the affordances of voting systems have on the type and level of participation achieved. In each one of the preceding chapters I have provided a thorough account of how the design affordances (of the voting systems presented) influenced participation.

For my first exploratory case study (Chapter 5), BallotShare was configured to reflect on the democratic practices of a workplace environment, by leveraging the gathering together of people in the same area. Participants' actions on the system were made visible to motivate argumentation about individual choices (see 5.1). Pairing this transparency of actions with a collection of affordances such as vote revocation, and multiple voting, enabled the surfacing of a political process to replace transient voting (section 5.3.3 Contextual Privacy and Exerting Influence). Furthermore, the visibility of participants' actions stressed the existence of hierarchical structures that were not salient, even though most of the questions asked were related to social events and other innocuous group decisions (section 5.3.1 Social Visibility and Inclusion.) As a result, the placement of a

voting system in the workplace revealed informal power relations and actuated the political in contexts in which politics were obscure and practices unknown.

In Chapter 6 I introduced PosterVote, a situated voting system designed to allow sustainable electronic voting in place. The sustainability of the PosterVote devices, allowed its utilisation by both individual activists and locally organised community groups that brought to light different ways that PosterVote can be appropriated to support different needs. The different ways in which the two communities used PosterVote for opinion collection, revealed diverse insights into interactivity, representativeness and social norms (section 6.3). For example, for the regeneration group, multiple voting was not perceived as affecting the representativeness of the data as the context in which the devices were used and the supervision of the process by community members enabled social norms of voting (e.g. one-person one-vote). Overseeing the voting process also initiated discussions between the community group and visitors as the lack of privacy of the vote motivated voters to justify their choices (section 6.3.2.1 Interview data). In this respect the voting system acted as the first step towards more meaningful participation, serving primarily as a tool to enable the political rather than facilitating the actualisation of local politics.

The road-planning group placed multiple PosterVotes unsupervised on the streets, and as a result situated discussions were not possible. The community activists cited problems of visibility of the voting posters, as their size and form prevented distinguishing them from planning notices (section 6.3.1.1 Interview data). In contrast to the regeneration group, placing the voting systems on lampposts permitted their possible abuse, which had an affect on participants' interpretations of data accuracy. The activists appreciated how PosterVote allowed the configuration of the participating demographics by their explicit positioning. However, participants raised concerns about the representativeness of the data, as their location also excluded specific demographics – for example people that do not walk along the streets. This was seen as a problem, as demographics are of particular significance for the representativeness of data for campaigning purposes (section 6.3.1.1 Interview data). Nonetheless, the posters primarily served as raising visibility about the campaign, which distinguished them from conventional methods of data collection (e.g. door knocking).

For both contexts (regeneration group and road planning group), the materiality and affordances of the voting system enacted the political in different ways, either by enabling situated political discussions or, in the case of the road planning group, allowing community residents to raise visibility about issues by placing the devices in the neighbourhood (section 6.3). In the first case, this was an outcome of the interactivity and novelty of the device, as its form and simplicity acted as a stimulus for discussions in the festival, whereas in my second case it was the low cost and sustainability of the technology that opened a new space of political engagement for the local residents.

Finally in Chapter 7, I described how multiple voting devices and channels can be used in parallel to allow participation of disparate groups with varied rhythms in a local community and how, amongst others, the affordances of the voting systems enabled or questioned this participation. With regard to the system's affordances, the situatedness and materiality of BullFrogs in residents' households played a significant role in the participants' expression (section 7.6.3 Participating for Expression). The physical form of the devices, answer and analytics cards enabled participation in the home in forms dissimilar to conventional voting. Features such as vote overwriting allowed negotiations about the last vote to emerge, whilst having the devices in people's homes provoked reflection on the polled issues and dialogues taking place there (section 7.6.3 Participating for Expression). The process of voting by using a BullFrog was seen as a process and a deliberate act that was explicitly differentiated from other means of digital voting through online websites and apps. This was a result of the material form of the BullFrog, answer and analytics cards that gave a sense of permanence to the vote while enabling in-situ discussions (section 7.6.3.1 Material voting in the home). Nonetheless, the limited number of answer cards, in addition to the lack of affordances of the devices for community discussion introduced barriers to more deliberative participation. The analytics cards were of particular significance for the project, as they highlighted the distribution of the votes across the community by geographically mapping the results. The transparency that the analytics cards introduced, initiated tactical voting, and also brought to light residents' understanding of community as homogenous.

BallotShare, the only system designed to allow discussions through its online interface, Twitter and SMS comments, was not used as much as had been expected. Nonetheless, the voting devices in homes, on the street and online were seen as the first step towards

more meaningful participation as in many cases they provided the stimulus for discussions in offline community activities such as weekly planned community meetings. Concerns of data representativeness were raised, especially around questions relevant for bringing change to the community. However, the multiplicity of devices designed to allow disparate demographics to participate, in addition to the transparency of the process and results, addressed some of these concerns (section 7.6.2 Participating for Data).

8.3.3 How do contextual parameters affect participation in voting?

A range of contextual parameters were explored in this thesis, and included the type of questions asked, the stakeholders affected by the implementation of a decision, the ownership of the voting system, and the social and temporal geographies of the environment where the voting process occurred. My first case study (Chapter 5), as a first enquiry of the design framework of participation, had a particular focus on the affordances of the voting system itself rather than the effect of the context on participation. Nonetheless, even though the questions asked were theoretically apolitical, the existence of the voting system in the workplace and the democratisation of the decision making process that this resulted in, brought to light hierarchical structures and power relations that were not immediately visible from the outset (section 5.4).

In my second case study, the use of the PosterVote devices by the two local groups in different contexts (i.e. in the first case as a tool for collecting data on the street for campaigning, and in the second as a survey tool on table stalls) allowed us to collect more concrete data about the effect of contextual parameters on participation. The regeneration group valued the devices in respect of enabling them to collect opinions that would otherwise have been harder to collect and process, citing conventional surveys as time consuming and tedious (section 6.3.2.1 Interview data). However, opening up the ownership of the devices to the rest of the community was viewed with scepticism. This scepticism can be interpreted as an attempt by the regeneration group to preserve recently enhanced power within the community and the utilization of the voting devices for this purpose (section 6.4.3 Governance).Conversely, the road-planning group valued the openness of the device and broadly supported the bottom-up approach of collecting opinions, comparing it with doing consultation exercises (section 6.3.1.1 Interview data). As a result, even though with low-cost and openly available devices for opinion polling, the

possibility to engender citizen political engagement can be fulfilled (e.g. road planning group), and open technology can also be used to reinforce existing power structures (e.g. regeneration group).

In Chapter 7, I predominantly focused on contextual factors, external to the design features and affordances. I identified how the involvement of Microsoft in this project affected residents' participation by seeing the research lab as the facilitator and the neutral third party to ensure the unbiased collection of data. This was possibly due to a number of reasons: the abstention of the research lab from the community's everyday practices; the apparent indifference of the research group to the community's micro-politics even though located in the same physical location; the efforts and time spent by the research group in designing and developing the data collection interventions that made a difference in how the research group was perceived and accepted (section 7.6.1).

The different types of questions asked through the multiple voting systems and participatory channels, distinguished two categories of data: 'hard data' that affords possible change in the community and 'opinion data' that was seen as apolitical and primarily serving community self-reflection (section 7.6.2.2 Factual and Opinion Data). The efficacy of the collected data was also reinforced by the leading role of Microsoft in the project. The involvement of an "independent third party" was seen as necessary, as residents were sceptical about previous data collection exercises, led by local organizations such as the council or the residents' association which were believed to affirm specific political agendas rather than the collection of unbiased representative data (section 7.6.1.1 Doing community politics with Microsoft as the facilitator).

Finally, contextual parameters also affected the accuracy and the representativeness of the collected data. Regarding accuracy, data collected on the street was seen as 'temporary' with questionable accuracy due to the exposure of devices to tampering. Contrastingly, data collected in the home was perceived as 'permanent' and 'binding' and thus possibly actionable. The participants also raised concerns about the self-selection bias in data that can possibly affect its utilisation for informing change in the community. Potential bias, however, is partially mitigated by the multiple channels of participation that allowed different demographics to take part in the data collection process (section 7.6.2.1 (non) Representativeness & (in) Accuracy of data).

8.4. Contributions

In the course of responding to my research questions, throughout this thesis, I have contributed new knowledge and two e-voting systems to the field of HCI and e-voting. The main contributions of this thesis are listed below.

1. Taking C. Mouffe's theory of agonism as a starting point, I introduced a new conceptualisation of 'politics' and 'the political' in the voting context. This conceptualisation recognizes the existence of politics embedded in the design of conventional voting systems, and initiates a discussion on alternative voting designs able to engage citizens in the political. My empirical studies explored how this can be achieved through extending and adapting the affordances of voting systems, and how this might relate to external contextual parameters.
2. I proposed an innovative and extensible framework for designing e-voting systems for political participation, which is the outcome of the materialisation of this novel conceptual understanding of the design of politics in voting, paired with the unpicking of established security requirements of voting. By applying this framework in designing novel voting systems in various contexts, I managed to identify underexplored dimensions of digital vote design (such as expression), and extend the affordances of voting for participation.
3. The design, development and evaluation of *BallotShare*[22]. Informed by the design framework proposed, BallotShare is a novel e-voting system that allows the configuration of polls depending on the context that it is deployed in. In this regard, my contributions are as follows:
    a. The development of a platform that allows the exploration of the design framework that I introduced in Chapter 4. I aim to conduct future work in this area by instantiating BallotShare for different contexts and practices, enabling deeper insights to be gained about the effect of the system's capacities on participation.
    b. The deployment of BallotShare in two of my case studies: (i) as an online voting system particularly designed for a workplace environment that revealed subtle hierarchical structures and enabled discussions and strategic

[22] Visit the polling site at: http://ballotshare.com

voting in the workplace (section 5.3); and (ii) as the online channel of participation in a local community voting context, providing four different channels of online access to community votes, and serving as the backend of various situated voting devices in the neighbourhood, that revealed the importance of the situated element for citizen participation in physically bounded communities (section 7.6).

