A City in Common

Explorations on Sustained Community Engagement with Bottom-up Civic Technologies

Mara Balestrini

Intel ICRI Cities

Department of Computer Science

University College London

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To my family and friends.

Finally!

Declaration

This dissertation is the result of my own work under the supervision of Dr Paul Marshall and Prof Yvonne Rogers carried out in the Department of Computer Science at University College London.

It has not been previously submitted, in part or whole, to any university or institution for any degree, diploma, or other qualification.

The text of the thesis is partly based upon the following publications:

- **Balestrini, M.; Creus, J.; Hassan, C.; King, C.; Marshall, P.; Rogers, Y. A City in Common: A Framework to Orchestrate Large-scale Citizen Engagement around Urban Issues. Accepted for inclusion in CHI 2017.**

  This paper presents the development of the "City Commons Framework", a model for the planning and orchestration of citizen sensing programmes, and its validation in the Dampbusters community intervention in Bristol. The paper reproduces content from the chapters 2 and 6 of this thesis.

- **Hassan, C. & Balestrini, M. (2016). "The Bristol Approach to Citizen Sensing: Dampbusters" Public Policies for commons collaborative economies and the experience of Bristol City. Under submission.**

  This book article reflects on the application of the "City Commons Framework", from a public policy perspective. It reproduces content from the chapter 6 of this thesis.

- **Balestrini, M., Marshall, P., Cornejo, R., Tentori, M., Bird, J., & Rogers,Y. (2016, February). Jokebox: Coordinating Shared Encounters in Public Spaces. In Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing (pp. 38-49). ACM.**

This paper presents the case study "Jokebox: coordinating shared encounters in public spaces". It received a **Honourable Mention**, which is for the top 5%. A summary is included in Annex 4 as an additional study that was carried out as a visiting researcher at CICESE in Ensenada, Mexico.

- **Balestrini, M., Diez, T., Kresin, F. From Participatory Sensing to Making Sense. Proceedings of the Workshop "Environmental Infrastructures and Platforms 2015 – Infrastructures and Platforms for Environmental Crowd Sensing and Big Data" co-located with the European Citizen Science Association General Assembly 2015 (ECSA GA'2015).**

This paper discusses the findings of the case studies presented in chapter 5, on Smart Citizen.

- **Balestrini, M., Diez, T., Marshall, P., Gluhak, A., & Rogers, Y. (2015) IoT Community Technologies: Leaving Users to Their Own Devices or Orchestration of Engagement?. EAI Endorsed Transactions on Internet of Things, 15, 1, EAI.**

This paper presents the case studies on Smart Citizen. Parts of this paper have been included in chapter 5. The quantitative assessment of user participation levels reported here was conducted in collaboration with Alexander Gluhak, from Intel Labs Europe.

- **Balestrini, M., Rogers, Y., & Marshall, P. (2015, July). Civically engaged HCI: tensions between novelty and social impact. In Proceedings of the 2015 British HCI Conference (pp. 35-36). ACM.**

Fragments of this paper have been included in the literature review of this thesis and on the 4th chapter, which presents the case study on CrowdMemo.

- **Pantidi, N., Ferreira, J., Balestrini, M., Perry, M., Marshall, P., & McCarthy, J. (2015, June). Connected sustainability: connecting sustainability-driven, grass-roots communities through technology. In Proceedings of the 7th International Conference on Communities and Technologies (pp. 161-163). ACM.**

Fragments of this paper have been included in the literature review of this thesis.

- **Balestrini, M., Marshall, P., & Diez, T. (2014, September). Beyond boundaries: the home as city infrastructure for smart citizens. In Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct Publication (pp. 987-990). ACM.**

This paper includes a summary of the findings of the case studies presented in chapter 5, on Smart Citizen.

- **Balestrini, M., Bird, J., Marshall, P., Zaro, A., & Rogers, Y. (2014, April). Understanding sustained community engagement: a case study in heritage preservation in rural Argentina. In Proceedings of the 32nd annual ACM conference on Human factors in computing systems (pp. 2675-2684). ACM.**

This paper received a SIGCHI Best of CHI **Honourable Mention Award**. The award indicates that the paper was identified as being among the top 5% of all submission to CHI 2014. The content of this paper has been included in the 4th chapter of this thesis where the case study on CrowdMemo is presented.

- **Balestrini, M. In favour of a multiplied self. Can empathy lead to personal behaviour change? In CHI 2013 Workshop: Personal Informatics in the Wild: Hacking Habits for Health Happiness, 31st ACM Conference on Human Factors in Computing Systems, (2013).**

This paper contains fragments that have been included in the literature review of this thesis.

Signed:

Mara Balestrini

Date: 23rd of March 2017

University College London

Abstract

Large technology companies and city councils are increasingly developing smart city programmes: augmenting urban environments with smart and ubiquitous computing devices, to transform how cities are run.

At a smaller scale, communities of citizens are appropriating technologies to tackle matters of concern and to effect positive change from the bottom-up. HCI researchers are also deploying civic technology in the wild, sometimes collaborating with these communities, in the pursuit of both scientific and societal impact. However, little is known about how impactful they have been, and the extent to which they have meaningfully engaged communities in the long term.

The goal of this PhD is to identify the factors that can guide the design and deployment of engaging, sustainable and impactful civic technology interventions, from the perspective of the communities that they are intended to benefit. Three case studies are presented: an ethnographic study of an existing civic technology, and two design and evaluation studies of novel interventions. A set of themes was derived from the studies that highlight factors that are positively associated to engagement, sustainability and impact. Based on these themes and on experience from deploying interventions, a framework was developed and validated. It comprises six key phases: identification of matters of concern, framing, co-design of community technologies, deployment, orchestration, and evaluation.

In line with a new wave of civically engaged HCI and participatory methods, the framework puts people at the heart of socio-technical innovation and technology in the service of the common good by fostering the development of a commons: a pool of community managed resources. Using this approach, the thesis explores how researchers, entrepreneurs, artists, city councils and communities can collaborate to address community issues using digital technologies. It further suggests how citizens can be supported to develop skills that will allow them to appropriate the intervention for their own situated purposes.

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1 Introduction

A “smart city” agenda, has emerged in the last decade to refer to an approach to city renewal that focuses on the opportunities provided by urban computing and big data to control and improve the management of urban resources and services [Hall, 2000].

The idea of the smart city has been characterised as technology-centred, top-down and corporation-driven, because it aims to use ubiquitous technologies to make the city manageable and controllable in a centralised manner [Teli et al., 2015; Townsend, 2013; Greenfield, 2013; Saunders et al., 2015], with a focus on efficiency and environmental sustainability [Hancke & Hancke, 2012; Townsend, 2013; Kitchin, 2014]. The smart city vision has often been associated with a neoliberal ethos championed by technology corporations, which prioritises market-led technological solutions to city planning and governance [Hollands, 2008; Kitchin, 2013] and overlooks how communities can be meaningfully involved in using, appropriating, and even designing the new technologies [Thomas et al., 2016].

A number of critiques have argued in favour of a more participatory approach to the smart city that promotes sustainable citizen-led initiatives and where the public ownership of technologies is a viable alternative over corporate-owned solutions [Greenfield, 2013; Townsend, 2013; Saunders et al., 2015; Teli et al., 2015].

An alternative approach is being developed by several grassroots community groups. Ranging from mothers and toddlers to students and artists, they are being galvanised into action, and are appropriating similar ubiquitous computing technologies in the hope of effecting positive change in their localities [Hargreaves & Hartley, 2016]. In Fukushima, for example, after the nuclear disaster at the Daiichi Power Plants in 2011, a group of citizens crowdfunded and used the SafeCast[1] DIY monitoring device to collect and share open data about radiation levels in their territory. This civic technology was motivated by a perception that the official radiation measurements published by the government were insufficient or unreliable [Kera et al., 2013; Ishigaki et al., 2013]. In Amsterdam, with the goal to power a grassroot and independent data network for the IoT, a group of social innovators launched The Things Network[2]. Through a crowdfunding campaign they funded and deployed enough nodes to cover the whole metropolitan area, thus delivering the world's first participatory technology to provide low power wireless connectivity over long range and power a grassroots IoT network. Communities in hundreds of cities[3] have already joined this open source initiative.

In the process of adopting technologies to collaboratively act on their environments and to address matters of concern, groups and communities also strengthen relationships among themselves, learn and share skills, and shape their cities [Paulos, et al., 2008; Foth, et al., 2011; de Lange & de Waal, 2012; Kera et al., 2013]. Waves of different technologies have progressively widened opportunities for community participation. Websites have been the main platform, but mobile networking tools, geolocation applications, and ubiquitous displays have become more prevalent. Now crowdfunding and open source sensing devices are increasingly available. However, little is known about how the availability of and access to new civic technologies might support bottom-up civic action [Bria et al., 2015; Diez & Posada, 2013; Kera et al., 2013].

Within academia, a similar focus on people rather than on technologies has been developed in the fields of "urban informatics" [Foth et al., 2011; Teli et al., 2015] and "civic tech" [Boehner& DiSalvo, 2016], which build on theories and methods from social sciences and participatory design, and whose research questions address the social and human implications of technology in the urban and civic realm. While researchers have employed the term "urban computing" to refer to similar foci [Paulos & Goodman, 2004; Williams & Dourish, 2006; Kindberg et al., 2007; Bassoli et al., 2007], Foth et al. [2011] have pointed out

1 http://blog.safecast.org

2 https://www.thethingsnetwork.org

3 https://www.thethingsnetwork.org/#communities

that the latter tends to focus more on the technological dimension, for example, discussing advances in big data and urban efficiency (e.g. [Zheng et al., 2014]).

There is much rhetoric in the media[4] about the benefits of community-centred approaches. However, there is a lack of evidence to support these claims. This hinders more detailed understanding of the mechanisms through which communities galvanise around technologies, take up and appropriate them to act at the civic level. Moreover, most studies of community engagement with civic technologies have been small scale and for short periods of time. Little is known about the impact of these new community technologies, or how new community engagement methods might foster effective and sustainable outcomes.

Moreover, there are many challenges associated with conducting research into communities and civic technologies in the wild. First, a key difficulty lies in the definition and framing of the object of study. A research problem in the realm of emergent contexts is normally defined as "wicked" [Rittel & Webber, 1973], which due to the conflicting perspectives of the stakeholders involved cannot be accurately operationalized and therefore is challenging to address using positivist science and engineering approaches. The problem itself is understood progressively as solutions are developed [Fitzpatrick et al., 1998; Zimmerman et al., 2007] and the aim of the researcher is not to find the solution or truth, but rather to improve some characteristic of the world where people live [Rittel & Webber, 1973].

This raises questions regarding the role of the researcher and the appropriateness of certain methodological approaches: whose questions should be asked – *those that matter to the researcher or those that matter to the communities? Who should benefit from the resulting technologies? Whose needs should be addressed? What are the tensions between technological novelty and usefulness?* Adams et al. have discussed the tensions between innovation and scalability in technology interventions. They referred to the researcher working in-the-wild as a *boundary creature*, required to navigate tensions emerging from discrepancies in expectations, motivations and perspectives [2013].

4 https://www.theguardian.com/cities/2014/dec/17/truth-smart-city-destroy-democracy-urban-thinkers-buzzphrase

Another concern for researchers collaborating with communities in-the-wild is how sustainable are the interventions, both of the technologies deployed and the practices that emerge around them. A TOCHI special issue on "The Turn to The Wild in HCI" discussed the methodological and ethical difficulties of working with communities in situ [Crabtree et al., 2013b], with a special focus on the benefits of sustained (years, not just a few weeks) large-scale engagement with whole communities [Carroll et al., 2013; Bonsignore et al., 2013]. Taylor et al. have highlighted the struggles that can emerge when researchers finish research projects and intend to hand over to communities technology prototypes that are not necessarily built to last or whose beneficiaries don't have the skills to repair and maintain [2013].

The main motivation behind doing "civically engaged research" [Hayes, 2011: 1] is that the tools and practices resulting from the interventions will be harnessed by people to effect positive social change [Merkel, 2004; Hayes, 2011]. However, apart from valuable examples such as the Blacksburg Electronic Village, which studied community engagement for more than two decades [Carroll et al., 2013], sustained and meaningful community engagement with technology has been identified as problematic in HCI [Taylor et al., 2013; Hosio et al., 2016]. More specifically, there are very few descriptions of HCI projects that demonstrate long-term community engagement and have empowered communities to effect social change. Merkel et al. argue:

> *"Community computing studies (...) tend to assign a rather passive role to users, viewing them as receivers of technical systems or as informants in the design process. As a result, we know very little about the challenges that community groups encounter when making technology decisions for their organization or the barriers they encounter in using such systems. We also do not know how to work with these groups to achieve their goals or even what counts as a "good" outcome when working with community groups" [2004:1].*

The piecemeal examples of sustainable community technology interventions together with an increasing interest in HCI to conduct more civically-engaged research reveals there is a paucity of knowledge as to how best to do this and what methods to use to engage and sustain communities. The main goal of this thesis is to understand better how civic technology interventions are instigated and sustained over time, the roles of both researchers and community members, and the impact that projects have. The focus is on how citizens collaborate to tackle matters of concern that are not instigated by public institutions or driven by commercial interests.

An overarching goal is to develop accessible frameworks, case studies and guidance that can be used by communities, themselves, to address pressing local issues, establish new forms of collaboration, strengthen social cohesion and effect positive change at the local level. Of particular importance, are how to scale up research to address community-wide concerns, what unit of analysis to use, and how to involve multiple parties?

1.1 Research questions

The research reported here is an investigation into how civic technology can empower communities to effect sustainable positive change in their localities.

In particular, it seeks to address this by answering the following four research questions.

1. **What factors underlie meaningful community engagement with civic technology interventions?**

Although researchers have widely studied the relationships between user engagement and technology, less work has focused on factors that underlie the engagement with technology by groups of individuals who share common interests and attributes [Brown & Schaff, 2011]. Moreover, there is still a need to understand how these factors operate in different community contexts and settings.

Community engagement is a planned process with the **purpose** of working with identified **groups of people**, who may be connected by geographic boundaries, special interests or affiliations, to **address issues** that affect their wellbeing [CDC, 1997; Hlalele & Tsotetsi, 2015; McCloskey et al., 2013]. The focus in this thesis is on notions of community engagement in terms of purpose, social interactions and shared issues. Specifically, it is concerned with how groups of people emerge around and/or meaningfully appropriate computing artefacts to achieve their goals.

2. **What factors contribute to the sustainability of a community, its practices and the resulting technologies?**

Few research-driven civic and community technologies interventions have continued to be used after researchers have left the field [Taylor et al., 2013]. This thesis aims to address this gap by investigating how notions of ownership and social interactions support the design of civic technology interventions that are sustained and impactful. In particular, it examines the sustainability of bottom-up civic tech interventions in relation to their capacity to be continued by communities when the research that motivated them has ended.

3. **What kind of societal impacts can bottom-up civic technology interventions have and how should they be assessed?**

This thesis will map the type of impacts that the studied interventions have had. In particular, it will consider how to assess the impact of research beyond the duration of a research project and determine which research methods to use to demonstrate this.

4. **How can the notions of meaningful engagement, sustainability, and impact inform strategies to achieve successful community-led, civic tech interventions?**

This question examines the efficacy and impact of different strategies, including open-ended design activity, co-design and infrastructuring; the latter described in terms of the "work of creating socio-technical resources that intentionally enable adoption and appropriation beyond the initial scope of the design" [Le Dantec & DiSalvo, 2013: 247]. A main output of the thesis is an accessible framework that is intended to enable groups at the grass-roots level to plan, design and deploy their own interventions to tackle matters of concern. To do so, it examines how the emergent themes of meaningful engagement, sustainability and impact can feed into a strategic framework to be used by community groups in collaboration with researchers to achieve their own goals. It also assesses the challenges associated with the application of these strategies.

1.2 Contribution

The contribution of this thesis is twofold.

Firstly, it provides a set of sensitising themes that identify and conceptualise important concerns:

i. The factors that are positively associated to meaningful community engagement with civic technology interventions: this includes the articulation of matters of concern, novelty, and narratives.

ii. The drivers that foster their sustainability: this requires a process of infrastructuring, here conceptualised in terms of participatory orchestration. It articulates notions such as valued ownership and community capital, which includes supporting community members to develop skills, capacity, and social interactions.

iii. The impact of these interventions in terms of their direct and indirect consequences. The direct impacts are internal to the intervention, and include: effectiveness, its capacity to achieve the goals that it was set up to achieve, its capacity to foster the emergence of social collaboration innovation; and its capacity to nurture community capital. Indirect impacts that mainly come in the form of external appropriation. These appropriations are likely to occur when the project achieves communication outreach and follows an open approach (using open source technologies and processes).

Secondly, it develops, applies and evaluates a framework (City Commons) that guides the design and deployment of novel, engaging, sustainable and impactful civic technology interventions. The model assembles notions of meaningful engagement, sustainability, and impact into a cohesive strategic model that supports participatory orchestration. Furthermore, this thesis also contributes recommendations and guidance stemming from the implementation of the framework. The framework and the guidance can be appropriated by community groups, organisations and stakeholders in governments to guide and scaffold participatory processes.

The thesis also contributes insights on the role of the researcher in the context of supporting the development of community-centred civic technologies. The studies reported here show how researchers can follow participatory methods to engage with stakeholders, without having to manage or control the intervention but rather contributing expertise, helping and fire fighting when necessary. This type of approach can support the sustainability of the intervention and contribute societal and academic impacts.

1.3 Thesis overview

The remainder of this dissertation is structured as follows.

The next chapter explores the background and relevant literature motivating the research. This includes: an overview of visions of the smart city and their relationship with civic participation; a survey of existing research studies into civic and community technology, particularly those supporting bottom-up engagement; and a survey of research methodologies used by researchers studying technologies in the wild.

Chapter 3 defines the general approach followed in this thesis, with a description of the methods, data gathering and analysis techniques used to conduct the different studies.

Chapters 4, 5, and **6** present the empirical studies of the thesis. **Chapter 4** is a long-term study of a community intervention, which aimed to support local heritage preservation using *off-the-shelf* technologies. The intervention, which was a result of the collaboration between the researcher and a group of stakeholders in a small locality in rural Argentina, lasted for over three years and achieved broad impact inside and outside the community. The study focuses on identifying the key factors that enabled this sustained community engagement and impact.

In **chapter 5** two case studies are presented of communities adopting and trying to use *a novel open source environmental sensing platform*. These took place in Barcelona and Amsterdam between 2013 and 2014, and the evaluation continued until 2016. Here the case studies investigate the engagement of communities in interventions that were *planned and organised with no participation* by the researcher.

The findings from the three case studies included key themes associated with the sustainability and impact of civic technology community interventions. **Chapter 6** describes the process through which these themes were organised in an *actionable* *framework for community-centred civic technology interventions* that was designed to be used in collaboration with stakeholders for them to be able to plan and deploy their own interventions. It also presents the validation of the framework, which was applied in the Dampbusters project in Bristol in 2015, which aimed to respond to the problem of damp homes. The framework continues to be used in projects that aim to co-design tools to tackle local issues.

Chapter 7 discusses the main findings derived from the case studies in relation to the research questions presented in this introduction, the challenges encountered during the fieldwork, the limitations of the research and the overall appropriateness of the methodological approach. It suggests future lines of research that follow from the experiences and findings derived from this thesis.

Finally, **Chapter 8** presents the conclusions and summarises that major and minor contributions of the thesis.

2 Literature Review

Research on community engagement with civic technology sits at the intersection of computer science, urban and social sciences, and participatory design.

It draws upon a wide range of related work from both social and technical domains. This literature review chapter begins by providing a definition of what is meant by civic technology, including key understandings of urban informatics and community technologies, with special focus on distributed and collaborative interventions such as crowdmapping, participatory sensing, and citizen science. It follows with a critique of the notion of the smart city, as the current context where three key players -citizen activists, governments, and private companies come together to form a 'civic technology movement' that focuses on the collection of data about people, phenomena and processes to attempt to improve cities [Townsend, 2013]. Furthermore, it presents arguments in favour of the need to develop new models for citizen participation and the governance of common resources.

This chapter also explains how recent approaches for HCI such as research in the wild [Rogers, 2011], civically-engaged HCI [Hayes, 2011], and the turn to openness in participatory design [Marttila & Botero, 2013] present new opportunities to investigate the appropriation of digital technologies by citizens. Finally, it draws from the literature on community technologies to discuss the challenges that researchers have faced when collaborating with communities in uncontrolled environments outside the lab to effect positive and sustainable change.

2.1 What is Civic technology?

Although HCI researchers have long investigated the use of technology in the civic sphere, the term civic technology, or “civic tech”, is relatively new.

It has loosely been defined as the design and implementation of technologies to empower citizen participation in the management and governance of their cities, by augmenting both formal and informal aspects of civic life, government and public services [Patel et al., 2013; Borhner & DiSalvo, 2016]. Borhner & DiSalvo have argued that the increasing interest in civic domains by HCI researchers could be understood as a “logical step” in HCI’s many articulated turns – from the cognitive, to the social, to the cultural, and now to the civic [2016: 2970].

A report by the Knight Foundation, published in 2013, mapped the landscape of civic technology (Figure 1), providing a taxonomy that organised existing interventions under two themes: open government, including projects that advance government transparency, accessibility of government data and services, as well as civic involvement in democratic processes; and community action, including interventions aimed at catalysing civic crowdfunding, peer to-peer sharing, and collaboration to address civic issues [Patel et al., 2013]. Open government includes technologies such as platforms that foster government transparency providing access to open data (i.e. Socrata[5]), data utility platforms enabling users to analyse and use government data to improve public services (i.e. MySociety[6]), systems supporting participation in public decision making (i.e. OurSay[7]) and the provision of citizens’ feedback and opinions (i.e. SeeClickFix[8]), platforms for the visualisation and

5 https://socrata.com

6 https://www.mysociety.org

7 https://oursay.org

8 http://en.seeclickfix.com

mapping of civic data sources (i.e. Azavea[9]), and voting technologies (i.e. TurboVote[10]). Community action civic interventions include civic crowdfunding platforms that enable citizens to collectively fund projects destined to have a positive social impact (i.e. Neighbor.ly[11] or Goteo[12]), campaign organisation tools (i.e. Change.org[13]), neighbourhood forums (i.e. Nextdoor[14]), peer-to-peer sharing systems (i.e. Lyft[15]), and data crowdsourcing systems enabling participatory sensing and mapping (i.e. NoiseTube[16]).

Despite its broadness, Borhner & DiSalvo have pointed out that the taxonomy provided by the Knight Foundation's report excludes other relevant non-Internet based interventions that rely on other technology such as videography or community workshops [2016]. This gap may be caused by the fact that the investigation focuses on initiatives led by organisations, both for profit and not for profit, that have received public and private funding and developed specific technologies. This sampling automatically excludes more spontaneous and grassroots initiatives that utilise combinations of engagement methodologies and off-the-shelf tools to effect collaboratively civic action. Other areas such as Urban informatics, Community Technologies, Information and Communication Technologies for Development (ICT4D), Community Displays and Participatory Design (PD) can also be considered forms of civic technology in this broader definition [Borhner & DiSalvo, 2016].

Many civic technologies such as community social networking sites and mobile and locative media - that enable novel interactions between people, community and place - have been studied within the domain of urban informatics. Urban informatics focuses on *"the study of urban experiences across different urban contexts that are created by new opportunities of real-time, ubiquitous technology and the augmentation that mediates the*

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9 https://www.azavea.com

10 https://www.turbovote.org

11 https://neighborly.com

12 https://en.goteo.org

13 https://www.change.org

14 https://nextdoor.com

15 https://www.lyft.com

16 http://noisetube.net

physical and digital layers of people networks and urban infrastructures" [Foth et al., 2011: 4] (although it has been sometimes defined as "the application of computers to the functioning of cities [Batty, 2014]). Moreover, community displays presenting neighbourhood forum data [Taylor et al., 2013; Cheverst et al., 2012] and voting and feedback systems have been studied within the domain of community technologies [Koeman et al., 2015; Vlachokyriakos et al., 2014]. This corpus of work is often guided by the understanding that technology should be participative and transfer power to the wider community instead of creating technical elites [Mason, 2001; Gurstein, 1999; Carroll, 2011].

Civic technologies are nowadays predominantly being designed and rolled out within the broader context of the smart city. This is happening both from the top-down, as part of government smart city programmes [Chourabi et al., 2012; Sherriff, 2015], and bottom-up, fostered by grassroots collectives, activists, social entrepreneurs, and organisations that want to participate in addressing issues of concern on their own terms [Townsend, 2013]. One approach is *community action civic tech*, in particular, data crowdsourcing interventions that provide infrastructure for citizens to participate in the collection, sharing and display of data aimed to address local issues [Patel et al., 2013]. The focus on community participation and data is found to be a common denominator across many civic tech applications and trending topics in HCI research such as big data, open data, Internet of Things, and citizen sensing [Boehner & DiSalvo, 2016]. It also enables the exploration of pressing questions that emerge in the context of the smart city, such as whose priorities should smart technologies address? Who should own and have access to data that pertain to the public domain? And how to democratise the access to and provision of goods and services for the common good?

Teli et al. explored similar concerns within the context of the project Smart Campus in Italy [2015]. The project aimed to create an ecosystem to foster students' participation in the design and development of services for their campus. In particular, they compared the case of a mobility application that had two different instantiations, ViaggiaRovereto and ViaggiaTrento. The first one was developed following a top-down "*smart city*" engagement strategy (the application was promoted by the local Municipality and through broadcast communication) [Teli et al., 2015: 17], while the second one followed a bottom-up approach where engagement was situated and participatory. The research suggested that following a bottom-up approach nurtured the relationship between designers and users, stimulated a more sustained engagement and supported the emergence of new social collaborations that enhanced the functionality of the application.