4. *PosterVote,* an instantiation of my design framework, is a novel voting technology that enables the exploration of the affordances of voting for participation in the local and situated. In this regard my contributions are the following:
    a. The design concept of PosterVote, which comprises conventional paper posters and low-tech hardware that when put together create a sustainable e-voting system. This drops the development and maintenance costs, whilst increasing the potential for local communities to engage in action (section 6.2).
    b. The exploration of sustainable methods for setting up and maintaining the PosterVote devices that involves: (i) an online tool that supports the design of PosterVote paper posters, which facilitates the appropriation of this voting tool by local communities[23] (see Figure 11); and (ii) non-technical ways of downloading data out of the PosterVote devices (by using a modification of the DTMF protocol) and the development of an IVR (Interactive Voice Response) platform that enables the sustainable use of this voting technology[24] (see 6.2). Over the duration of my PhD, the sustainability of the voting technology allowed its use in various local community contexts in the UK (Newcastle, Cambridge and London).
    c. The evaluation of PosterVote in three case studies: (i) as a situated voting system on lampposts for the collection of data from community activists in order to campaign for changing parking regulations, which resulted in bringing to light perceptions of data efficacy and affordances of voting for representation (section 6.3.1 Case study 1: Road planning group); (ii) as a

[23] For details visit http://postervote.co.uk

[24] For more information see http://postervote.info

situated survey system on table stalls during a community festival for local regeneration planning, which resulted in engaging visitors in discussions about local planning and revealing hierarchical structures of the community group (section 6.3.2 Case study 2: Regeneration group; and (iii) as one of the situated voting devices used in my last case study, where PosterVote enabled the collection of votes on the street, extending the reach of the voting devices to the wider community and revealing residents' understanding of community, representativeness and data (section 7.6.2 Participating for Data).

5. The evaluation of three voting devices that were deployed in parallel to explore how the affordances of the voting devices and contextual parameters mediate participation, viewed in terms of how participation is enabled and perceived in place[25]. The concurrent deployment of multiple data collection devices with various capacities is also a methodological contribution, as it provoked my participants to reflect on the different types and levels of engagement that can be achieved through design. In my findings, I revealed the research lab's impact on community participation, the distinction between "factual" and "opinion" data and their effect on doing politics, and the practice of voting as a method of expression (section 7.6).

8.5. Future Work

The results and discussion in this thesis suggest a number of potential future research directions.

8.5.1 Political design in e-Democracy

In Chapter 2, I reviewed some of the most prominent work in how political activism and ways of doing politics are embodied in the design of artefacts and systems, from roads and bridges in New York to modern information and communication technologies. I believe that the conjunction of politics and political design with e-democracy is an area of research that deserves more attention in computing and HCI research. Work on the development of online and situated systems for civic engagement and democratic

[25] In collaboration with Microsoft Research Cambridge

participation has existed for decades, however most of this work interprets technology as a tool which is primarily beneficial to the mediation and accessibility of conventional methods of doing politics – from electronic voting to online deliberation. It is my contention that some of the failures of these online platforms to extend participation come from these assumptions embedded in the design. I call for the design and development of alternative platforms able to engage citizens in the political through the creation of vibrant public spaces of contestation in which different opinions can be democratically challenged.

In spite of the fact that the field of e-democracy has existed for decades, the appropriation of technology for everyday democratic practices remains underexplored, with most work concentrating on the facilitation of large-scale politics. This focus assumes that participating in big 'P' Politics somehow differs from citizen participation in the politics of everyday life. In this regard, A. Giddens calls for enlarging the domain of politics in the main institutions of society traditionally considered to be unrelated to politics, such as local communities, families, and the workplace. I contend that one of the problems of conventional e-democracy research is that it measures participation mainly via the turnout of citizens in exceptional and transient occasions (e.g. elections) rather than measuring it in the spaces that citizens participate in in their everyday lives. Rather than attempting to increase turnout by designing more accessible, more usable or more secure democratic systems, HCI and e-democracy research can contribute in creating a more civically engaged citizenry by inventing systems for political engagement and by inventing new methods of assessing levels of engagement both quantitatively and qualitatively.

8.5.2 Exploring and Extending the Design Framework of e-Voting

By proposing a design framework, and through conducting my three case studies (the design of three novel voting systems, and the exploration of three seemingly apolitical contexts) I have taken the first steps in designing e-voting and e-democracy systems for citizen participation in the political. This inquiry needs to be sustained, first and foremost by the extension of this design framework for participation. The design categories of expression, eligibility, fairness, secrecy and the context in which the system is deployed are descriptive for many voting systems but they need to be extended and more systematically investigated.

In this thesis I chose to instantiate this design framework by taking C. Mouffe's theory of agonism as a starting point. Future work should also explore the appropriation of this framework for supporting other, more conventional models of democracy (e.g. deliberative democracy). In addition to generating innovative e-participation systems, this design framework can also be used for assessing the affordances and contexts of other systems in use, in order to come up with new solutions or novel understandings of their successes and failures. For example the application of this framework in political elections might bring new information to light that contrasts with some of my current findings.

Finally, in this dissertation a case study approach has been followed with a mainly qualitative method of enquiry. This allowed for an in-depth, multi-faceted exploration of a complex socio-political issue within an everyday context. Alternative methods, such as quantitative studies with controlled experiments are also necessary for a more systematic investigation of the effects of small changes in system's design on participation. I believe that such rigorous experimentation is necessary, and that future work is needed to possibly generalise findings by identifying a subset of design affordances that facilitate participation in many disparate contexts.

8.5.3 Civic-centred Security

Voting is typically associated with decision-making and consensus. The most common way of reaching a consensual decision is through the quantification of votes. The minimal citizen-system interaction that this entails enables the formal description of the voting problem in a language that can be easily understood by security researchers. This in turn allows them to invent encryption-based algorithms to secure the voting process and ensure its verifiability.

For the voting systems described in this thesis, aiming to engage citizens in the political, security is also necessary but much harder to formally define. More work is needed to identify the features of voting systems able to engage citizens in the political, and some of these features (such as unspecified methods of citizen feedback, decentralised and sustainable ownership and maintenance etc.) might contrast with conventional understandings and models of security. In order to achieve a security relevant for a participatory electronic democracy, the security requirements of systems need to be extended from conventional frameworks of security such as the CIA principles (Confidentiality,

Integrity, Availability) to also include the requirements of the equivalent model of democracy and participation.

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Appendix A

BallotShare Screenshots

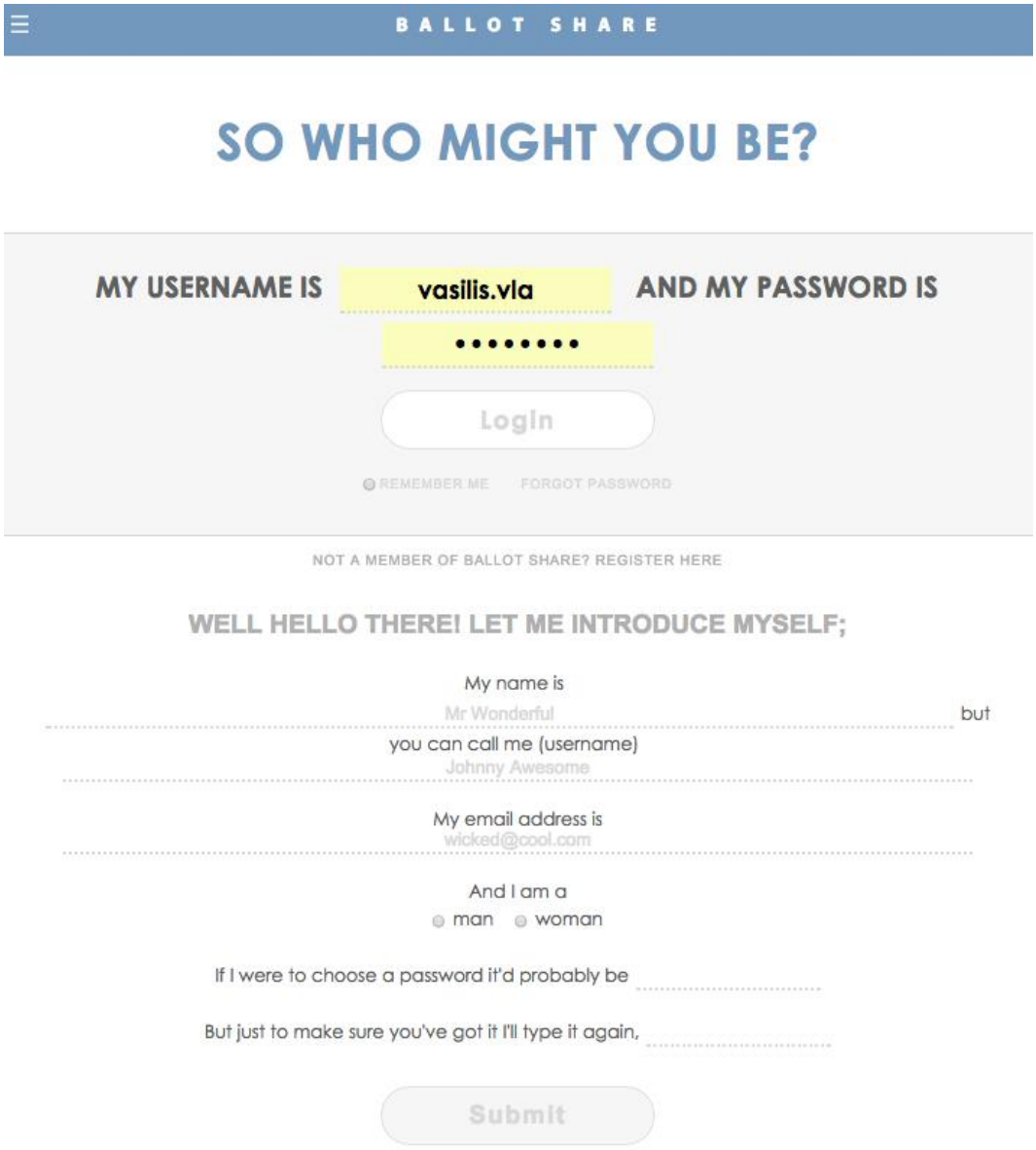


Figure 24. BallotShare 2.0 login and registration page

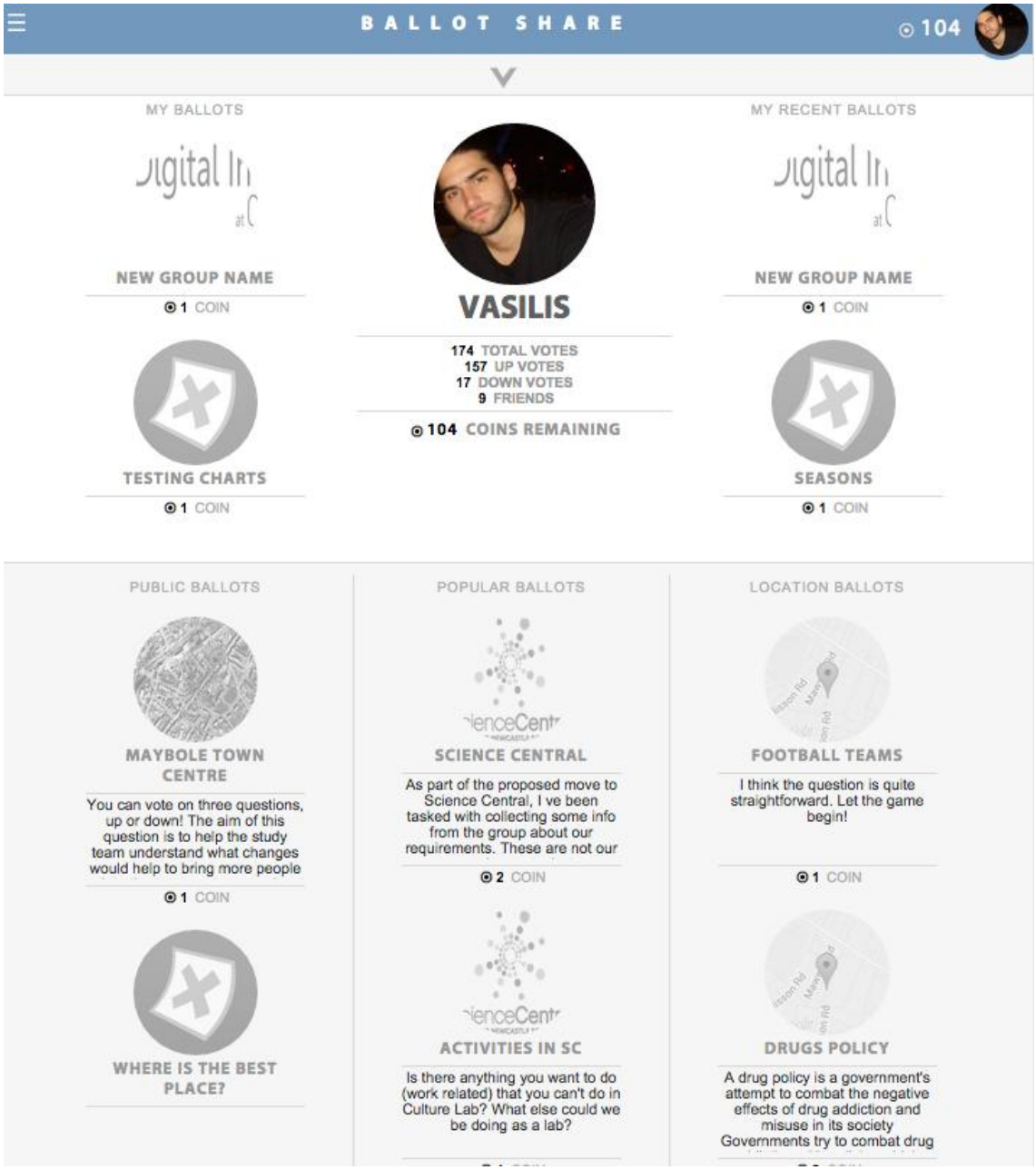


Figure 25. BallotShare 2.0 home page, listing user, recent, public, popular and geolocation ballots; also user stats such as number of votes cast, type of votes cast and total number of coins remaining

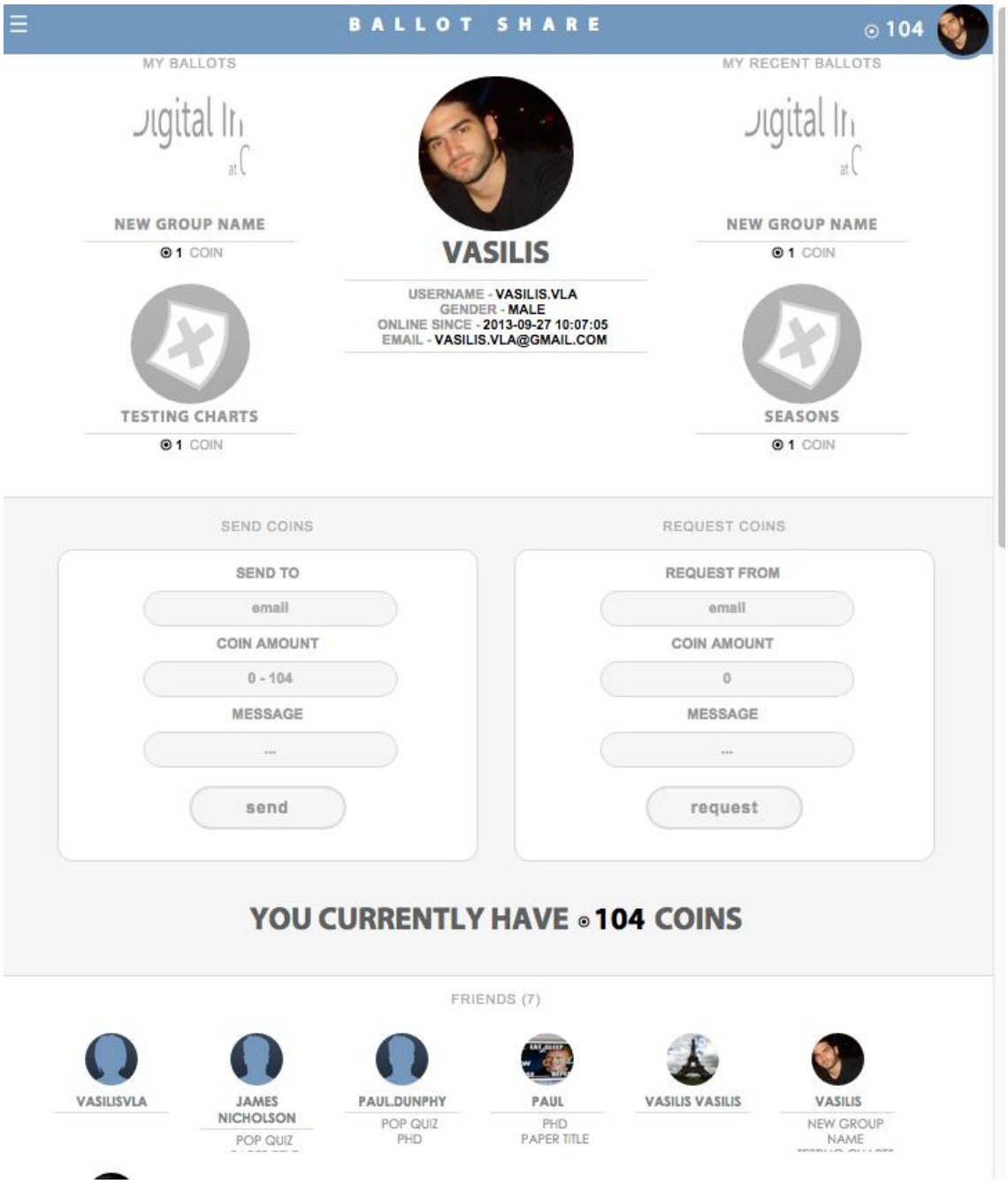


Figure 26. User profile page with BallotShare send and request coins feature

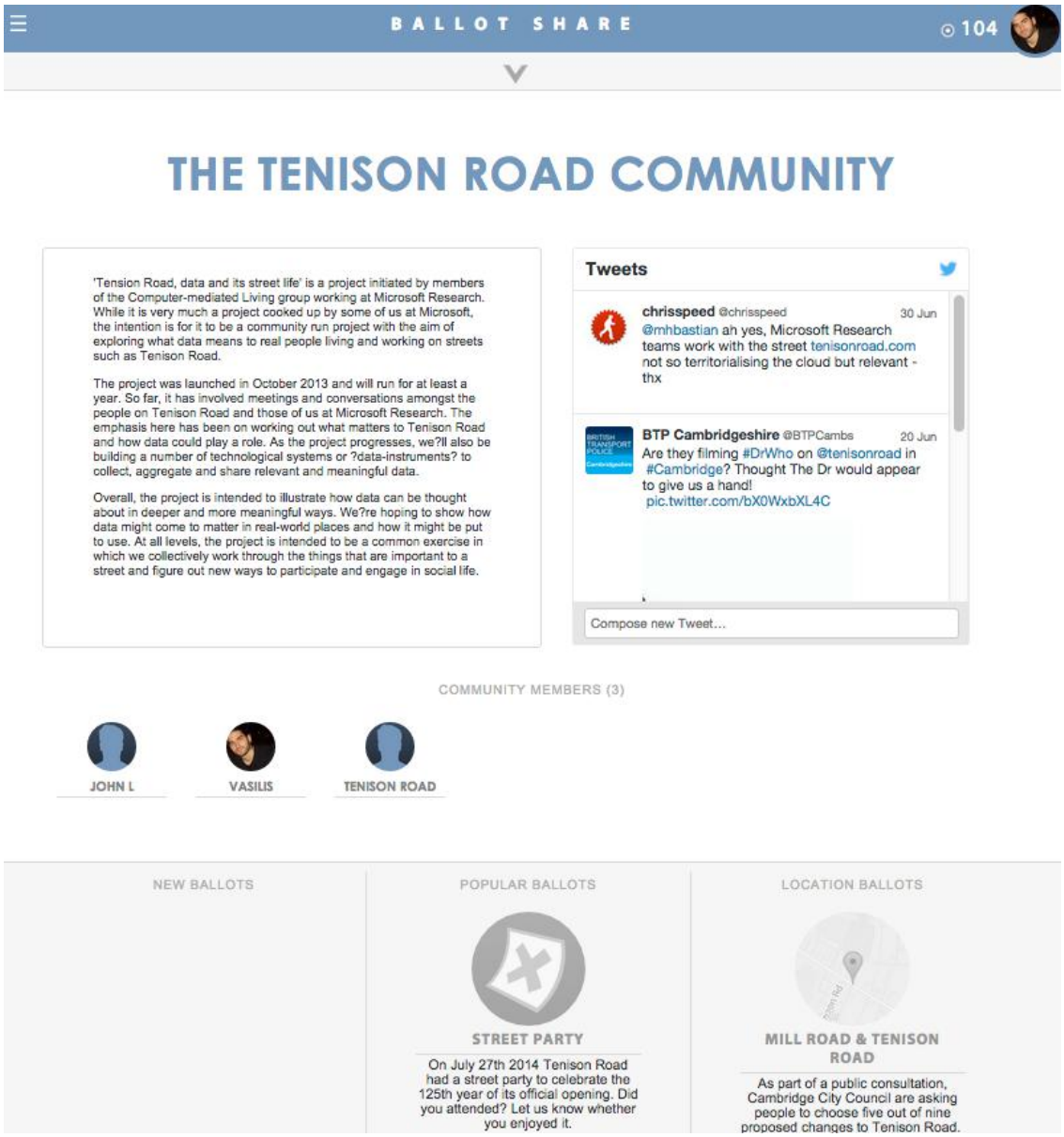


Figure 27. Community page on BallotShare showing a description of the community, a twitter feed and related polls. The above figure depicts the Tenison Road's community page described in Chapter 7