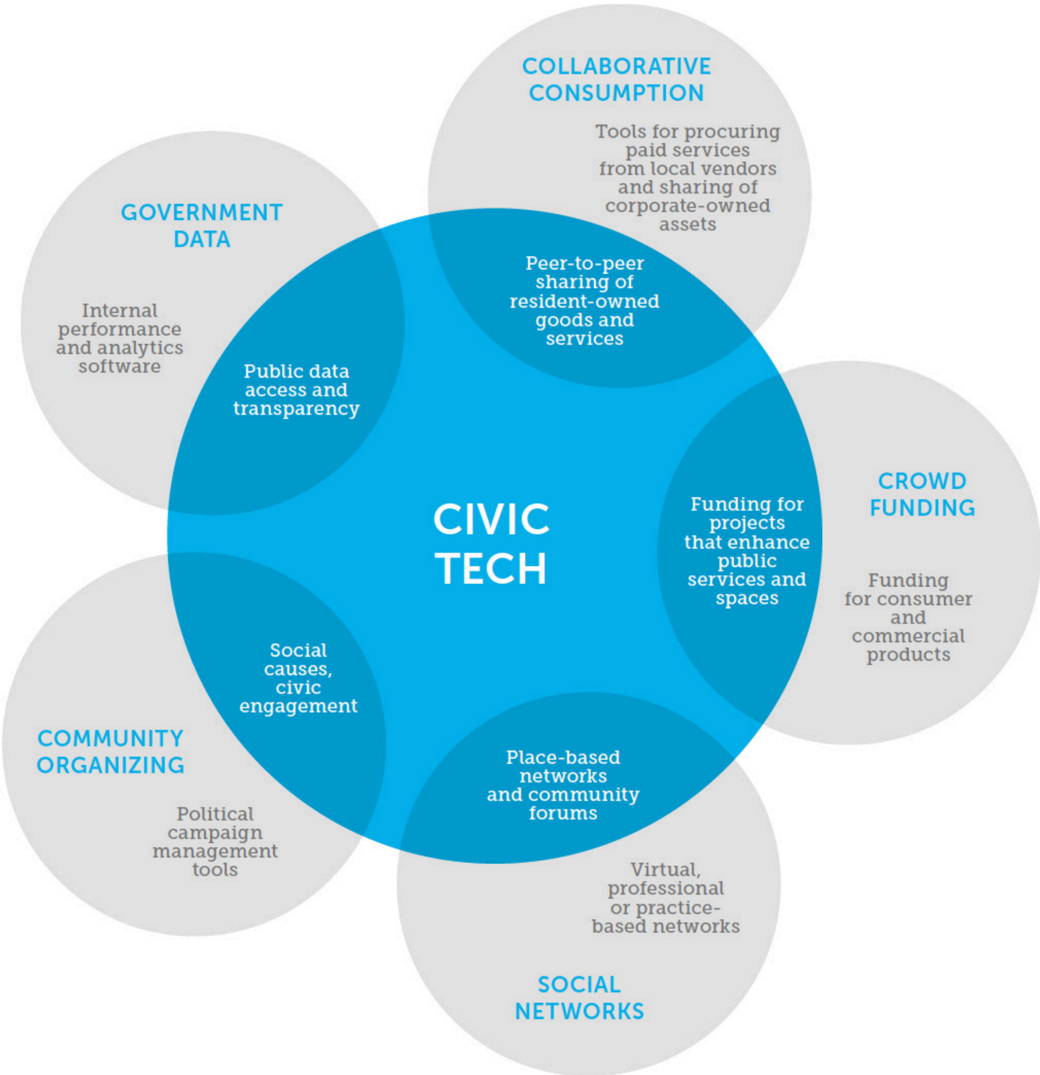

Figure 1. The landscape of civic tech by the Knight Foundation

2.2 Civic technologies: a historical perspective

Computing technologies have changed in type and scope in the last 40 years, evolving from desktop to mobile systems, including social media, situated displays, to the most recent developments around the Internet of Things (IoT).

Throughout time, people and communities have developed different strategies to appropriate these innovations and transform them into tools for civic action. While personal computers and mobile phones have been pervasive in everyday life since the 1970's, more novel technologies such as sensors and IoT devices are still novel and largely unfamiliar to most people [DiSalvo et al., 2009]. What follows is not intended to be an exhaustive list but rather a selection of the most significant types of civic technologies. Needless to say, evolution has not been linear, with many of these tools and research domains evolving in parallel and even overlapping. The section begins with one of the earliest forms of computing artefacts developed to support collective civic action, known as community informatics, and then covers related developments such as community displays, mobile mapping, citizen science, urban participatory sensing, and crowdfunded participatory sensing.

2.2.1 Community informatics

The vision that designing and evaluating community technologies can offer both research contributions as well as social development has been around for over four decades now [Mason, 2001]. The field of Community Informatics stems from the practices of community organisation and development, and research disciplines such as sociology, planning, computer science, critical theory, women's studies, library and information sciences, management information systems, and management studies. Its outcomes — community networks and community-based ICT-enabled service applications — are of increasing interest to grassroots organizations, NGOs and civil society, governments, the private sector, and multilateral agencies among others.

Bottom-up community initiatives, sometimes developed in collaboration with researchers, are motivated by exploring ways to harness ICT to foster social capital and empower local communities [Graham, 2005]. An early example was the Community Memory Project (CM), deployed between 1972 and 1974 by a group of activists and researchers in San Francisco [Schuler, 1994]. Their goal was to explore how people would react to using a computer to exchange information. CM is considered to be one of the first public computerised bulletin board systems. It was deployed in Berkeley California, and enabled users to post and browse messages. Although it was initially conceived as an information and resource sharing network linking social organisations with each other and the public, CM soon became a public information market by providing a two-way access to the messaging database through public computer terminals. Its instigators conceived of CM as a tool to strengthen the Berkeley community and were in favour of low cost, decentralised, and eco and user-friendly technology [Schuler, 1994]. While there is little research evidence of how the system was used and appropriated by citizens, CM was considered to be very innovative, as few members of the public had used a computer prior to its deployment. The novelty of the system had a positive impact on creating engagement, with people sometimes gathering around the terminal while waiting as other used it, excited about having an opportunity to use a computer [Colstad & Lipkin, 1975].

Another early example, well known for its long-term collaboration between researchers and a community of users, was the Blacksburg Electronic Village (BEV[17]) [Carroll & Rosson, 1996], initially conceived at Virginia Tech in 1991 and launched in 1993. The goal of the project was to create an online community that would link the entire village and allow public information sharing and broad participation in civic matters. Although the intervention was designed and implemented from the top-down with little participation from citizens, it later achieved widespread community participation, demonstrating new applications and concepts for online community activity [Carroll, 2005]. In more than 20 years since its creation, the intervention has hosted over eight different projects. While they were initially simple websites enabling actions such as posting and sharing stories, the projects evolved to include more complex technologies such as geolocation systems, and social network features such as likes and shares.

Through their long term engagement with the Blacksburg community, the researchers found that one of the key contributions of the project had been to create opportunities for the development of knowledge and skills of community members and possibilities for cooperation; and that the projects had created infrastructures that in many cases had been successfully appropriated and owned by other community members. However, they also warned that while participation in a community setting is rewarding, it can often be inefficient, has a significant developmental time course, and requires a high level of commitment [Carroll & Rosson, 2013].

In the 80s and 90s, similar community networks emerged both in developed and developing countries, such as Big Sky Telegraph[18] (1980) and Cleveland Free Net[19] (1986). It has been argued that the first generation of community networks had strong civic motivations, while a second generation emerging later had a stronger commercial motivation [Carroll, 2005].

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17 http://www.bev.net

18 http://davehugheslegacy.net/index.php?option=com_content&view=article&id=424:big-sky-telegraph-1&catid=102&Itemid=210

19 http://www.atarimax.com/freenet/common/html/about_freenet.php

2.2.2 Summary

The focus of much of the research, coined as Community Informatics, has been to investigate and strategize how ICTs could enable and empower people living in geographically bounded communities. This is the case for communities where ICT access was provided on a community basis, for example, through telecentres, and community media centres. Community informatics [Mason, 2001; Gustein, 2009, Carroll & Rosson, 2003; Carroll & Rosson, 2013] projects initially used desktop computers, but this has been overtaken by community interventions that profit from the widespread uptake of mobile devices and ubiquitous connectivity [Steels & Tisselli, 2008; Bidwell et al., 2010], and social media [Erete, 2013]. These newer interventions promoted a variety of actions and types of content, ranging from digital storytelling [Tacchi et al., 2009; Bidwell et al., 2010] to crowdsourcing or "community mapping" [Hagen, 2011]; mobile community memories [Steels & Tisselli, 2008], crowd and participatory sensing [Ganti et al., 2011], and citizen science [Irwin, 1995].

In many cases these early efforts have effectively enabled the formation of communities and fostered social capital [Carroll & Rosson, 2013]. They have given a voice to often marginalised communities [Hagen, 2011; Steels & Tisselli, 2008], supported the development of technology literacy among citizens [Carroll & Rosson, 2013], and developed infrastructures to enable people to act upon matters of concern [Erete, 2013]. They have even created opportunities for people to use a computer or connect to the Internet for the first time, democratising access to ICT and encouraging appropriation from the bottom-up [Colstad & Lipkin, 1975; Irwin, 1995]. However, these systems have tended to be driven by the concerns of researchers rather than communities, and there is little evidence with regards to their potential for sustainability and scalability.

2.2.3 Community displays

The increasing availability of connected LED screens in the public space has fostered the development of situated community displays. One of the pioneering prototypes of a screen-based system designed to enable public interaction was Opinionizer, a wall display where people could cast their opinions by entering words using a keyboard placed on a table near the display [Brignull & Rogers, 2003]. This project showed how the engagement could be represented as a public interaction flow model. It also identified the *honey-pot effect* (the phenomenon by which social activity around a display can draw attention to it and encourage others to engage) as a key social affordance. The findings of the early research in this area revealed that Opinionizer was an effective ice-breaker fostering social interactions among strangers. Using text input to contribute opinions could reduce social embarrassment [Brignull & Rogers, 2003].

A more recent example of a public display, aimed at promoting civic opinion was Discussions in Space (DIS) [Schroeter, 2012]. Users could contribute their views using their own mobile devices by means of SMS or Twitter. The aim of this project was to evaluate whether this intervention could engage those citizens who do not tend to participate in civic discussions. The results showed that although most participants were reticent to sharing their views, some contributed ideas they were unlikely to have expressed in face-to-face settings. A similar approach was adopted by Ubinion, which enabled young people whose voices are not otherwise heard to contribute opinions on municipal issues [Hosio et al., 2012].

A different approach has been to create large-scale installations or media facades. For example, the MÉGAPHONE Project [Fortin et al., 2014], an architectural-scale art installation, was designed as an interactive agora space where people could express their opinions and listen to those by their fellow citizens. As in many other cities around the world in 2012, in Montréal (Canada) thousands of citizens engaged in street protests during the so-called Maple Spring. The system comprised a microphone, loudspeakers, two media façades and responsive stage lighting. It was deployed at the heart of Montréal in late 2013 for a total of 37 evenings and engaged over 4800 people. Using speech recognition software, the speakers' words were converted into written text presented on the large media façade. It was found that the installation gave users the feeling that it was a self-publishing tool in the public space, that it was used as situated "social media" where speakers could concatenate opinions, and a place for social connectedness [Fortin et al. 2014]. Although this technology was successful at meeting its goal (creating a digitally augmented space for citizens to share views and opinions) it provided few opportunities for appropriation. For instance, users were asked to use the installation following a protocol provided by the instigators and published on the project's website (known as the "speaker's guide[20]).

Community displays can also be designed in collaboration with the beneficiary communities. For example, Taylor and Cheverst [2009] collaborated with an English rural community in North West England to investigate how public displays could support social interactions at a local level. They adopted a set of user-centric and participatory methods to design and deploy the Wray Photo Display. Between 2006 and 2010, researchers worked closely with the residents and a 'champion' who acted as an access point, to investigate how use of the display emerged over time and how real experience with relevant technologies could help community members to engage in participatory design process.

During the project, a number of public display prototypes were deployed in the village. First, was the Wray Photo Display, a touchscreen display through which residents could share photographs. Over time, the display evolved to also show upcoming events and advertisements, all of them posted by residents themselves. After three years, a second display was installed in a local café. The researchers found the display to be a successful community technology, as it became integrated into residents' photo sharing behaviours, with residents sharing over 1,500 photos by the end of the project. The event listings and advertisements also augmented existing methods of sharing this content in the village [Taylor & Cheverst, 2012].

From 2009 to 2011, Taylor et al. [2012] organised the Bespoke project to investigate the use of citizen journalism and design novel technologies for a specific community facing challenges such as digital exclusion in Preston, North West England. Viewpoint (Figure 2), for example, was a public voting device that allowed residents to make their voices heard through

20 http://www.megaphonemtl.ca/en/speaker-s-guide

a simple interaction. The intervention attempted to make participating in local decision-making as simple as possible, by allowing local politicians and community organisations to post binary questions that appeared on devices in public locations. Residents could cast their votes using two large buttons on the front of the device or sending a text message. Viewpoint devices were installed in a local shop, a community centre and the offices of a local housing association during two months and questions were posted weekly. During the trial period around 1,800 votes were placed by the public in response to eight different questions.