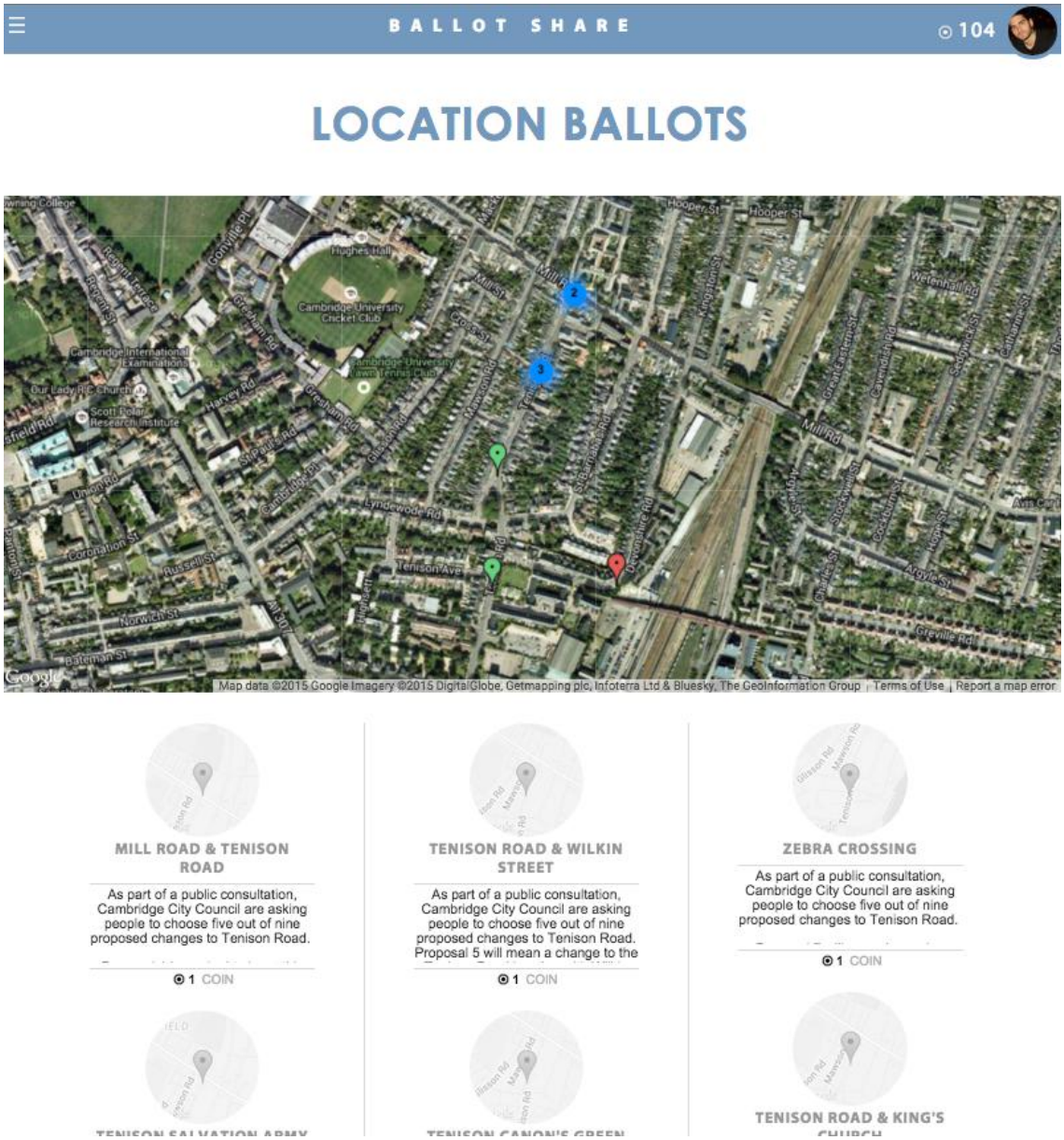


Figure 28. Location-based ballots page showing a map with pins indicating the locations of relevant polls (e.g. locations where PosterVote devices are placed). The above figure shows PosterVote devices deployed on Tenison road during the project described in Chapter 7

Figure 29. Available poll configuration options at BallotShare's "Create Poll" page

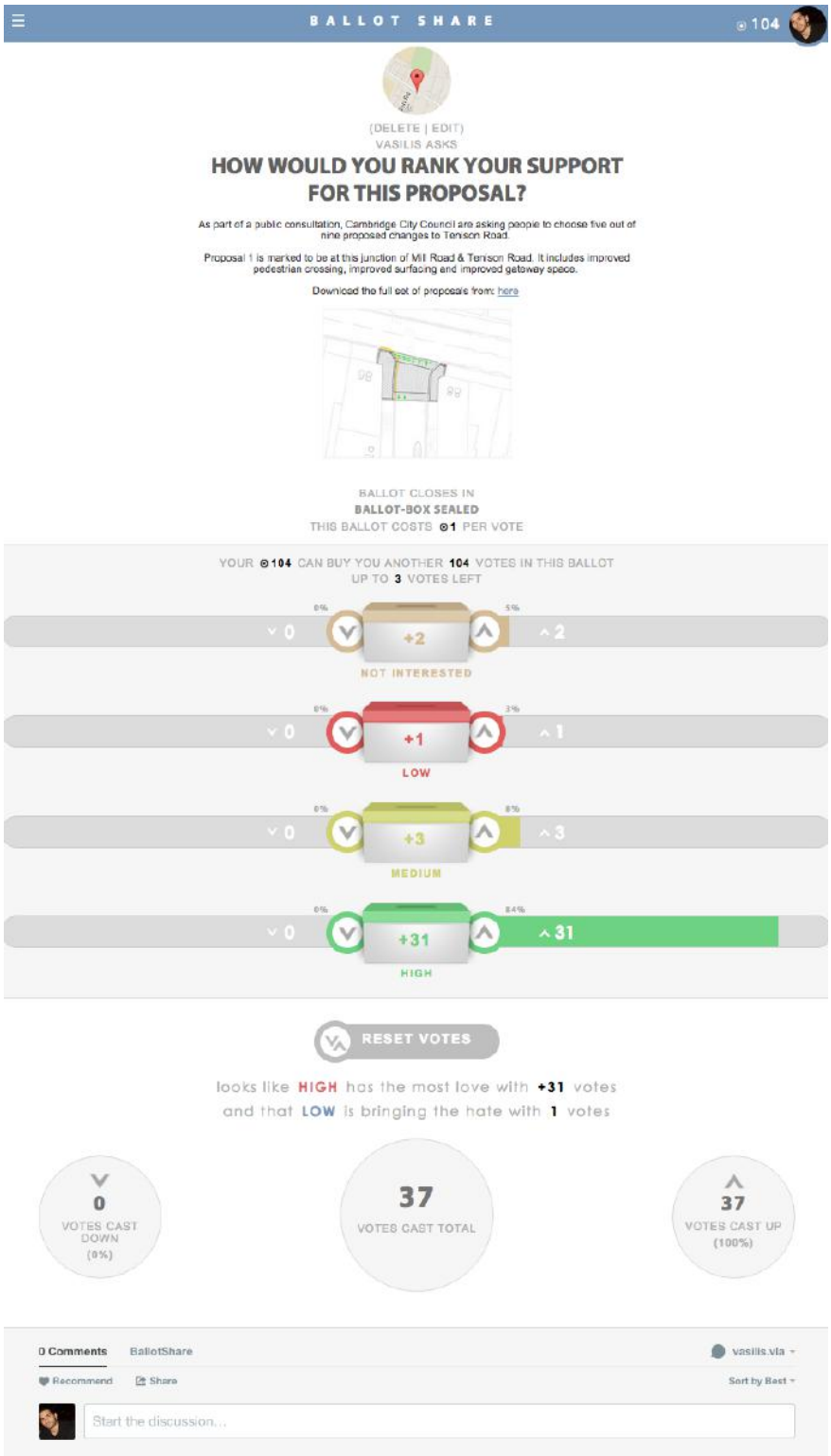


Figure 30. Example poll page including: poll's location (if applicable), title, description, picture, 'cost of participation', time left till poll closure, voting options, live results, reset votes button and social features enabled (total number of votes cast, commenting area etc.)

Appendix B

PosterVote Poster Creation Website V2.0

Figure 31. PosterVote V2.0 of poster creation website. The website allows users to add a question and the available options, select poster color, type name/organization running the poll and their contact details

Appendix C

PosterVote Device Pictures

Figure 32. PosterVote V2.0: Low profile flexible PCB including a speaker module for the audio download feature. The flexibility and design of the hardware allows chopping off unnecessary buttons to integrate the device with smaller posters/objects

Figure 33. PosterVote V2.0: Demonstrating the size of the device, development of wholesale disposable e-voting devices and example poster use

Appendix D

Example Transcripts

File: **MM_17_12_2014.mp3**
Duration: **0:23:17**
Date: **29/01/2015**
Typist: 704

START AUDIO

Interviewer: See if that's working. Yes. Because we are halfway through, as you said, we wanted to try and meet as many people – we've got 10 households we're meeting this week. We just wanted to get a halfway point and get the families to talk about what they thought. One of the first things we wanted to ask was if you were to try and sum up the project, for example if you ___[0:00:33] and tell them what…

Female: What they're doing.

Interviewer: How would you…?

Female: I think it's a community project that Microsoft Research are doing to try and get engaged in the road. Also, from our point of view, it's useful because it's trying to test this new prototype in terms of how communities interact and how we all talk to each other or not, or whether there are any local issues and stuff. I guess I'd just say they've got this little Bullfrog machine that you plug into your house and it keeps you asking you questions each day. You slot a card in and get the results.

Interviewer: I mean I know there's been lots of little hiccups which are obviously not intended.

Female: Yes. I suppose that's the point of testing it isn't it really? It's obviously a prototype.

Interviewer: What's your sense of it been?

Female: I didn't have a clear sense of your objectives I suppose when we started in terms of I'm still not 100% sure about what it is that, as a company, you are trying to do, or what the ultimate end is going to be with it. I don't know that. Maybe we're not privy to that information or whether it's just…

Interviewer: They're real secrets but I'm more than happy to go through that.

Female: It's funny because I was talking to my husband about it and he said he was very interested in it as well. He's done a few of the answers. He said, "Why are they doing a little box like that?" He said, "Why aren't they doing something that connects to people's phones or an app or something?"

The one thing I would say is because I'm really busy, a busy mum, I don't always go into this room but it's the best place for it to be, probably. I don't always spot the question and therefore I don't always think about it. I sometimes miss it maybe or I maybe think a couple of days, "I haven't done it". Whereas I suppose if it beeped or if it was part of your phone, you'd probably get instant answers I suppose. I don't know whether…

Interviewer: We liked the idea of it being a slow – because so many things we have on our phones that distract us so there was an element of just making it something that you didn't go to every day if you didn't want to.

Female: Yes. I mean that's quite nice in terms of no pressure because when we signed up to do it I said to Nick, "I don't know what level of involvement there's going to be". I don't know how – Isabelle, listen. Mummy's just talking, darling. Can you try and be quiet just for 10 minutes. You do

something nice and quiet. Yes please, good girl, because this man has come especially and he's busy. Good girl.

Interviewer: Isabelle, have you tried using this book to put your card in?

Female: She does it every time.

Interviewer: Ah good.

Female: Yes, she's very good.

Interviewer: My son and daughter do it. They like doing that.

Female: It doesn't feel totally robust. Whenever she pulls it out I worry that she's going to take that little black thing, the little flap thing out with it as well.

Interviewer: I mean this is basically a piece of card. This was an afterthought, we realised it wasn't reading the card as well as it should. It's a piece of card, if it comes out it comes out. Pop it back in.

Female: Because it's such a small screen, when we've been suggesting questions and stuff, some of them I thought of in my head but I didn't bother to suggest because I thought it will never fit on the screen. I guess it depends what sort of depth you want to go into really.

Interviewer: Yes. For me what was interesting is these are a vehicle into other ways that communities can engage with each other and participate in local

issues and things. They're not meant to be the final – otherwise obviously the functional is pretty minimal. That was what was interesting to us: how does it, if at all, ___[0:04:56] other networks. Is that something you've found?

Female: I think I can see how that's happening, yes definitely. I mean we haven't been able to get involved by going to the pub or anything like that. It sounds as though there's lots going on. One of the nicest things is it's just a sense of community which is now apparent, the fact that a few of us are doing this together and it gives a sense of identity to the street.

I like seeing the votes because I think there's no other way to get people's opinions on this street because you never really engage with lots of people on a regular basis, particularly about issues. If I do see people it's just, "Hi," and a chat and whatever. It's about light stuff, not about issues. That's been really nice to gauge people's opinions and what matters to people.

There was a really useful one, because I have some real safety concerns about the zebra crossing here. I have felt powerless to be able to gauge other people's reactions about it, even to the point of which I don't feel I can really ask my neighbours about it.

Interviewer: Yes. Oh, why is that?

Female: Well, one of them works for the council so I didn't want to put him in an awkward position because I don't know whether he's involved in it or anything. Also, I don't know, people are busy, whereas this was great because people were taking the time to think about it. I was prompting it. There was a little one about safety, have you seen the accident campaign. I thought that was quite incredible how many people had.

Interviewer: Yes. I think it's the vast majority of people.

Female: It was. It really was, wasn't it? That was really interesting. Yes, it's just nice to – the votes are quite interesting I think. It's nice to see them on the Microsoft window, nice to get the little sheets.

Interviewer: Do you have a sense of the other things that are going on on the street?

Female: I think so. I mean people are creatures of habit aren't they? We tend to always go the same route so we only ever see the same thing. I don't often see the thing at the station but my husband does every day. He goes straight past it. He tells me about that. Then we walk this way all the time towards Tenison Avenue so we always see the community thing that you press…

Interviewer: The posters.

Female: Yes. My kids enjoy doing that, obviously once. We're not skewing the results.

Interviewer: That's fine. Actually what happens if you keep pressing it, it records the fact that that's a lot of presses rather than…

Female: That's very clever, yes. That's been nice as well. It's been a bit of a novelty thing. I think also I just get the sense it gets people thinking about the local community because a lot of the time people don't think about local issues, unless they're upset about something or something has angered them. They don't think about how to increase cohesion or any of it really but this is prompting them to think which is nice.

Interviewer: Yes. I think obviously a lot of people are very concerned, and rightly so, about development. I think that's been really helpful to us as a project

but at the same time it takes over everything. As you say, we're also interested in just the sense of community, of belonging.

Female: It makes you think actually. There was a question about would you invite your neighbour over for a cup of tea. That got me and my husband talking quite a bit. I'm sure it would have done the other households as well and maybe will prompt people over Christmas because we were like, "Well we should. We should get a couple of people over," and hopefully we will. That was a bolster to do that really. It gives you a voice…

Interviewer: What was the discussion about?

Female: He said, "Yes, of course we would". I said, "Well we haven't". We've lived here two years and we've maybe had our neighbour over once perhaps when we first moved but it wasn't a proper sit down thing, it was just a quick in and out kind of thing. He said, "Oh, well yes, that's interesting," because in theory we would but in practical terms we haven't. We said maybe we should.

It also got me thinking because there's an elderly lady in the building next door and it got me thinking about her and the fact that she probably doesn't interact with any of her neighbours particularly. We always say hello but there's not much more interaction beyond that. Again, we thought we might just ask her in for a cup of tea or whatever at Christmas. Christmas is a good opportunity to do it, isn't it? It's a good excuse.

Interviewer: Yes. It's a nice way to broach that kind of thing without being awkward about it. I mean you raised some of the issues around how it's built and other things. If there were a way to imagine it being an everyday object in your home, could you see it fostering some of those connections?

Female: Yes, definitely. I could. I think people – it's a sad fact isn't it - unless they were going to get something out of it, probably they wouldn't do it because it's – I don't know sweetheart, keep looking and you'll find him. He's over there look.

Interviewer: What sort of things would you imagine getting out of it?

Female: Well, just in terms of the interesting feedback. As long as that continued. I suppose people probably wouldn't do it if they weren't going to get regular feedback from it or if they didn't find it useful I suppose or if it was an ongoing thing. Yes, I think we would definitely be interested.

It just gives you a voice I think, which on this road as well with big developments and a couple of big companies and stuff, it's not nice for – I think a lot of people do feel with the development that perhaps they weren't listened to so it's nice to feel like your company has come along and just chatted to us and everything.

Interviewer: Okay. Just having someone listen?

Female: Yes.

Interviewer: I mean I think one of the things we've learnt over the course of this project is these need to be plugged into bigger networks, politicians and councillors.

Female: Yes, that's a great idea. In fact, because with the road thing, the road safety, I did think about – I suggested another question about do you think that zebra crossing is unsafe or something.

Interviewer: Has that come up yet because I know it's on the list.

Female: Oh okay. We've had one so I didn't know whether I'd missed it. I thought if that was useful, that would be a useful tool to go back to the councillor and say, "Look, this is a problem". I've been in touch with the councillor, I've been in touch with the MP and feel that they're being very good, they're saying lots of things and stuff.

Unless you can come back and say, "Look, this many people have done it," and actually getting on to the streets and doing the petition, sadly I'm a busy mum, I'm just not going to have time to do it. I mean did you feel like the numbers were big enough that you were getting…

Interviewer: That's why we have done the multiple ways of voting so there's also an online system. We wanted to build what we call an ecosystem, lots of little ways to draw people in. We've got over 30 of these in people's homes. Then we're getting about 100 plus votes on the posters a week, a question. Then we get 100 votes a week on the charts as well on the website.

Female: That's good. That's interesting.

Interviewer: I think with all those things together, then it starts to become something that you can actually legitimately have some voice.

Female: Maybe I should tell my husband about the online vote because he's had less of a role in this and I've had no online involvement whatsoever.

Interviewer: Okay. Yes, it's harder if you're…

Female: Yes, exactly. That's been helpful just because it's there. It's been fun. It's been fun with the kids. It's also nice to involve them a bit and get them thinking a little bit.

Interviewer: Just about voting and the mechanisms?

Female: Yes, exactly. My older boy, he is interested in it.

Interviewer: How old is he?

Female: He's nearly five.

Interviewer: Oh okay.

Isabelle: I'm nearly three.

Interviewer: You're nearly three.

Female: You're nearly three, yes.

Interviewer: Like my son and my daughter is five so same age as you.

Female: You've got similar type gap, yes.

Interviewer: Very similar.

Female: It's been nice to be involved really. Also, what was interesting is seeing what questions are coming up. Just seeing what people are thinking about is interesting. The one about the milk, I thought, "That's a really good question".

Interviewer: Gets people thinking.

Female: Yes.

Interviewer: What did you think of the – I've got one here as well – way we presented back some of these?

Female: That was lovely, yes. That was nice. I suppose the only further thing was whether there was any – there was no further analysis. It was left up to you to…

Interviewer: You'd want something a bit more?

Female: Maybe, but again it's your time and stuff isn't it? Wow. Is this the new one? I don't think I've seen that one. That's interesting.

Interviewer: Yes. That one came out this week I think.

Female: Oh okay, that's really interesting.

Interviewer: It's a little bit more.

Female: Yes, that's nice. No, that's lovely. That's a really nice control, yes, because this is relatively similar isn't it. Maybe a little summary or something at the end of the day would be nice. I suppose this what's the mood in this house today?

That was interesting to begin with but I thought, "Well, what's the point beyond that?" I'm not really looking at that anymore. I don't know how these people have put all these quirky little answers in. Is that online?

Interviewer: Okay.

Female: Are they just being very clever?

Interviewer: I can't remember where we notify people. Oh, actually on the – again, we're well aware of hard it is for people to actually sit down and read these. I think somewhere in here we've said that behind those posters we've got little envelopes that you can take cards out. They're secret cards. Some of them are those are bah-humbugs or ___[0:14:59].

Female: How funny. I thought that was really clever. Yes, that's good. I mean I must admit, I do like the visual aspect of it. This is great because you can just quickly see. I think that's brilliant. It's better than a chart. It's better than just numbers. I do like [the pie chart 0:15:11] thing. I think that's nice and clear, yes.

I don't know, maybe the ability to follow up so if you're interested in any of them. I don't know, did you think about doing it thematically each week because they're all random questions aren't they? They're not particularly linked.

Interviewer: Yes. I suppose for us as researchers we've ___[0:15:36] them but probably not…

Female: Not apparently to us, yes.

Interviewer: That might be a nicer way to do it so people get a more coherent picture of something.

Female: Yes, right. Can people tweet to each other or interact with each other about the results? Have people been talking about the results?

Interviewer: We talked a lot about that as an option. You can comment on the online talks. The online votes are not the same as the Bullfrog questions because we wanted the Bullfrog questions can be about the community of Bullfrog users.

There's only one question a week which is the same across the posters, the website and we thought that would cut across all of them. I mean I think ideally there would be a forum, whether that's dedicated or it's say Twitter or something.

Female: Yes, maybe some of them I'd go, "I'd like to know more about that," like the accident one I suppose because it matters to me. I think, "That's interesting".

Interviewer: Yes. I mean what we will do just as a – it doesn't fit into how you use it now – in January have a final meeting where we bring everyone together and talk through things. Hopefully that will be a forum for people to talk about it.

Female: In terms of your objectives though, what was it that mattered most to you?

Interviewer: I suppose idealistically what mattered to me was how we built something that helped the community, whether that was a pragmatic thing or for example dealing with the developers or whether that was about building a community, it was open – [the whole community led that 0:17:26].

Female: Yes, which is nice because ___[0:17:30] both those things hasn't it?

Interviewer: That's really…

Female: Don't worry, we can put them all back.