Figure 2. The public voting device Viewpoint displayed at a shop.

With Viewpoint, Taylor et al. [2012] found that the deployment of situated voting technologies enabled the collection of vast quantities of feedback, but struggled to address the low sense of efficacy in the community. Since the questions posted on the device were determined by representatives from local government and other organisations, community members could not appropriate the intervention in terms of proposing an agenda themselves. During the study, community members expressed that there was lack of awareness of activities being carried out by local groups. As a result, a novel form of noticeboard called Wayfinder was created. The device could receive and display SMS messages containing a description and location of an event. An arrow on top of the device would rotate to point in the direction of the event. Wayfinders were deployed for a two-month period, outside a church, a housing association office and at a community centre. Content was moderated by local institutions [Taylor et al., 2012].

Both Wray Display and the Bespoke projects were successful in engaging the community to participate either by contributing photos, opinions or votes. However, when researchers left the field and handed these prototypes over to the community, participation waned and technical issues emerged. As a result, all of the Viewpoint and Wayfinder deployments were removed from the community within six months of the project's conclusion. These issues regarding community technology handover have been addressed in [Taylor et al., 2013] with a focus on issues such as lack of robustness of technology prototypes and lack of technical skills of community members who are usually unable to fix or maintain the infrastructures.

Another example of a distributed community display was created as part of the project Visualising Mill Road [Koeman et al., 2015], which studied how technology could encourage citizens living on opposite ends of the same street in Cambridge (UK) to overcome social divisions based in prejudices. The approach taken was to design a set of electronic voting devices to be deployed at shops on both sides of the perceived division to elicit opinions about aspects of the community. These data were then aggregated and presented as public community visualisations (Figure 3), designed to draw attention and provoke discussion. The system was deployed for 24 days. During the first two weeks, the questions on the devices were changed every other day and the data from the previous question was collected. Visualisations representing the aggregated votes were sprayed onto the pavement outside the shops.

Figure 3. Visualising Mill road intervention

The project in Mill Road was successful in creating opportunities for reflection, social interactions and conversation. The results showed that the divide residents of Mill Road feel between the Petersfield and Romsey areas of the street was not just a perception: the Romsey side of the bridge felt happier, more neighbourly friendly and safer. The findings of the study show the potential of low-tech, low-cost community technology, public visualisations and participatory design approaches to engage community members to reflect on and discuss their perceptions. It also highlights the importance of not thinking about communities as being homogenous entities [Koeman et al., 2015].

2.2.4 Summary

Community displays have evolved from situated screen-based interventions to large-scale interactive facades or distributed systems. They have increasingly offered opportunities for more complex forms of interaction, such as sharing content via social media and casting votes through distributed ubicomp artefacts. Despite these developments, the potential of this technology seems to be its capacity to enable situated social interactions, conversation and reflection. If deployed for prolonged periods of time, such as in the case of the Wray Display [Taylor et al., 2012] situated displays can support the formation of new habits and become integrated into people's routines. However, engagement with these technologies has been shown to wane, which is associated with users feeling like there is not enough room for appropriation. For example, in the Megaphone project people had to book a slot and follow a protocol to cast an opinion and in Viewpoint community members wanted to expand their contribution from simply answering questions posted by politicians to deciding on what should be asked.

2.2.5 Mobile mapping

A number of mobile interventions aimed at connecting, empowering and giving voice to often excluded or stigmatised communities appeared in 2000s. The project Finding a Voice, investigated creative engagement and ICT in deprived communities across India, Nepal, Sri Lanka and Indonesia to empower people to communicate their voices using technology [Tacchi, 2009]. In Voice of Kibera, citizens of the largest slum in Nairobi used handheld portable devices and OpenMapStreet to map their neighborhood and geo-locate stories about their daily life [Hagen, 2011].

Tisselli and Abad [2003] collaborated on a series of projects where communities created and distributed online media representations of themselves, their daily struggles and community practices. For example, Megafone.net invited groups of people living on the margins of society to express their experiences through face-to-face meetings and also online by using digital media. Their participants used a mobile application that allowed them to publish pictures and audio files directly from the device to an online platform. Over ten projects were conducted with different urban communities: Taxi drivers from Mexico City (2004), young gypsies in Lleida and Leon (Spain 2005), prostitutes in Madrid 2005 (Spain), Nicaraguan immigrants in Costa Rica (2006), motorcycle messengers (motoboys) in Sao Paulo 2007, or displaced and demobilized people in Colombia [Steels & Tisselli, 2008]. From these projects, Steels and Tisselli [2008] analysed how they created community memories – as a medium for recording and archiving information relevant to a community and for distributing this information among members.

The prerequisite for a community memory is that there is an existing community and a commons to be managed. It has also been found that a key aspect of community engagement with community mapping tools is a sense of ownership and empowerment. It is considered the community who takes action to protect its commons, not some external expert who lacks knowledge of their territories [Lewis, 2004].

Research on community memories has shown that the technology really accounted for only a small part of the success of a project. Success was defined as the management or resolution of the tensions that galvanised the community to take action in the first place. Instead, a key factor towards success was the set up of the social organisation of the community communication itself. This work has to be done by skilled social workers who hold strong ties to the community and can orchestrate the process [Steels & Tisselli, 2008]. Moreover, it was found that enabling face-to-face meetings among community members was crucial to the success of the intervention, as well as ensuring that members' contributions to the Community Memory were identified rather than anonymous.

Other projects have used the GPS integrated in mobile phones to explore how a community network might facilitate a sense of belonging in the urban space. An example of this type of urban technology intervention was the application Familiar Stranger [Paulos & Goodman, 2004]. The system comprised a set of personal wearable devices and mobile phones that used GPS to identify other users who were in the vicinity. After repeated interactions the system could notify each user, in real time, whether other familiar stranger was nearby. While protecting the anonymity of all users, the system aimed at improving community solidarity and a sense of belonging in urban spaces. Despite this being a well known project, the resulting technology, called Jabberwocky, was only really a research prototype that was not evaluated in situ. Therefore, it is unknown to what extent it facilitated a sense of shared space among familiar strangers and improved community solidarity.

Another form of community mapping is often referred to as citizen reporting or civic crowdsourcing [Surowiecki, 2005]. These systems aim to open channels for citizens to participate in the maintenance of their cities and/or have a say in civic matters [Harding et al., 2015]. Examples of these technologies are applications such as FixMyStreet[21] or Citizen Connect[22] that allow people to report urban issues such us broken street lights, graffiti or waste dumps to the official agencies. However, it appears citizens find it difficult to use community-based tools in the long term [Hardin et al., 2015]. Different factors have been associated to the low perceived value of civic crowdsourcing applications. On the one hand, technology designers tend to focus on one of the stakeholder groups involved (typically the citizens) instead of adopting a more inclusive design approach that considers the complex dynamics and relationships between different stakeholders (citizens and city authorities, for example). On the other hand, designers tend to overlook the fundamental trust issues that impact the relationship between these agents.

For example, by not questioning why citizens would engage with a civic process when they often believe nothing is likely to happen as a consequence of their contributions [Harding et al., 2015].

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21 http://www.fixmystreet.com

22 http://newurbanmechanics.org/project/citizens-connect

Civic engagement tools tend to be designed for smartphones, which makes them relatively easy to prototype and implement. However, designing applications for civic authorities is more complex, requiring integration with existing large and bespoke platforms used to manage city infrastructure, as well as the orchestration of relationships between different stakeholder groups throughout the design process [Harding et al., 2015].

2.2.6 Summary

The wide adoption of mobile technologies had a significant impact in field of civic technologies. Early projects such as Tisselli & Steels' [2008] community memories or The Voice of Kibera [Hagen, 2011] were instrumental in giving a voice to communities often living in the margins of society, feeling excluded and disenfranchised. They galvanised people facing similar needs and encouraged the formation of commons: from personal stories and memories to open maps, new networks of action and social capital. Unlike situated displays, community projects leveraging mobile phones enabled low-cost, distributed channels for personal and ubiquitous contributions. They leveraged the technologies that were already owned and used by people.

To date, citizen reporting and crowdsourcing are rather established domains enabling citizens' contributions on a wide variety of formats and types of content. Nevertheless, the research here presented demonstrates that while the role of the technology is important, enabling social interactions in face-to-face settings was still necessary to foster sustainable communities and build trust [Tisselli & Steels, 2008].

2.2.7 Citizen Science

Crowdsourcing platforms, from desktop to mobile based have fostered other forms of participation such as citizen science, a socio-technical system that entails a collaborative process of data collection, curation, and analysis in which members of the general public contribute towards a scientific project [Hand, 2010]. One of the oldest citizen science projects is The Christmas Bird Count[23], which was launched 1900 by the Audubon Society in North America and has provided long-term comprehensive data for many bird species for over 100 years. A more recent example is the online citizen science project GalaxyZoo[24], where participants help to classify astronomical photographs. It started in 2007 with the publication of a data set made up of a million images of galaxies and it has become one of the most successful projects in terms of volume of contributions: more than 50 million classifications were received during its first year, contributed by more than 150,000 volunteers. The project is still on-going and the project instigators have already published 48 scientific articles using the data contributed by citizens.

Unlike many online communities, citizen science projects are not self-organising but typically are instigated by professional scientists or environmental organisations [Wiggins & Crowston, 2011]. This means that they often have a top-down structure where research questions, methods and outcomes are often planned a priori by experts. Frameworks developed to account for how citizen contributions occur in practice have shown how a number of factors are at play [Haklay, 2013; Wiggins & Crowston, 2011; McQuillian, 2014; Wilderman, 2007]. These include projects that are centralised and where citizens' participation is limited (collecting or curating data) and those that are more decentralised, allowing citizens to participate in decision-making and goal planning in addition to the data collection tasks. Nov et al. [2010] and McQuillan [2014] argue that the adoption of Internet technologies enabled this shift from top-down centralised approaches to distributed and community-centred ones.

23 http://birds.audubon.org/christmas-bird-count

24 https://www.galaxyzoo.org

Wiggins & Crowston argue that citizen science projects can have different foci such as civic action, conservation, investigation, virtual action, or education according to their organisational and macrostructural properties [2011]. While civic action projects are community-centred and use scientific tools to support civic agendas, investigation projects focus on scientific research goals and have a top-down structure. An example of the former would be "Re-clam the Bay[25]", which promotes environmental involvement aimed at growing and maintaining millions of baby clams and oysters in New Jersey, USA. The project began in 2005 as an educational institutional effort but a year later the participants' took ownership and continued the intervention. Although being a small volunteer-based movement of around 50 participants, it has been successful: in 2008 1.4 million clams were planted in two estuaries and scientist have used the data collected by volunteers (such as water quality and clams growth rate) to produce research [Bonney et al., 2009]. A key element supporting the success of the intervention is that volunteers are trained and certified as a prerequisite for participation.

An example of an investigation project is the Monarch Larvae Monitoring Project[26], which involves volunteers from across the United States and Canada in Monarch research. The project has sustained for almost 20 years, involving a wide population of participants: from teachers to families, biology enthusiasts and scientists. Like in Re-clam the Bay, the success of the project is partly due to the fact that people are trained to participate. With the years the process of training has become more sophisticated and volunteers can now either learn from online materials or attend "nature centres" were face-to-face training is offered [Bonney et al., 2009]. Moreover, participants have a high level of autonomy, as they can chose and report their own mapping sites, deciding where and when to map Monarch Larvae.

The vast majority of citizen science projects have been virtual interventions, where all project activities are mediated by ICTs and therefore the place from where users participate is irrelevant [Silvertown, 2009]. They are top-down, organised and led by scientists typically affiliated to an academic institution, and make use of custom-made websites. A notable

25 http://reclamthebay.org

26 http://www.mlmp.org

example is FoldIt[27], an online puzzle game where users fold models of proteins. The online game is part of a research project and was developed by the University of Washington's Centre for Game Science in collaboration with the UW Department of Biochemistry.

Although user participation in these types of projects is very similar to peer-production, their hierarchical form is likely to create a different sense of community with respect to authority, leadership, decision-making and sustainability [Butler, 2001]. Nevertheless, issues of motivation and progressive engagement in citizen science projects do share similarities with those arisen in virtual communities or networks of practice [Wiggins & Crowston, 2011]. For example, Nov et al. [2010] found that online citizen science project participants are often motivated by the opportunity to learn. This is unlike those who take part in crowdsourcing for non-scientific purposes, who are typically driven by reputation and identification with a community. Community building is also a key motivator for participation in citizen science [Rotman et al., 2012], in contrast to other volunteer activities for which acknowledgement and rewards are more common motivators (e.g. open source software development).

Haklay's [2013] framework outlining citizen science efforts focuses on the role played by users, from basic crowdsourcing where users act as sensors to extreme citizen science, a situated and bottom-up practice that takes into consideration local needs, practices and culture. Along similar lines, Bonney et al. [2009] distinguish among three types of citizen science: contributory (observing and collecting data); collaborative (data collection and refining project design, analysing data, disseminating results); and co-created (public and scientist design the inquiry together and share the majority of steps in a scientific project/process).

27 http://fold.it/portal

2.2.8 Summary

Technology-enabled citizen science projects have existed for decades now. They vary in aims and organisational structures, ranging from the most top down investigation projects to bottom-up community-led ones. Despite the existence of different types, the great majority of projects have been instigated by researchers who set the goals of the intervention and organise strategies to recruit and train participants. Learning about specific topics is one of the key reasons why people contribute to these efforts. In many cases hobbyists and amateurs see them as an opportunity to further explore topics of their own interest while contributing to advancing the state of the art. Nevertheless, new and more bottom-up approaches are increasingly being investigated where citizens are empowered to participate in the organisation of the project, collaboratively acting on the process of scientific enquiry from the outset.

2.2.9 Urban Participatory Sensing

Citizen science and participatory sensing have a varied history [Corburn, 2005] and it is not uncommon to see either term used interchangeably, or the latter to be considered a type of the former [Haklay, 2013; Wiggins & Crowston, 2011]. Moreover, the existing literature on urban participatory sensing can broadly be divided into two main kinds of projects: art and research.

Urban participatory sensing is a socio-technical process in which citizens use lightweight and accessible sensor-technologies to collectively monitor the environment by gathering and sharing data [Burke et al., 2006]. The aim of the intervention is not necessarily to contribute towards scientific research but rather to monitor the environment, raise awareness on local issues, and possibly change behaviours or inform policy changes [Bria el al., 2015]. Urban sensing technologies designed to be used by citizens have been around for over a decade now, ranging from specific sensors or applications augmenting mobile phones [Stevens & D'Hondt, 2010; Paulos et al., 2008; Mun et al., 2009] to IoT (Internet of things) smart and connected devices such as Air Quality Egg[1] or Smart Citizen [Diez & Posada, 2013].

Three seminal participatory sensing projects were designed and deployed by artists in the early 2000s. The Air Project[28] was instigated by a group of New York based artists who invited participants to use a device that could measure carbon monoxide (CO), nitrogen oxides (NOx) or ozone (O3) levels in the users' immediate surrounding. The aim of the project was to create a tool for citizens to monitor pollution and a platform for discussion around energy politics [Da Costa et al., 2006]. In the system's display participants could simultaneously view measurements from their device and from the other devices in the network. These data could also be accessed in real time from a web platform, and was used to produce artistic visualisation works. During the deployment participants were asked to use the device for no longer than 24 hours before passing it to a different user.

In 2006 another artistic project aimed at sensing the environment was designed and deployed in California. Tripwire[29], by Tad Hirsch, used audio sensors hidden in coconuts and connected to mobile phones to monitor sound levels in a neighbourhood nearby the San Jose airport. When sound signals above a given threshold were detected the system would automatically call the City of San Jose noise complaint line to register a pre-recorded complaint.

The Feral Robotic Public Authoring project[30] developed by Natalie Jeremijenko in collaboration with neighbours in New York used off-the-shelf toy robot dogs comprising wheels and sensors as mobile sensing devices. The robots were deployed in parks and other public spaces to collect data on pollution.

A key aspect of the project was its capacity to attract media coverage and in turn instigate discussions about the environmental conditions affecting local communities.

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28 http://www.pm-air.net

29 http://rhizome.org/editorial/2008/jan/30/tripwire-2006-by-tad-hirsch

30 https://www.nyu.edu/projects/xdesign/feralrobots

The project was also run in London where it was found that community members required some level of technical skills to assemble and deploy the feral dogs. The instigators concluded that the project was better suited for hobbyists who have technical literacy [Airantzis et al., 2008].

Within the arts, these kinds of participatory sensing initiatives have largely focused on issues of engagement and the capacity of critical technology designs to elicit new rhetoric and discourse [DiSalvo et al., 2009]. In doing so, several of the 'art-based' initiatives were able to support novel forms of public authoring. By this was meant the mapping and sharing of local knowledge using pervasive technologies in order to foster relationships beyond established social and cultural boundaries and the development of new practices around place, identity and community [Airantzis et al., 2008]. These kinds of projects have tended to be proof of concept and as such are not evaluated in terms of their impact. Although they were deployed for short periods of time and did not seek to achieve sustained community participation in sensing, they inspired further efforts in bottom-up participatory citizen sensing [DiSalvo et al., 2009].

Research projects on participatory sensing and crowdsensing grew during the 2000s. Well known projects were the N-SMARTS[31] and CommonSense[32]. With CommonSense, Aoki and Willet et al. explored outdoor sensors in different contexts such as mounted on street sweepers or carried by users. The street sweeper deployment aimed at augmenting a city's existing sensor network with vehicle-mounted sensors [Aoki et al., 2009]. They found that engagement and sensemaking can be fostered by breaking down analysis tasks into mini-applications designed to facilitate and scaffold novice contributions [Willet et al., 2010]. Another project – Citisense – highlighted that real-time display of distributed data from a region together with permanent monitoring facilitated sensemaking [Bales et al., 2012].

One of the limitations of these studies is the quality and reliability of sensor data, calibration accuracy and social aspects of mobile sensing. Issues around privacy,

31 http://www.eecs.berkeley.edu/Research/Projects/2008/105386.html

32 http://www.urban-atmospheres.net/CitizenScience/

authenticity of the data and security have also been raised [Paulos et al., 2008; Mun et al., 2009]. NoiseTube used a mobile application and an online community memory to map noise pollution. In a two-week deployment with a small group of users researchers identified usability issues (phones are usually in pockets or purses and therefore contribute biased measures); the need to coordinate large campaigns to promote mapping in areas that are not frequently visited by users; and the importance of data quality to foster users' trust [Stevens & D'Hondt, 2010].

Other citizen sensing projects include Citizen Sensor (CS[33]) or and Air Casting (AC[34]) (Figure 4). These both provided IoT devices for citizens to assembly and program using instructions provided by the developers. Along similar lines, a number of initiatives such as the Citizen Sense kit[35]; or ALLARM Shale Gas Monitoring Toolkit[36] have aimed to provide the technical infrastructure for communities to tackle local issues such as monitoring air pollution around fracking sites. These are relatively new developments and as of yet there are no available accounts reporting on their effectiveness.

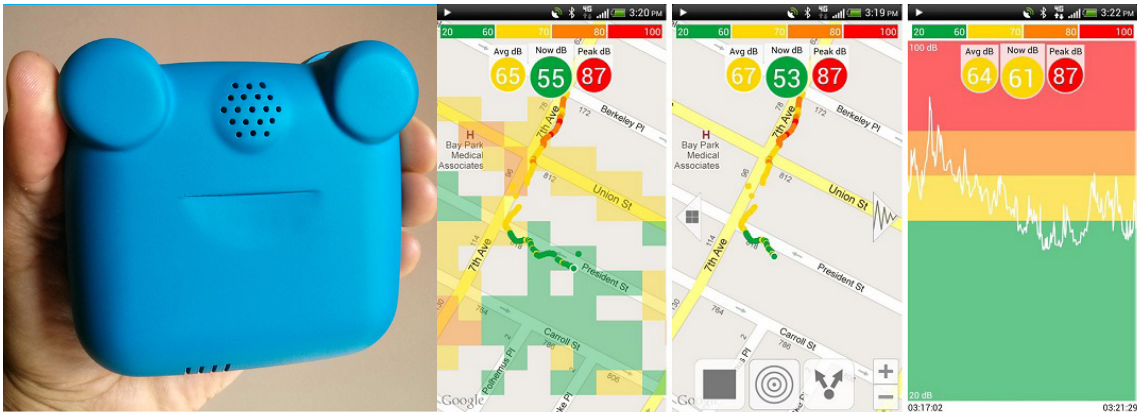

Figure 4. The Aircasting sensor and mobile app

33 http://citizensensor.cc

34 http://www.aircasting.org

35 http://www.citizensense.net/sensors/citizen-sense-monitoring-kit-pennsylvania

36 http://www.dickinson.edu/info/20173/alliance_for_aquatic_resource_monitoring_allarm/2911/volunteer_monitoring/3

2.2.10 Summary

There are some key differences between traditional citizen science projects, and initiatives that emerge around open participatory sensing platforms. In the majority of research and traditional citizen science interventions, the questions, goals, engagement and operational strategies stem from the project instigators, who even train users or provide them with technology. In addition, the project instigators benefit from the data collected by citizens, whilst the citizens themselves rarely make use of the data for their own purposes. Furthermore collated datasets are not typically available in a form that is accessible. In contrast, bottom-up initiatives show that issues are at a local level, while goals and strategies have to be negotiated by groups of citizens who gather around the issue or share a common purpose, and need to gain access to technology and acquire the skills to operate them.

Most citizen sensing initiatives have been part of artistic or research projects, being deployed for relatively short periods of time and where data was rarely made open and available to third parties. Investigations have identified a number of problems involved with participatory sensing, especially around the quality and reliability of the data collected [Aoki et al., 2009; Mun et al., 2009, Stevens & D'Hondt, 2010]. The main challenges are how to enable and moreover scale participation [Stevens & D'Hondt, 2010], how to support the development of technological and data literacy among participants [DiSalvo et al., 2009], and how to enable data sensemaking [Bales et al., 2012] to increase the likeliness that data contributions will be harnessed and utilised by communities.

2.2.11 Crowdfunded participatory sensing

More recently, with the proliferation of open source technology such as Arduino, the creation of makerspaces like Fab Labs, and the growing popularity of crowdfunding platforms, new urban sensing technologies have been designed and released to citizens without being part of specific citizen science projects or research agendas. Their goal is often to empower citizens with more open systems that they can appropriate for their own purposes [Diez & Posada, 2013]. The fact that even before the technologies are developed, a community of users becomes involved with the project [Abe et al., 2014] reveals a new dimension of citizen empowerment that introduces investing in and using open-ended technologies for environmental monitoring as a type of collective and political action [Kera et al., 2013].

There are three forms of investment in crowdfunding platforms: (i) pure donation (users don't expect a reward) and (ii) investment, which can be active (users participate in the project providing feedback, for example) and (iii) passive [Belleflamme et al., 2010]. Research has suggested that backers are motivated by interest, compassion and even moral consciousness [Schwienbacher et al., 2010]. Additionally, crowdfunding success appears to be linked to project quality (those that signal a higher quality level are more likely to be funded) and having a large numbers of friends on online social networks [Mollick, 2014].

Apart from the adoption of crowdfunding, the creation of the Pachube platform (now Xively and sold to LogmeIn), an open data sharing and visualisation platform played an important role in the popularisation of this kind of IoT devices. Projects like Air Quality Egg (AQE) (which is different from the Air Project mentioned before) or Community Sensing (CS) were closely linked to Pachube. However, AQE has faced problems the hindered community participation: there were delays in the delivery of the kits to the backers (in some cases more than a year), the sensors have been criticised for being defective and unreliable, and there have been constant changes in the platform's design and development [Air Quality Egg, 2014].

Two other crowdfunded projects were motivated by matters of concern. SafeCast developed an affordable Geiger counter to measure radiation levels after the Daiichi nuclear disaster in Japan in 2011 [Kera et al., 2013]. The initiative was led by a network of stakeholders including Joichi Ito (Director of the MIT Media Lab) and the Tokyo Hackerspace [Abe, 2014] and was crowdfunded by 290 backers in 2011. By July 2014 it had reached over 20 million data entries, although the 10 most active volunteers have contributed almost 3/4 of the data [Safecast, 2014].

In Radiation-watch.org, launched as a non-profit project a few months after the disaster, the stakeholders developed open source, affordable tools including the POKEGA radiation detector - that connects to smartphones, and a bespoke device for remote sensing. The backers not only helped fund the project but also played a role in improving its design by suggesting recommendations [Ishigaki et al., 2013]. There are currently around 12000 POKEGA users.

It is important to consider that there are key differences between traditional ICT and the more novel sensing and IoT technologies. While personal computers and mobile phones are pervasive in everyday life, sensing technologies are still novel and largely unfamiliar to most people [DiSalvo et al., 2009]. DiSalvo et al. introduced sensor and robotic technologies to residents in a neighbourhood, organising a set of activities that helped people learn about the devices, including a “Neighborhood Sensor Walk”. They later used approaches such as scenario writing and mock-up development to inspire people to envision novel applications of the devices. The findings showed that when the residents gained familiarity with the technology, they appropriated it in ways that had been unanticipated by the instigators [2009].

Until very recently, sensing technologies tended to be seamlessly embedded into existing products and the environment, which meant that the public had little access to them. This unfamiliarity with the technology and lack of skills to operate them can have an impact on how effectively people engage in data collection processes. Moreover, low-cost tools are sometimes still unreliable and hard to use [Schnyder, 2013]. A tension between citizens’ expectations over the data and the reliability of data coming from low-cost or DIY sensing devices is often present in both bottom-up participatory efforts and citizen science. However, several studies have documented the capacity of citizen science models to provide reliable data in different domains ranging from geographical information [Haklay, 2013], bird habitat [Nagy et al, 2012] or air pollution [Tregidgo et al, 2013].