Interviewer: Oh dear. What's happened? I think the world isn't that idealistic of what it is so there's been a lot of ways that we've had to work that out in the company. I suppose what Microsoft would be interested in is new technology, not this device per se, but new technology platforms that might be about places rather than this software running on PCs or whatever it is.

Female: It obviously has captured 30 families imagination hasn't it because they've taken it up to view it, which is nice actually.

Interviewer: I mean I think we could have had more, it was just it takes a lot of work, supplies that are needed to build these little things.

Female: I'm sure, yes. It is money as well isn't it?

Interviewer: Yes. Our next project is going to be in a housing estate in London where there really is a real struggle to build a community there.

Female: Yes, how interesting.

Interviewer: Again, I'm a sociologist and my interests are in community.

Female: Interesting.

Interviewer: For me it's not about selling or making products, it's about a better understanding of how communities work.

Female: That's really nice, that's lovely. It's nice that the company are bothered and interested.

Interviewer: Microsoft Research is very open in that way, they let the researchers…

Female: I don't know much about what they do. That's terrible isn't it? They're right down the road but…

Interviewer: Why would you?

Female: It's nice. It's such a big business. It makes you feel part of the road and it makes us feel a part of your road.

Interviewer: Yes. Did you manage to get to the street party?

Female: No. There was a street party was there?

Interviewer: Yes, in…

Female: Oh, Mill Road.

Interviewer: In July we had a party on the green.

Female: Oh yes, we were away for that. I liked the sound of that. Were you something to do with that history project?

Interviewer: Yes.

Female: Because again I'm really interested in history so I did think about that but we were away.

Interviewer: I think one of the things we realised more than ever is just how busy everyone is.

Female: Yes. I suppose Christmas is a bad time as well isn't it because every-one's lives get infinitely busier.

Interviewer: Even worse. I'm seeing it at both ends. This is not, as you said – we've got one stage further. It is saying connected to network but it's not – let me just check it.

Female: I wondered if it was my fault because I've been unplugging it quite a few times to use that plug. That should be okay should it?

Interviewer: It's fine. What I might do is take it away.

Female: Yes, that's fine, yes.

Interviewer: Are you home this evening?

Female: Yes.

Interviewer: I'll just drop it off with you so hopefully not interrupt you.

Female: Yes, that's fine. Shall I give you my number because the kids might be asleep and they wake up if the bell goes or just knock?

Interviewer: What time do they go to bed?

Female: Seven.

Interviewer: We'll definitely be round before then but sometime – I don't want to, I know exactly what it's like. Oops. Are you okay?

Female: Yes, any excuse to get out of your bed because you think it's daddy if they ring the doorbell don't you?

Interviewer: I know people like that, indeed.

Female: Yes, most little people.

Interviewer: Does daddy have to go to work every day?

Female: Yes.

Interviewer: Oh dear.

Female: Daddy goes early doesn't he?

Interviewer: Does he?

Female: Yes.

Interviewer: Some days you don't see him?

Female: That's it, yes.

Interviewer: Okay. Well I'm hoping it won't take that long to fix.

Female: Yes, don't worry. That's kind of you.

Interviewer: If it is after seven…

Female: It's fine, just knock.

Interviewer: We'll bring it round tomorrow rather than interrupt you.

Female: Yes. No, that's no problem. That's very kind of you. That's great. Are you planning to write anything up at the end of it about the street?

Interviewer: Yes.

Female: Ah great.

Interviewer: We'll write it up as an academic piece but also I think try and write a newsletter style piece about just what we did and the kinds of things we found. We'll definitely share that.

Female: Yes, fantastic.

Interviewer: I mean it's very much an experiment in the making. Many of the things that you've probably thought and wondered are the things we are thinking and wondering too.

Female: Yesterday on the television, I didn't watch it, it was on daytime telly which we don't watch but we were switching CBeebies off I think. There was a programme on, it was a popular one, but it was about trying to get communities to engage. This celebrity, I think it was a chef or something, he was trying to get celebrities to go back to their home towns and start people talking.

It was focusing on what a lonely country the UK is, how we've got so many – I think we've got more single households than any other country in Europe or something. They were trying to garner a bit of community and get people doing street parties and all that kind of thing.

Interviewer: Yes, I think for me there's a lot of political talk about that. It's the same old things are happening so trying to draw something else in and make a difference. That's what's interested us. Okay, well thank you very much given…

Female: Thank you

END AUDIO

Appendix E

PosterVote Example Output File

UART download

The UART output uses the PGD pin of the ICSP (programming connector) to output the events. A standard USB to UART cable with TTL signal levels is ideal for the download. Below is an example output from one of our deployments' posters which follows the format: [Timestamp, 1st button, 2nd button, 3rd button, 4th button, 5th button, reset, optical download, UART download]. For more details see Appendix F.

```
658,1,0,0,0,0,0,0,0
660,0,1,0,0,0,0,0,0
661,0,0,1,0,0,0,0,0
662,1,0,0,0,0,0,0,0
665,1,0,0,0,0,0,0,0
666,0,0,1,0,0,0,0,0
667,0,0,0,1,0,0,0,0
668,0,0,0,0,1,0,0,0
669,1,0,0,0,0,0,0,0
791,0,1,0,0,0,0,0,0
1017,0,1,0,0,0,0,0,0
1092,0,0,1,0,0,0,0,0
20089,1,0,0,0,0,0,0,0
20090,1,0,0,0,0,0,0,0
20097,0,0,1,0,0,0,0,0
20098,0,0,0,1,0,0,0,0
20099,0,0,0,0,1,0,0,0
20102,0,0,0,1,0,0,0,0
20112,0,1,0,0,0,0,0,0
20113,1,0,0,0,0,0,0,0
20127,0,1,0,0,0,0,0,0
20129,0,0,1,0,0,0,0,0
20131,0,0,1,0,0,0,0,0
20133,0,0,1,0,0,0,0,0
20134,0,1,0,0,0,0,0,0
20138,1,0,0,0,0,0,0,0
20140,1,0,0,0,0,0,0,0
20141,0,1,0,0,0,0,0,0
…
```

Appendix F

PosterVote Documentation

This document is written by Dr. Karim Ladha and summarises the features and behaviour for firmware release 1.0. It is written to assist users successfully deploy PosterVote for their applications. The user should include basic instructions on the poster itself to allow voters to interact successfully with the device. Most of the functionality in this document is not applicable to voters.

Hardware considerations

The microcontroller used is the PIC16F1824, which will need to be selected when programming devices with alternate firmware. The internal watchdog timer is used for the low power timing functions, this is a very inaccurate clock source and the result is the flasher function interval having a large error. The static idle mode current consumption is 29uA at 3v. The default flasher interval of approximately 60 seconds increases this to ~50uA. The white LEDs have a minimum visible voltage of 2.45v but sunlight visibility requires at least 2.75v. The poster should be designed not to attenuate the LEDs much to increase the visible brightness of the LEDs. The battery voltage drops from 3v to 2v during normal discharge resulting in a large region where the device is operating without visible LEDs. However, a CR2016 cell is approximately 90 mAh and at 2.75v has used ~25% of its capacity or 22 mAh; With low duty cycle usage this translates to over 2 weeks of sunlight visible LED operation. Placing the poster out of direct sunlight will increase the useable life to more than a month. The piezo buzzer operates for the whole battery life.

Button press functions at reset

After putting in the battery, the device will reset and show a light chaser effect on its LEDs. For these first five seconds the user can select from several advanced features. To re-access this mode, the user can usually hold a button and press on the battery clip to disconnect the cell temporarily. The cell can also be briefly shorted using a metal implement (prolonged shorting of the battery is unlikely to be unsafe for such small cells but is not recommended).

Pressing the buttons during the start-up sequence will cause the device to beep and after five beeps the device will stop beeping to indicate the function has been latched. Multiple buttons can be pressed together and the buttons are OR'ed together (holding 1 and 2 selects the functions of both), the final combination is latched at the final beep. The user

must release the buttons after this point and the device will flash the selected LED options for a further 5 seconds before the options are carried out.

The options are:

- Button 1: RTC reset
- Button 2: Reset votes, events
- Button 3: Regenerate the device id (will also flash out the new one)

Button press functions during operation:

The normal user is the voter and there are only two options for them; vote selection and vote upload to get the results; refer to the flow diagram (later in this appendix) to see how these paths are followed. Voting is achieved by pressing a button to indicate their selection after which the device will flash the LED next to the button to indicate their vote was counted. As any button(s) is pressed, the device will beep and the LED next to the button will illuminate. Holding the button longer than one second will result in a second beep. The length of time the button is held for has no impact on normal voting behaviour. If multiple buttons are pressed, the length of time they are held for becomes important. If the multiple buttons are pressed and released before the second beep, the device will flash all LEDs to indicate no vote was counted. If the button press is longer than one second a second beep will sound and a special function may be triggered if the button pattern matches one of those shown below.

- Buttons 1+2: Audio download
- Buttons 1+3: UART download
- Buttons 1+4: Flash the device id
- Buttons 1+5: LED flash download

Audio download

The audio encoding has been carefully engineered to pass over GSM networks used with mobile phones. These networks have low audio bandwidth, aggressive compression techniques, dtmf tone detection with deletion and rapid automatic amplitude levelling. The scheme uses 4 frequencies with bursts of 75ms and 25ms bursts of white noise between them. The microphone needs to be saturated by holding it close to the piezo transducer to avoid the levelling methods distorting the message. The 4 'symbols' (1050 Hz, 1168 Hz, 1302 Hz and 1420 Hz) carry 2 bits of information each. The message contains the device

id, the vote counts and the ccitt crc16 of the data. Messages begin with character 0xE4 which has bit pairs 11, 10, 01, 00. The bytes are sent least significant pair first so 0xE4 is sent as symbols 1, 2, 3, 4 and heard as an ascending sequence. Each byte is also XOR'ed with 0xE4 to whiten the data.

UART download

The UART output uses the PGD pin of the ICSP (programming connector) to output the events. The modulation settings are 2400 baud and 8N1 encoding. A standard USB to UART cable with TTL signal levels is ideal for the download and should be securely attached to the connector in either a jig of by soldering; this is because a full eeprom with 16000 events will take 2 hours to download. The Tx pin of the cable can be connected to Vdd of the ICSP pins to power the poster if no battery is installed; Powering in this way is possible because the device draws so little current and removed the possibility of the power failing during the download. The event output is csv encoded as: epoch, button 1 or bit 0, button 2 or bit 1 .... button held or bit 5, bit 6 is zero, bit 7 indicates reset. A header showing the current time, device id and vote summary is also added at the start of the download. A terminal application such as hyperterminal or putty is recommended for downloading.

Device ID flash encoding

The device id may be visually output for checking purposes by holding buttons 1 and 4. The 16 bit device id is output as 4 binary 'nibbles' on LEDs 1,2,3 and 4 representing bits 0, 1, 2 and 3 respectively. LED 5 is the 'clock' to allow transmit of zero (pattern 00001). Ordering is most significant nibble first, for example:

For device 50441. 50441 in hexadecimal is 0xC509 and the nibbles will be sent in order C, 5, 0, 9.