These experiences indicate that data quality in citizen science depends on the design of the interventions and the integration of adequate data validation protocols or mechanisms [Bonter & Cooper, 2012]. Successful initiatives combine multiple methods to ensure data quality [Wiggins & Crowston, 2011], while operating in different organisational settings and approaches to quality assurance.

2.2.12 Summary

The adoption of bottom-up civic tech can enable new relationships between state actors, private businesses, citizens and communities, as well as powering new forms of urban citizenship and governance [Gabrys, 2014]. Data is situated and contextually bounded, that is, it comes from somewhere, it is intended for someone and it has purpose for the actors involved in these collective activities of making data matter [Taylor et al., 2015]. Participation through bottom-up civic technology triggers broader questions regarding who has the power to make sense and act on the city.

Many aspects that are fundamental to making bottom-up civic tech successful for community empowerment, however, remain unexplored. In particular, questions raised include: What methods are better suited for mobilising citizens and communities? How can engagement be inclusive and sustain beyond limited pilot interventions? How can data contributed by citizens be validated; who should own it and who can use it? What type of resources and practices can support the development of skills for communities to appropriate technology and make sense of data? How can citizens' insights be incorporated in new governance models with other actors in urban settings? These will be addressed as part of the thesis.

2.3 The vision of the smart city

The smart city is the current context where three key players — citizen activists, governments, and private companies come together to form a 'civic technology movement' that focuses on the collection of data about people, phenomena and processes to attempt to improve cities [Townsend, 2013].

The notion of the smart city emerged in the late 90s as a proposed solution to the problems of urbanisation, coupled with the promise of environmentally sustainable, economic growth [Caragliu et al., 2011]. Most of the discourse around smart cities falls broadly into four categories: (i) the development of new infrastructures put forward by technology corporations (e.g. [Yoshikawa et al., 2012; IBM, 2016]); (ii) new models of architecture and urban planning proposed by academics [Caragliu, 2011]; (iii) new technology advances developed for the urban context (e.g. [Chen et al. 2013; Wan et al. 2012]); and (iv) technology innovations proposed by citizen activists and social entrepreneurs aimed at fostering civic action [Townsend, 2013].

Although there is no one definition of the smart city, the term is typically associated with technology, data, sustainability, efficiency and growth. For example, Hitachi defines a smart city as "an environmentally conscious city that uses IT (information technology) to utilise energy and other resources efficiently" [Yoshikawa et al., 2012] while IBM argues "the opportunity presented by smarter cities is the opportunity of sustainable prosperity. Pervasive new technologies provide a much greater scope for instrumentation, interconnection and intelligence of a city's core systems" [IBM, 2016]. For Caragliu, a city is smart when "investments and human and social capital and traditional ICT infrastructure fuel a sustainable economic growth and a high quality of life, with wise management of natural resources" [2011].

Visions of smart cities have been strongly technology-centred and corporation-driven, positing that ubiquitous technologies can improve citizens' quality of life by making the city manageable and controllable in a top-down manner [Teli et al., 2015; Townsend, 2013; Greenfield, 2013; Saunders et al., 2015] with a focus on efficiency and environmental sustainability [Hancke & Hancke, 2013; Townsend, 2013; Kitchin, 2014]. Moreover, they are driven by a neoliberal ethos that prioritises market-led technological solutions to city planning and governance [Kitchin, 2013; Hollands, 2008]. They often consider the role of the urban citizen in terms of how they can fuel economic growth (cf. [Thomas et al., 2016]). Similar descriptions have been labelled as "U-city" [Hwang, 2009]; Digital City, Wired City, Knowledge City and Green City, which also suggest blending technological transformations with economic, political and socio-cultural change [Hollands, 2008].

In the last decade, researchers have begun to point out the potential drawbacks of the vision of the technology-driven smart city. For example, the focus on urban computing infrastructure that seeks to deliver efficiency and control has been criticized because it overlooks a wider range of urban community activities and behaviours [Thomas et al., 2016]. There have also been critiques that examined the role of citizens and the ownership of public assets and data. For example, questions being asked include: How are citizens meaningfully involved in smart city programmes? Whose concerns and perspectives are being addressed by the technologies? [Thomas et al., 2016], and who should own the technologies and resulting data if they are of public interest? [Saunders et al., 2015; Teli et al., 2015].

Commentators have raised concerns about the prospects of smart cities questioning examples such as that of Dolhera, in India (Figure 5) or Masdar City in the United Arab Emirates. The former is one of the many new smart cities planned by the Indian government in Gujarat where everything will be connected, from citizens to houses that are linked to a smart grid that controls gas, water and electricity supply and collects urban data. So far, the government has faced challenges due to public outrage following the dispossession of communities of farmers that lived in the area, and experts' warning that technologies will not prevent the city from flooding due to geographical constraints[37]. Masdar city, meanwhile, has failed to achieve the promise to become the future of sustainable urban living, with

37 https://www.theguardian.com/cities/2014/apr/17/india-smart-city-dholera-flood-farmers-investors

zero cars and zero emissions. For example, after ten years of development the city lacks affordable housing meaning that most of the city's workforce must drive to their jobs[38].

A number of researchers have argued that that new forms of citizen engagement are needed, because traditional methods for governing the complex interplay of technology, politics and city management are not sufficient [Lombardi et al., 2011; Nam & Pardo, 2011; Chourabi et al., 2012; Albino et al. 2015]. Some have advocated for a more participatory approach that promotes sustainable citizen-led initiatives and where the public ownership of urban and civic technologies is a viable alternative over corporate-owned solutions [Greenfield, 2013; Townsend, 2013; Saunders et al., 2015].

Figure 5. Proposed plan for Dolhera Smart City

38 http://www.wired.co.uk/article/reality-hits-masdar

2.4 Other approaches to making cities smarter

Besides the smart city agenda, other approaches to making cities smarter, more sustainable and inclusive have begun to emerge.

These focus more on sharing, making and commoning [Bollier, 2007] practices as a way of fostering citizens' participation in the city and encouraging new forms of collective ownership of the urban assets and services. For example, the cities of Seoul and Milan are promoting a sharing city approach, which advocates a strong public-private sharing economy ecosystem. Another approach is the Fab City[39] model that emphasises self-sufficiency. For example, Barcelona and other eight cities have committed to the Fab City model with the hope of achieving self-sufficiency by empowering communities through openness and digital fabrication opportunities. A more radical approach is one called Co-city that advocates open commons. For example, the Co-city Bologna is passing a bill of rights and duties for citizens to co-create urban commons at the grassroots level [Iaione, 2015]. Each has a different emphasis in terms of technology and community engagement, which are described below.

39 http://Fab.city

2.4.1 The Sharing city

The "sharing city" model is championed by Seoul[40]. The initiative was launched in 2012 when the mayor committed to improving the city by fostering a local sharing economy. The programme aims to make the sharing economy open to all citizens by expanding sharing infrastructure, promoting existing sharing initiatives and startups, utilising idle public resources, and providing more access to open data" [Johnson, 2013]. Sharing is seen as a way to collectively tackle social, economic and environmental problems in innovative ways. In particular, the sharing economy has the potential to create jobs, increase income, reduce unnecessary consumption and waste, and recover trust-based relationships between people [Agyeman et al., 2013].

To ensure the openness and sustainability of the approach, Creative Commons Korea was appointed to set up and manage the Seoul ShareHub platform and other means to help the government to spread information about the sharing initiatives as well as to promote the use of public data under open licenses [CCKorea & Bo-ra Jung, 2016].

In Milan, the approach has been different, with the public administration investing in physical spaces that can be used as hubs for sharing and commoning: from the House of Collaboration to various incubators, and the handover of unused spaces to associations, start-ups and citizens pursuing initiatives based on common or shared resources.

While in Seoul and Milan, the sharing city vision was promoted by the city council in consultation with the citizens, in Amsterdam the approach has been more citizen-led. Amsterdam Sharing city began with two masters students who co-founded ShareNL[41], a knowledge and network platform for the collaborative economy. Soon afterwards, the initiative was supported by the Amsterdam Economic Board and a network of local sharing economy community champions. In 2015, Amsterdam became Europe's first sharing city, describing itself as a test-bed for pilot projects to start getting direct experience and knowledge in the Sharing Economy and its impact in Amsterdam [van de Glind & van

40 http://www.sharehub.kr

41 www.sharenl.nl/#sharenl

Sprang, 2016]. Examples of local sharing initiatives include the borrowing platform Peerby, ShareYourMeal or SnappCar (P2P Car Rental).

2.4.2 The Fab City

The Fab City approach focuses more on self-sufficiency and digital maker practices[42]. This initiative was launched in 2011 at the Fab7[43] conference in Lima, instigated by the Institute for Advanced Architecture of Catalonia[44], the MIT's Centre for Bits and Atoms[45] and the Fab Foundation[46]. The broad Fab Lab network galvanises around 1000 Fab Labs around the world. Fab lab means fabrication laboratory, a small-scale workshop space that offers opportunities for people to collaborate in personal digital fabrication projects. These labs are generally equipped with different computer-controlled tools that cover several different length scales and various materials, including laser and plasma cutters, 3D printers, CNC machines, among others [Gershenfeld, 2008].

In 2014, at the Fab10[47] conference, the mayor of Barcelona announced the adoption of the Fab City model and committed to make the city "globally connected and locally self-sufficient" in a period of 40 years. This entails the local production of at least 50% of what its consumed in the city, the utilisation of digital and locally sourced materials, and contributions to a global repository of open source designs for city solutions. Because achieving such goals requires that citizens are supported to acquire fabrication and technological skills, the mayor also presented the first public network of local Fab Labs, known as the Red de Ateneus de Fabricacio[48] comprising nine Fab Labs distributed in key city districts. Since then other cities such as Boston, Somerville, Cambridge, Ekurhuleni, Kerala, Georgia,

42 http://fab.cba.mit.edu/about/faq

43 http://cba.mit.edu/events/11.08.FAB7

44 iaac.net

45 cba.mit.edu

46 fabfoundation.org

47 https://www.fab10.org/en/home

48 http://ateneusdefabricacio.barcelona.cat

Shenzhen, and Amsterdam have subscribed to the Fab City model and committed to the 40-year countdown to become self-sufficient by 2054.

The primary aim of the Fab City approach is to change how cities source and use materials by shifting from a 'Products In Trash Out' model to a 'Data In Data Out' (Figure 6) model [Diez Ladera, 2016: 5]. This means that more production takes place inside the city in response to local needs, fostering the citizens' creativity and using recycled and local materials. The city's imports and exports would mostly occur in the form of data, ranging from knowledge to design and code [Guallart, 2014; Diez Ladera, 2016].

The application of this model is intended to reduce the energy that is consumed and the pollution that is generated when cities import goods and materials. However, for this to be effective the city needs to be connected to a larger innovation ecosystem that produces the open source designs, code and knowledge (a digital "commons") necessary to nurture the productive ecosystem at the local level [Diez Ladera, 2016].

The benefits of such an approach are not only environmental. The instigators of the Fab City argue that their model has the potential to foster economical prosperity by creating new types of jobs and professions related to the knowledge economy and the development and implementation of new approaches and technological solutions. This includes local manufacturing, distributed energy production, new cryptocurrencies for value exchange, and food production and urban permaculture. It is proposed that the approach could also lead to new collaborations between the government and citizens as well as a renewed education system based on learning-by-doing, finding solutions for local needs through digital fabrication technologies, and sharing them with others through the global network [Diez Ladera, 2016].

A prototype of a Fab City was deployed from April to June 2016 at Amsterdam's Java Island in the city's Eastern Harbour District[49]. It was conceived as a green, self-sustaining city comprising almost fifty innovative installations and prototypes. Over 400 citizens, including young students, professionals, artists and designers were invited to turn the site

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49 http://europebypeople.nl/Fab City-2

into a sustainable urban area, and were provided space to work on solutions to urban issues. However, to date, little is known about the outcomes of this intervention.

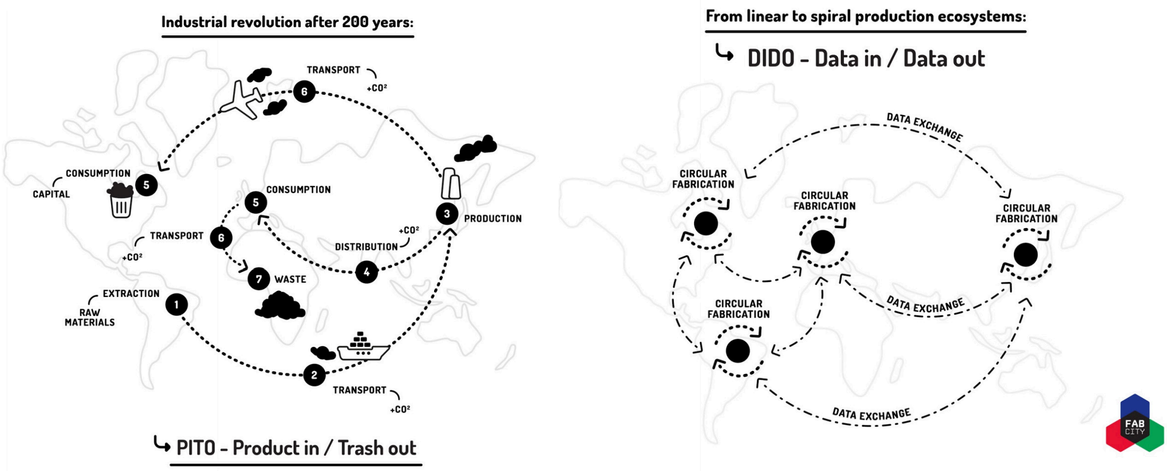

Figure 6. Fab City model from ‘Product In Trash Out’ to ‘Data In Data Out’

2.4.3 The Co-city

The idea of the city as commons differs from the technology-driven and market-led smart city, in its focus on new forms of governance that promote citizen involvement in the improvement and management of the common good (cf. [Foster & Iaione, 2016]). It contests the increasing privatisation or public spaces, services and assets [Sassen, 2001], stemming from movements such as “the right to the city” championed by Henri Lefebvre that argues for urban policymakers to provide more opportunities for people to access existing urban resources and even to change them [Lefebvre, 1996].

There is an assumption that there is common interest in resources that are shared with other citizens that should resist privatisation so as to prevent inequality, alienation and social injustice [Harvey, 2003]. There are four major principles of the city as commons [Foster & Iaione, 2016]:

i. The city is an open resource where all people can share public space and interact

ii. The city exists for widespread collaboration and cooperation

iii. The city is generative, producing for human nourishment and human need

iv. The city is a partner in creating conditions where commons can flourish.

The concept of the commons refers to the cultural and natural resources which should be accessible to all members of a society, including natural materials such as air, water, and a habitable earth. These resources are held in common, not owned privately [Ostom et al., 1999]. More recently, The European Commission proposed that the commons should include natural resources, such as parks or lakes. In a digital context, it refers to resources that are critical for the digital environment, which should not be transformed into private property [2016].

Bollier [2007] extends this notion by arguing that the commons is a resource plus a defined community and the protocols, values and norms devised by the community to manage its resources. The commons should, therefore, be defined as:

i. A social system for the long-term stewardship of resources that preserves shared values and community identity;

ii. A self-organised system by which communities manage resources with minimal or no reliance on the market or state;

iii. The wealth that we inherit or create together and must pass on (from natural resources to civic infrastructure, cultural works and traditions, and knowledge);

iv. A sector of the economy that generates value in ways that are often taken for granted [Bollier, 2007].

It has been argued that socio-technical systems based on the commons can be highly beneficial to society as they offer both a medium of production for diverse information goods and serve as a context for the formation of virtuous, contributive behaviours [Benkler, 2003]. The most well known example of the digital commons is Wikipedia, the free and open encyclopaedia created through millions of voluntary contributions. While it was initially argued that a small group of elite users contributed most of the work [Wales, 2005], research has shown that since 2004 there was a dramatic shift in the distribution of work to the common users, with a decline in the influence of the elite [Kittur et al., 2007]. Despite this shift, the quality of Wikipedia is comparable to that of traditional encyclopaedias [Giles, 2005].

Bologna has adopted aspects of the idea of the city as commons in planning how to manage and run the city. Co-city Bologna began in 2011 after the council acknowledged that the existing legislation prevented citizens from contributing time, efforts or assets to the city. The council, in collaboration with the research group Laboratory for the Governance of the Commons[50] (LabGov) and civic groups asserted that the city and its public and private institutions should give citizens the opportunity to take care of their own city [Iaione, 2015]. They also hoped that this opportunity could support citizens in improving their individual and social capabilities and to build social cooperation, reciprocity and solidarity networks (cf. [Bowles & Gintis, 2011]).

In Bologna, the implementation of the Co-City model focused on questioning who owns and manages the city by promoting a new vision of government based on the distribution of powers among public, social, economic, knowledge and civic actors [Iaione, 2015]. It resulted in a novel policy known as, "The Regulation on Collaboration Between Citizens and the Administration for the Care and Regeneration of Urban Commons[51]" that acts as a framework for citizen engagement and collaboration. Since the Bologna City Council adopted it in 2014, the regulation has become a model in Italy and around 60 municipalities have followed Bologna in adopting it.

Following the Co-city model, the city council also contributes to cover the costs incurred in carrying out the actions of cure or regeneration of urban common: from improving the facilities of an urban park to instigating a p2p lending scheme among neighbours. Citizens who engage in shared care of the commons cannot be paid for the activities performed that are carried out personally, spontaneously and without charge. The city supports and

50 http://www.co-cities.com/

51 http://www.comune.bo.it/media/files/bolognaregulation.pdf

develops a range of self-funding strategies from providing municipal spaces for fundraising events to civic crowdfunding with partial municipal support, among others [Comune di Bologna, 2015].

Even though the policy has been implemented in Bologna for less that two years, it has already produced beneficial outcomes. To date more than 130 agreements between citizens and the city have been created involving more than 20 thousand people[52]. Many of the projects involve citizens collaborating to clean up city streets, parks and squares, remove graffiti and other maintenance of public spaces. But there are a number of social initiatives as well, which emerged after the project instigators mapped existing community champions to support them. An example is Social Streets[53], which evolved from being a network of neighbourhood Facebook groups to become a non-profit organisation that carries out projects including a neighbourhood bulletin board. Social Streets groups have now launched in 400 other streets and squares worldwide, including 57 in Bologna alone. Another initiative is Reuse With Love[54], a group of 50 neighbours who joined forces to fight waste and improve the lives of children and the poor.

2.4.4 Summary

The notion of the smart city emerged over a decade ago as a solution to the problems of urbanisation coupled with the promise of environmentally sustainable and economic growth [Caragliu et al., 2011]. Descriptions of the smart city often focus on how technology can help to solve environmental challenges, increase efficiency, and enhance economic growth. Commentators and researchers have critiqued this technology and corporation driven approach, with a particular focus on the lack of emphasis on the role of citizens [Thomas et al., 2016].

52 http://ecflabs.org/sites/www.ecflabs.org/files/build_the_city/Build_the_City_good-practices.pdf

53 http://www.socialstreet.it/international/info-english

54 http://www.reusewithlove.org

It has been argued that new forms of citizen engagement are needed, because traditional methods for governing the complex interplay of technology, politics and city management are not sufficient [Lombardi et al., 2011; Nam & Pardo, 2011; Chourabi et al., 2012; Albino et al. 2015]. Some have argued in favour of a more participatory approach that promotes sustainable citizen-led initiatives and where the public ownership of urban and civic technologies is a viable alternative over corporate-owned solutions [Greenfield, 2013; Townsend, 2013; Saunders et al., 2015].

More recently, new approaches to making cities smarter, which problematize notions of ownership and citizen participation have emerged. These include the Sharing city, the Fab City and the Co-city. These alternative models view citizens not just as users of city services and resources but also as creative and autonomous agents who hold a significant contributive power. The assumption is that more horizontal and open models can lead to new forms of citizen empowerment and democratic participation, and that citizen-led innovation in the production and governance of the city and its infrastructures can lead to more effectiveness in tackling urban challenges [de Waal, 2011; Iaione, 2015; Diez Ladera, 2016; Iaione & Foster, 2016].

While these are promising approaches, that could transform the way cities and localities operate, by promoting new forms of civic participation and contribution for the common good, they often lack more granular and strategic frameworks that are necessary to enact them. There are very few reports in the academic literature of their implementation and their efficacy. What is lacking is an explication of the steps required to become a Co-city or a Fab City. Questions remain as to what is the best mechanism to orchestrate citizens' engagement and which tools and methodologies can be used to foster community action and contribution. A central consideration is the role of technology mediating the community engagement and supporting communication. The next section explores notions of community and how engagement with technology can be facilitated.

2.5 Community engagement with technology

HCI researchers have long recognised the value of developing technologies with and or for communities [Gurstein, 1999; Merkel et al., 2004; Carroll, 2011], arguing in favour of better integrating community computing and HCI to make the field “richer and more comprehensive, both conceptually and methodologically” [2001: 307].

However, there are many challenges associated with achieving this. For example, for researchers to gather valuable insights, users have to willingly engage with technologies, integrating them into their own routines in meaningful ways, either opportunistically or in the long-term.

What is meant both by community and engagement can be problematic. The term community is increasingly used as a rather common label for very different types of social arrangements. From people who buy the same product in Amazon [Danescu-Niculescu-Mizil et al., 2009] to neighbours who leave on the same street and share matters of concern [Koeman et al., 2015]. Drawing on an exhaustive literature review, reported in [Carroll, 2014], Carroll articulates a conceptual model of community that entails three key facets: identity, local participation and awareness, and support networks.

Identity is fundamental to community, it is built through shared experience and traditions and it enables a sense of membership and attachment [Hummon 1992; Brown & Schaff, 2011]. Participation and awareness transform identity commitments into publicly visible activity. Examples of participation are being out in public, keeping updated regarding local news and issues, socialising and deliberating with neighbours, volunteering for community projects, and even bowling in leagues [Putnam, 2000]. Finally, community members typically play a variety of roles, and provide and reciprocate social and material support through different types of ties. In sum, a human community can be characterised as a group of people who share a sense of identity, whose members publicly participate in shared events and are aware of community activity, and are linked by ties that engender forms of mutuality and reciprocity. The community is a relatively densely interconnected sub-network of the larger social network [Carroll & Rosson, 2013].

Along similar lines, engagement is a broad concept that combines social, psychological, cognitive and physical factors. It is sometimes viewed as a process or as a stage in a process [O'Brien & Toms, E. G., 2008], as an experience, or as a cognitive or affective state [Peters et al., 2009]. It has also been associated with a state that is characterised by energy, involvement, and efficacy [Maslach et al, 2001] and as a combination of attributes that influence the user's experience, ranging from challenge, positive affect, endurability, aesthetic and sensory appeal, attention, feedback, variety/ novelty, interactivity, and perceived control [O'Brien & Toms, 2008]; motivations, perceived value, satisfaction, and intention [Kim & Kim, 2013]. Attfield et al. describe it as "the emotional, cognitive and behavioural connection that exists, at any point in time and possibly over time, between a user and a resource" [2011: 3]. More generally, it is seen as occurring when there is attentional and emotional involvement [Peters et al., 2009].

Although novelty is often highlighted as a factor that can trigger engagement, researchers have noticed that it might not be enough to sustain it in the long term. In HCI this issue is often referred to as the novelty effect [Draper & Brown, 2004; Han et al., 2008; Poppenk et al., 2010] and it is related to the changes in behaviour (caused by positive emotions associated to engagement: surprise, motivation, excitement) produced by the introduction of a new technology that might wane after users become used to the tool and lose interest in it. How to sustain engagement passed the novelty effect remains a challenge in technology design (cf. [Hosio et al., 2016]).

Being recognised within a community has also been found to play an important role for sustaining personal engagement. When studying participation in citizen science projects, for example, Rotman et al. [2012] found that users were particularly motivated by being recognised and appreciated for their contributions. In addition, community involvement may have an impact on the formation of social ties among users, which will be further discussed in the next section on social interactions. Engagement has also been regarded as a state of being *captivated* by technology and therefore being motivated to use it [O'Brien & Toms, 2008], as well as with an experience of *enchantment* [McCarthy et al., 2008]. Both concepts are tightly coupled with the notion of novelty that can elicit curiosity and inquisitive behaviour, both known to support repeated or sustained use [O'Brien & Toms, 2010].

Community engagement is often used generically to describe a wide range of interactions between people. It is typically used in disciplines like sociology, public policy, political science, anthropology, organisational development, and psychology. It usually refers to a planned process with the **purpose** of working with identified **groups of people**, who may be connected by geographic boundaries, special interests or affiliations, to **address issues** that affect their well-being [CDC, 1997; Hlalele & Tsotetsi, 2015; McCloskey et al., 2013]. In this context, the term 'community' often refers to a group of individuals that share common interests and attributes that foster the emergence of a sense of shared identity [Brown & Schaff, 2011]. It has been suggested that communities galvanise with the purpose to tackle shared issues that are articulated as *matters of concern* [Latour, 2007; DiSalvo et al., 2014]. As Latour argues, participatory processes should be issue-oriented if they aim to trigger engagement because the public is most of all interested in a particular issue at hand than on the participatory process itself [2007]. A public is here understood as *"a particular configuration of individuals bound by common cause in confronting a shared issue"* [Le Dantec & DiSalvo, 2013: 242].

Within HCI, researchers working with communities (or publics) following participatory processes increasingly recognise the value of identifying matters of concern as a driver for meaningful engagement [DiSalvo, 2012; Le Dantec & DiSalvo, 2013; Teli et al., 2015]. A sense of reward might also be related to engagement. Kahn has pointed out to the importance of psychological meaningfulness as a key enabler of personal engagement either with a task, a tool or others. He defined meaningfulness as the feeling that one is receiving a return on investments of one's self in a currency that is physical, cognitive or emotional energy [Kahn, 1990]. People tend to experience such meaningfulness when they feel worthwhile, useful and valuable.