The flashes will be:

11001 = 1100 = 0b1100 = 0xC

00000 Inter character gap

01011 = 0101 = 0b0101 = 0x5

00000 Inter character gap

00001 = 0000 = 0b0000 = 0x0

00000 Inter character gap

10011 = 1001 = 0b1001 = 0x9

00000 Inter character gap

LED flash download

This is a legacy mode designed to be read by a computer vision system. So far no reliable implementation of a reader has been released. The specification is given as a separate note at the end of this document. The data sent is the same as the audio download but without the leading sync byte and without data whitening. Only 3 bits per symbol are sent with LEDs 1 and 5 being the 'clock' signals. The data is: device id, vote 1 count, vote 2 count ... vote 5 count, ccitt crc16.

Device memories

The device contains two separate non-volatile memories. The internal eeprom stores the device id and the vote counts. The external eeprom stores all the events and their time stamps. The device id and all the vote counts are 16 bits allowing a maximum value of 65535. However, to avoid confusion with blank devices (which will have the value 65535 set), the maximum count is set to 65000. After ANY of the vote counts reaches this value, no further votes are counted; So the practical limit on vote counts is 65000. The external eeprom logs all button press events and reset events. This allows the usage of the device to be accurately recorded to one second temporal accuracy. It is important to reset the RTC and record this time to make the time epochs of the events meaningful. The time epoch is stored as a 24 bit value (up to 194 days before wrapping) and an 8 bit button mask. The button mask bits 0 through 4 represent the buttons 1 to 5. Bit 6 indicates the button(s) was held and can be used to detect downloads. Bit 7 is set when a reset event occurs. The external eeprom has capacity for 16382 events. The events are downloaded using a serial cable as described in the UART download section.

Optical download details

5 LEDs, in the following layout: T A B C U

The decoder needs to know the location of the two end LEDs: T and U (so the location of the other LEDs is known even when they are off).

The decoder also needs to know when to re-sample the remaining data LEDs (A/B/C).

The scheme toggles the two end LEDs on each frame (only one on at a time) to aid in-the-dark reconstruction of the position of the other data LEDs when off. This also allows timing reconstruction – when the toggle pair change, it's time to re-sample the data bits. The T/U strobe indicates that the adjacent data LED is the least-significant bit, to allow reading in any orientation. The three remaining LEDs allow transmission of 3 data bits per frame.

The scheme allows each frame to be checked for consistency: (i) the data values should not change while for a given T/U frame; (ii) the outer two values should not match.

This last point can identify a frame subject to a rolling-shutter issue. Careful ordering of the LED updates is required to allow this (see pseudo-code below). Any such frame can be safely ignored as the camera frame rate ensures we will see one valid frame just before or just after the issue occurs.

In pseudo-code:

1. Have a start sequence identifier that cannot be mistaken for valid data (all LEDs on for 1 second, then all off for one frame).

2. Turn off the strobe LEDs (T & U), keep the data LEDs untouched - wait a brief time (e.g. 1ms).

3. Set the data LEDs (as below), keep the strobe LEDs untouched - wait a brief time (e.g. 1ms).

4. Turn on the correct strobe LED (T or U, as below) - wait a long time (e.g. 85ms to work on cameras at >12 Hz).

5. Repeat the process from step 2 while data bits remain.

6. Turn off the LEDs for one frame.

7. Repeat the entire sequence from step 1 multiple times for redundancy (e.g. three times)

On even frames, light the LEDs with the LSB on the left:

T A B C U

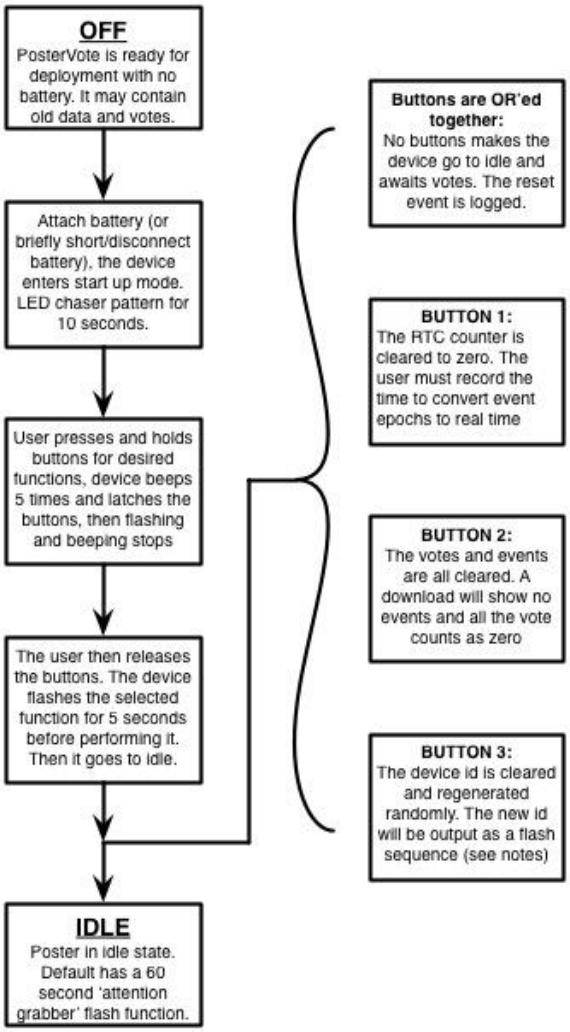
1 b0 b1 b2 0

On odd frames, light the LEDs with the LSB on the right:

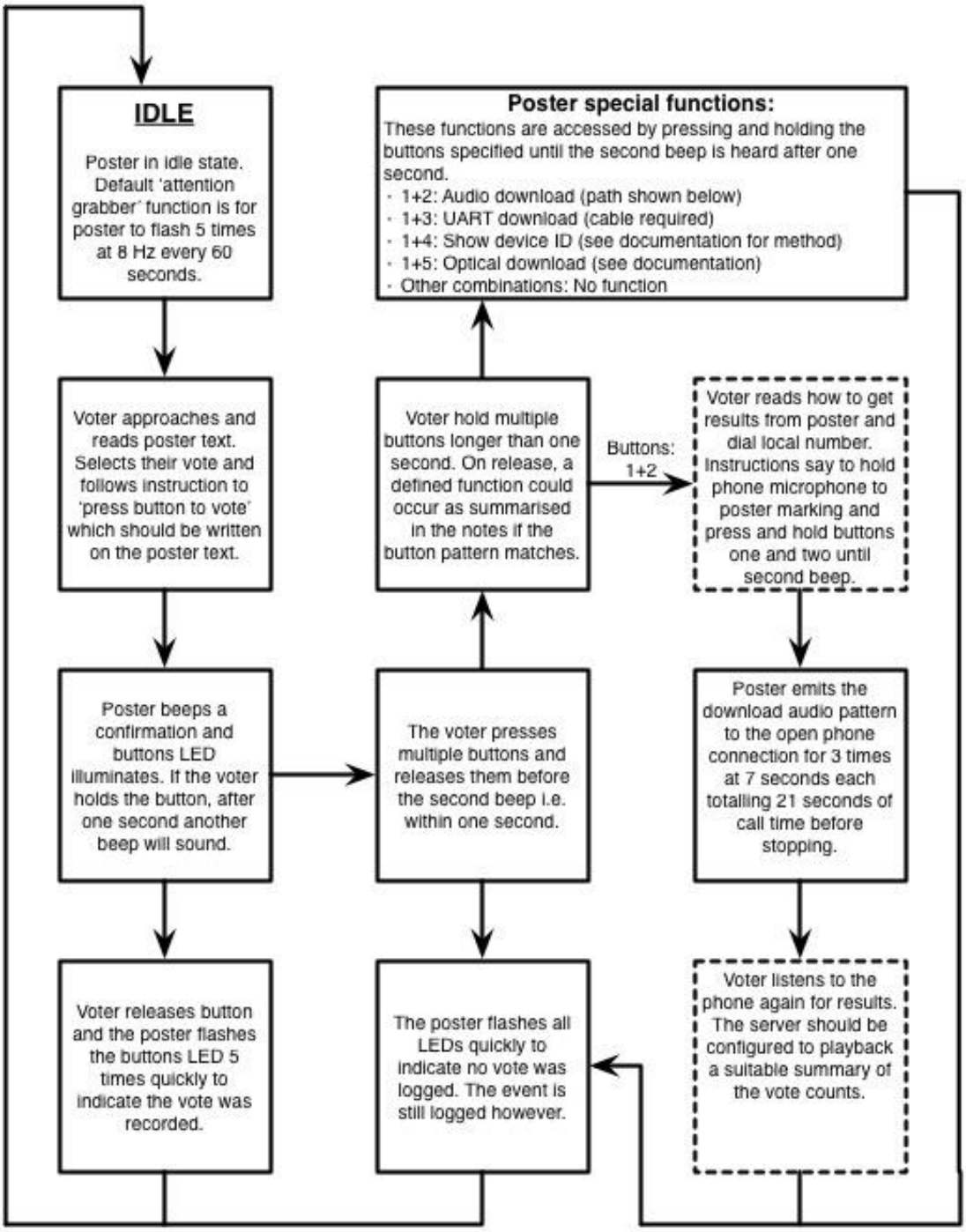
T A B C U

0 b2 b1 b0 1

Button sequences for setting up PosterVote:



Voter Interaction states:



Device Programming Instructions

- The PosterVote should not have a battery installed for programming
- To program in MPLAB select device PIC16F1824 and connect the PICKIT3
- Select the PICKIT3 in the programmer menu
- In the same menu select the settings dialogue
- Under the power tab there is an option to power the target; Select this option and 3.5v
- In the file menu select import; Use this dialogue to select the required firmware file (.hex)
- The programming button should be enabled, the PosterVote can be programmed now
- Use a jumper connector temporarily or make a solder connection to the PosterVote
- Click the program option and the firmware should be loaded

The 'ProgrammerToGo' function can make multiple programming operations quick; Instructions on how to use this functionality can be found at Microchip.com.

Appendix G

BallotShare API

For the case study reported in Chapter 7, an API was developed in order for BallotShare to serve as the backend system for voting through Wordpress, Twitter, SMS and BullFrog devices and transmitting data to the mechanical charts. This document lists the various API methods.

Authentication

With any API call (see below) use the following get parameters for authenticating the device (the username can be the device's MAC address).

!! All characters used in parameters need to be HTML encoded, e.g. for MAC address 28:cf:e9:47:83:01 => 28%3Acf%3Ae9%3A47%3A83%3A01

where : => %3A

Table 7. BallotShare API authentication GET parameters

GET parameters	Description
`api_username`	The device username
`api_password`	The device password

e.g.

`http://ballotshare.com/api/myballots?api_username=test&api_password=test`

API Methods

Register device/user

Method to register a new device.

`http://ballotshare.com/api/register/username/password`

Input
username: the requested username for the device
password: the requested password for the device

Output
0: Either no username or password provided
-1: Registration failed, the username is already in use
1: Successful registration, the device can log in by using the credentials

Vote

Method to vote negatively or positively for an option.

http://ballotshare.com/api/vote/answerId/voteSign

or to authenticate the device (for the rest API methods the same GET parameters should be used):

http://ballotshare.com/api/vote/answerId/voteSign?api_username=test&api_password=test

Input

answerId: the ID of the answer to vote for/against. Each answer ID is associated to a poll ID in the database.

voteSign: 1 if the vote is positive; -1 if the vote is negative

Output

-1: No answer with the given ID was found

-2: The poll is not public and the user/device has no access to this poll

-3: The poll is not open yet or the poll is closed

-4: User has not enough coins to vote

-5: Poll has a "votes limit" which is reached by the user/device

-6: Tried to vote negatively while is not allowed by the poll

-7: Error while saving the vote

-8: Error while updating user's coins count

1: Success

My Ballots

Method to get the list of polls to be displayed on the LED screen – ballots that the authenticated device/user has access to.

http://ballotshare.com/api/myballots

Input

No input.

Output

Echoes a JSON array (to be handled by the device's display).

e.g. one cell of the array echoed contains:

```
{
        Access: {
                id: "300",
                user_id: "1",
                poll_id: "177",
                created: "2014-03-26 11:37:57",
                modified: "2014-03-26 11:37:57"
        },
        User: {
                id: "1",
                name: "Vasilis",
                email: "vasilis.vla@gmail.com",
                username: "vasilis.vla",
                password: "71a283243280d7ed3fd2cce34566756c60465fb611",
                totalCoins: "108",
                created: "2013-09-27 10:07:05",
                modified: "2014-04-24 15:21:27",
                active: "1",
                activation_hash: "3c0b77049a4c75ff0d585443e898fb9478a5b026",
                dob: null,
                image_flag: "1",
                sex: "1"
        },
        Poll: {
                id: "177",
                title: "urban planning",
                question: "what should the ouseburn have in the future??",
                description: "",
                cost: "1",
                category: "0",
                user_id: "1",
                created: "2014-03-26 11:37:57",
                end_time: "2014-03-29 11:37:57",
                add_option: "1",
                add_comment: "0",
                allow_reset: "0",
                public: "0",
                openPoll: "0",
                votesLimit: "10",
                image_flag: "1",
                negative_vote: "0",
                hidden_results: "0",
                endEmail: "1"
        }
}
```

Get Poll's options

Method that returns the poll's options.

http://ballotshare.com/api/getoptions/pollID

Input

PollId: The poll for which to retrieve the list of options

Output

Echoes a JSON array with the options' details.

Get Comments

Method to get the list of comments for a poll.

http://ballotshare.com/api/getcomments/pollID

Input

PollId: The poll for which to retrieve the list of comments

Output

Echoes a JSON array (to be handled by the device's display).

e.g. an example entry


```
{
        Comment: {
                id: "114",
                user_id: "1",
                poll_id: "125",
                comment: "Hello dude",
                created: "0000-00-00 00:00:00"
        },
        User: {
                id: "1",
                name: "Vasilis",
                email: "vasilis.vla@gmaisssl.com",
                username: "vasilis.vla",
                password: "71a2827180d7ed3fd2cce277a6756c60465fb611",
                totalCoins: "97",
                created: "2013-09-27 10:07:05",
                modified: "2014-04-24 16:14:40",
                active: "1",
                activation_hash: "3c0b77049a4c75ff0d585443e898fb9478a5b026",
                dob: null,
                image_flag: "1",
                sex: "1"
```

```
        },
        Poll: {
                id: "125",
                title: "syria",
                question: "Cry for help from Syria",
                description: "Blah Blah.",
                category: "1",
                cost: "3",
                user_id: "1",
                created: "2014-01-28 12:04:42",
                end_time: "2014-03-28 12:04:42",
                add_option: "0",
                add_comment: "1",
                allow_reset: "0",
                public: "1",
                openPoll: "1",
                votesLimit: "1",
                image_flag: "0",
                negative_vote: "0",
                hidden_results: "0",
                endEmail: "0"
        }
}
```


Reset votes

Reset votes for a specified poll.

http://ballotshare.com/api/reset/pollID

Input

polID: The poll ID from which to reset the vote casts of the authenticated user/device.

Output

0: Reset not allowed for the specified poll.

1: Reset successful

Get Poll details

http://ballotshare.com/api/getPoll/pollID

Input

polID: The poll ID

Output
0: In case of empty poll ID or no authentication.
json_arrray: Poll's details (title, question, description etc.) + Answer(s) details + vote counts for each answer (sorted by answer ID)

Get Community Polls

http://ballotshare.com/api/getCommunityPolls/communityID

Input
communityID: The ID of the community the polls should be returned

Output
0: No ID submitted with request
-1: No community with such ID
json_array: list of polls with details and associated arrays for this community

Comment

Post comment for specified poll.

http://ballotshare.com/api/comment/pollID/comment

Input
pollID: The poll that the comment will be associated with
comment: The content of the comment (has to be urlencoded).

Output
0: Poll doesn't exist
-1: Poll's configuration doesn't allow commenting
-2: The content of the comment is empty (empty string posted)
-3: Error while saving data in the comment table
1: Successful post of comment

Donate coins

http://ballotshare.com/api/coins_request/userID/donation

Input

UserID: The receiver ID of the donation

donation: The number of coins to be donated

Output

-1: Receiver of donation not in user's friends list

-2: User is donating coins to himself

-3: User donates more coins than available

-4: Error while trying to save data in User table (receiver)

-5: Error while trying to save data in User table (sender)

1: Successful transfer of coins

Create poll

Method to create a poll.

Input

The following variables can be submitted with an HTTP request:

title, question, answer (can be submitted multiple times), end, communityId, addOption, addComment, reset, public, negative

The 'answer' and 'end' variables are optional, all the others have to be submitted for the request to succeed.

The 'answer' variable can be submitted multiple times (for multiple answers for the poll) as shown below.

The 'end' variable represents the closing time of the ballot in seconds from the current time (timestamp).

communityId: The community ID to assign the poll with. Default if not set 0

addOption: 0 if not allowed, 1 if allowed. Default if not set 1

addComment: 0 if not allowed, 1 if allowed. Default if not set 1

reset: 0 if not allowed, 1 if allowed. Default if not set 1

public: 0 if not allowed, 1 if allowed. Default if not set 1

negative: 0 if not allowed, 1 if allowed. Default if not set 1

votesLimit: Maximum number of votes per user. Default if not set 10.

Output

-1: Empty input, one of the required parameters not submitted

-2: 'end' of the poll submitted but not numeric

-3: Not logged in (this shouldn't happen as it should be caught by the beforeFilter method)

-4: Unexpected error while saving the data in Polls table. db error

-5: Unexpected error while saving the data in Answers table. db error

`http://ballotshare.com/api/createPoll/title:……/question:…… /answer:…/end:…`

Where dots should be replaced with data. Special characters must be URL ENCODED: e.g. spaces must be replaced by their URL equivalent %20

Create poll (location based poll)

Method to create a poll with map coordinates.

Input

The following variables can be submitted with an HTTP request:

title, question, latitude, longitude, answer (can be submitted multiple times), end

The 'answer' and 'end' variables are optional, all the others have to be submitted for the request to succeed.

The ‘answer’ variable can be submitted multiple times (for multiple answers for the poll) as shown below.

The 'end' variable represents the closing time of the ballot in seconds from the current time (timestamp).

Output

-1: Empty input, one of the required parameters not submitted

-2: Latitude or longitude provided not numeric

-3: 'end' of the poll submitted but not numeric

-4: Not logged in (this shouldn't happen as it should be caught by the beforeFilter method)

-5: Unexpected error while saving the data in Polls table. db error

-6: Unexpected error while saving the data in Coordinates table. db error

-7: Unexpected error while saving the data in Answers table. db error

`http://ballotshare.com/api/createMapPoll/title:……/question:……/longi-tude:…/latitude:…/answer:…/end:…`

Where dots should be replaced with data. Special characters must be URL ENCODED:

e.g. spaces must be replaced by their URL equivalent %20

Appendix H

Academic Community Service

During the course of this PhD two HCI workshops were organised and one political science conference chaired.

SIGCHI Workshop

The first workshop entitled "*Designing Alternative Systems for Local Communities*" was a two-day workshop organized at SIGCHI 2015 in Seoul, South Korea on 18-19th of April 2015. This was co-organized with Clara Crivellaro and Rob Comber from Newcastle University, Nick Taylor from University of Dundee, Stacey Kuznetsov from Arizona State University, Andrea Kavanaugh from Virginia Tech, Christopher A. Le Dantec from Georgia Tech and Joon Kim from Kookmin University.

The goal was to explore the role of technology in supporting alternative local systems of community self-organization. During the workshop, researchers, activists and practitioners from the fields of citizen science, maker communities, DIY electronics and design for activism, explored the design of alternative technology for decision-making and democracy; science and education; and commerce.

ACM Digital Library citation: Vlachokyriakos, V., Comber, R., Crivellaro, C., Taylor, N., Kuznetsov, S., Kavanaugh, A., ... & Kim, B. J. (2015, April). Designing Alternative Systems for Local Communities. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems* (pp. 2333-2336). ACM.

Additional workshop details, outcomes, accepted submissions etc. can be found at the workshops website:

http://alternativesystems.co.uk/

BHCI Workshop

The second workshop entitled "*HCI and Notions of Democracy, Participation and Self-Organization*" was organized at British HCI 2015 in Lincoln, UK on 13th July 2015. This was co-organized with Clara Crivellaro, Andrew Garbett and David Green from Newcastle University. The goal of the workshop was to reflect on how HCI research can contribute to democracy, taking into consideration the heavily subjective nature of both "democracy" as a value and "participation" as a means to achieve it.

More information and workshop outcomes can be found at:

http://hci-democracy.co.uk/

PDD Conference

Finally, I chaired the conference on Participatory and Deliberative Democracy conference organized at Newcastle University, Culture Lab on 9-11 July 2014. The conference theme was exploring the connection between participatory and deliberative democracy in the light of contemporary challenges and opportunities introduced by digital technology. The goal of the conference was to facilitate a conversation between the fields of deliberative and participatory democracy, and in particular to open a discussion around the use of digital technologies to facilitate greater political engagement. Invited speakers included Tiago Peixoto from the World Bank, Professor Stephen Coleman from University of Leeds and British Member of Parliament Chi Onwurah.

For more details, the list of program committee, call for participation etc. visit:

http://pdd2014.co.uk/