When it comes to relationships with technology, researchers have measured engagement with regards to frequency and duration or intensity of interactions [Jacques, 1996]. Gaver has suggested that when assessing engagement with technology *"perhaps the most fundamental sign of success is that volunteers engage with a design prototype and continue to do so over time"* [Gaver et al., 2009: 2219].

2.5.1 Summary

Community and engagement are broadly used and generally underspecified notions. The term community engagement had been defined here as a process with the **purpose** of working with identified **groups of people,** who may be connected by geographic boundaries, special interests or affiliations, to **address issues** that affect their well-being [CDC, 1997; Hlalele & Tsotetsi, 2015; McCloskey et al., 2013]. Researchers in HCI have long recognised the value of collaborating with communities in pursue of better and more inclusive socio-technical systems [Gurstein, 1999; Carroll, 2011]. However, fostering genuine engagement can be challenging for researchers. When running studies at the lab technologies can be evaluated with participants that have been previously recruited. Collaborating with communities in authentic settings requires for the researcher to establish partnerships, build trust, understand motivations, become embedded in a new context and make sense of shared identities [Crabtree et al., 2013].

2.6 Sustainability

A key challenge when conducting research with communities in the wild is how long technology interventions should last for [Rogers, 2011] and how to promote their appropriation so that they become meaningful and empowering to users [Merkel et al., 2004; Hayes, 2011; Taylor et al., 2013].

There are several interpretations of appropriation. However, a common denominator across them is the notion that users are active actors who play a role in the adaptation of technologies to serve their own situated purposes [Dix, 2007]; and that people integrate technology into existing practices or create new uses that differ from common use patterns. In all cases appropriation is both the process of evolving technology associated practices and the results of new emergent uses [Ventä-Olkkonen et al., 2017].

Recent discussions in HCI have revealed the difficulties that can emerge after community technology projects finish and researchers leave. The difficulty is what happens when the funding and support for the maintenance of the prototypes and overall support to the project stops [Taylor et al., 2013; Adams et al., 2013]. For example, Taylor et al. observed that while both their community technologies Wray Display and Viewpoint were successful in engaging the community their participation waned after the projects ended and the tools were handed over. As a result, all of the prototypes were removed from the community within six months of the project's conclusion.

These issues regarding community technology handover have been discussed in [Taylor et al., 2013] who synthesise these challenges in three different categories.

- The first one refers to **technological issues**, which naturally arise when researchers deploy prototypes (rather than finished products) that are prone to failure, and require technical support or replacement. Other researchers have made similar claims. Along these lines, Adams at al. [2013] used a fashion metaphor to explain how communities expect ready-to-wear technologies while designers often deliver catwalk artefacts. Wolf et al. [2006] discussed this in terms of the differences between the *creative design-oriented approach* and the *engineering design approach*. Catwalk technologies would represent the creative design-oriented approach, while the latter intend to produce more robust and durable tools.
- The second one refers to usage issues, in particular how to sustain technology use and how and who will contribute fresh content to keep them updated (in the case of a community display this is a crucial concern). Too often the researcher acts as a champion who catalyses engagement and therefore contribution. However, who can take up this role when the research project finishes?
- The third one refers to resource issues, both financial and human. Research funding is usually limited and community ventures often lack the resources to support new technologies. The question this arises is who can repair a broken prototype and/or cover such cost?

These are fundamental concerns that need to be taken into consideration if the aim is to design technologies to address social issues and support positive sustainable change. One way around the technological issues is to use easy to maintain technology that can be bought off the shelf rather than novel prototypes [Adams et al., 2013; Taylor et al., 2013]. While these tools are less likely to fail, if it happened users could easily access replacements or even repair them by themselves. Another solution is to build networks of expertise, as proposed by Merkel et al. [2007] who asserted that community enterprises can and should leverage the skills of volunteers who can use their technical knowledge to help develop and support infrastructures. Moreover, for communities to be able to sustain their technologies a number of assets should be put into place: documentation, training programmes, strategies to manage and sustain technology use, etc. [Merkel et al., 2007].

Regarding the second item, usage issues and the challenge of sustaining contributions, researchers have suggested that a fruitful approach is to engage local community champions [Corburn, 2005; Taylor et al., 2014]. Champions are individuals who embrace a cause and become an advocate of it, enthusing others to follow. They are sometimes recognised among communities as opinion leaders who voluntarily carry the flag for causes and mobilise others to join in [Taylor et al., 2011]. Engaging local champions who can take leadership of the intervention after researchers have left the field can help sustain contributions and overall engagement with a project. Another suggestion is to foster social interactions [Steels & Tisselli, 2008]. The idea is that in creating better social cohesion between community members can help with the uptake of the resulting technologies and foster the sustainability of the practices after the researchers have departed.

Finally, an approach to fund community projects is through crowdfunding and civic crowdfunding platforms. As seen in previous sections, community interventions such as Air Quality Egg, Safecast or Smart Citizen [Diez & Posada, 2013] have been developed as a result of the financial support provided by crowdfunding platforms users. Moreover, some community technologies have sustained by becoming social enterprises or cooperatives, which are fully sustainable by means of donations or charging a fee for their services and/or products [Patel et al., 2013].

Designing for sustainability and appropriation goes beyond the creation of material and digital objects and the definition of user interaction modalities. Researchers in participatory design and HCI increasingly convey that design *for future use* entails the process of *staging* encounters between humans and non-humans where matters of concern can be dealt with [Ehn, 2008]. In this sense, the notion of *infrastructuring* [Ehn, 2008; Bjögvinsson et al., 2012; Le Dantec & DiSalvo, 2013], entails building the ground to sustain the participation of publics in the long term, by identifying and supporting the formation of *attachments* – the social and material dependencies of the participants [Latour, 2004]. In sum, the process of infrastructuring can be understood as the creation of socio-technical means and resources that enable appropriation and adoption beyond the initial scope of the design [Le Dantec & DiSalvo, 2013]. Long term commitment and open-ended design are crucial to the process of infrastructuring [Marttila & Botero, 2013].

2.6.1 Summary

This section demonstrated how notions of sustainability are key in the pursuit of community empowerment through technology. Rather than associated to the environment, in the context of civic technologies sustainability often refers to the durability and appropriation of the technologies and practices emerging from collaborations between researchers and communities. However, researchers have identified a number of challenges that often hinder sustainability efforts. They have been characterised in terms of technology issues, usage issues, and resource issues. These can be addressed by using off-the-shelf technologies [Taylor et al., 2014], supporting participants to develop technical skills and/or build a network of volunteers with technical expertise [Merkel et al., 2004], collaborating with community champions who can foster and sustain community engagement [Corburn, 2005; Taylor et al., 2014], and finding alternative ways of funding interventions, such as donations or even crowdfunding (e.g. [Diez & Posada, 2013]). Finally, related to sustainability is the notion of infrastructuring, defined as the creation of socio-technical means and resources that enable appropriation and adoption beyond the initial scope of the design [Le Dantec & DiSalvo, 2013].

2.7 Social interaction

Social interaction can also act as a motivation and help sustain community engagement.

After analysing a number of projects where communities achieved positive social change, Rosenberg concluded that a key factor to their success was their common strategy based on a powerful human motivation: "*Our longing for connection with one another*" [2002: 10]. In addition, research has shown that facilitating social interactions between users fostered the development and persistence of new habits through the use of social factors such as peer pressure [Rosenberg, 2011] and social norms [Consolvo et al., 2009; Schultz et al., 2007].

An example of how peer pressure and social interactions can foster behaviour change was the LoveLife[55] campaign in South Africa. It was launched in 1999 and focused on prevention of HIV infection by encouraging young teenagers to demystify the use of condoms and talk about it. LoveLife used assemblages of media, celebrities and school sports to create a club that teens wanted to be part of. In that club girls could share stories about their relationship, and how they dealt with boyfriends who didn't want to use protection. By listening to the stories of others, girls reflected on their own lives and were likely to apply the strategies that were more accepted by the group. The approach has been successful and the World Health Organisation has reported on significant decreases in HIV infection rates following the LoveLife campaigns. In technology design, peer pressure, social norms and social interactions have been particularly exploited in the field of personal informatics and persuasive technologies, with a focus on nudging people to adopt healthier behaviours such as exercising or eating healthier [Fogg, 2002].

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55 http://apps.who.int/iris/bitstream/10665/43453/1/WHO_TRS_938_eng.pdf

A number of HCI civic projects investigating behaviour change, such as The Tidy Street [Bird & Rogers, 2010] and Reveal-it! [Valkanova et al., 2013] (Figure 7), have addressed the importance of the community as a driver for engagement. For example, the Tidy Street project explored the feasibility of publicly displaying household's domestic energy usage and its effect on energy consumption. Tidy Street is a residential road in the centre of Brighton (UK). 17 residents were given low cost devices to measure their energy consumption. A public display made of spray chalk on the road was updated every night to show the street's average energy use against the Brighton average. After a three-week deployment, all participants reported that their awareness of their electricity usage had increased and that they had a greater insight into which appliances used the most electricity. Also, there was a 15% average reduction in domestic electricity use in participating households between the first and third weeks. Most importantly, the social dimension of the street display inspired neighbours to champion the intervention, explaining what the project was about to passers-by and taking pride for the achievements of the community [Bird & Rogers, 2010]. The results showed that socialising the data via a shared street display fostered the emergence of social norms that in turn supported behaviour change.

A similar approach was followed by Reveal-It!, a life-size, public visualization, where people could submit, visualise and compare with others their energy consumption data. It was found that the display was successful in creating awareness and encouraging behaviour change: approximately 87% of the participants who submitted the data entry form of the visualization reflected on their own consumption behaviour afterwards. Moreover Approximately 24% of the interviewed participants claimed that the visualization motivated them to enhance their consumption habits in a positive way.

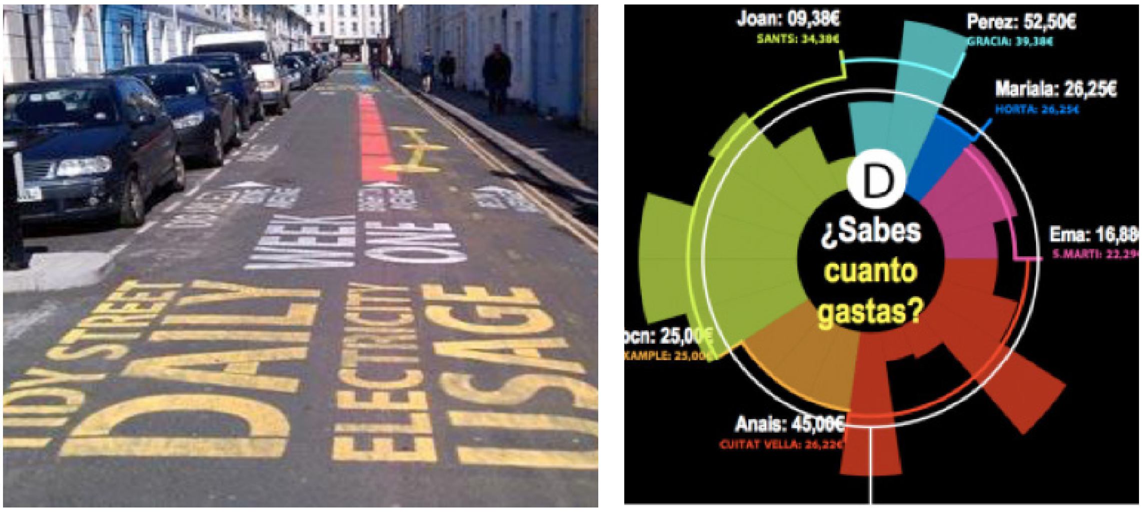


Figure 7. The Tidy Street community display (left) and Interactive visualisation of Reveal-it! (right

Citizen science projects have also highlighted the importance of social interactions to sustain community and individual engagement. Corburn [2005] found that leveraging citizen engagement in crowdsensing projects requires not just tools for data collection, but also mechanisms to enable interactions and collaboration between users with local knowledge and experts. Chamberlain et al. [2013] argued that for community technology projects to be successful requires collaborating with local institutions, community groups or champions who can act as catalysers driving processes of engagement within the community and taking leadership of the project after researchers have left [Taylor et al., 2013].

Others have argued that to scale up, participatory sensing projects need to include features for campaign orchestration. However, in this context orchestration has been described in technical terms, as a predefined set of operations that are enacted in a specified order by an autonomous workflow engine to meet a desired goal [D'Hont et al., 2014]. Orchestration has been also deemed fundamental to other technology-enabled collaborative systems. In education, for example, the teacher may use technology to orchestrate the classroom: distributing resources, assigning tasks and making decisions on the fly to enable a conductive space where collaboration can be productive [Dillenbourg et al., 2011].

Another concept that is used to refer to the value of social interactions for group cohesion is social capital [Coleman, 1988; Forrest & Kearns, 2001]. The concept refers to the interpersonal ties that allow people to participate in social interactions and build other ties. Such interpersonal relationships can be strong ties (or bonding capital) or weak ties (bridging capital), where a strong tie is a very close relationship and a weak tie may be a temporary or superficial bond [Kavanaugh et al., 2003]. Social capital is typically measured in terms of the level of reciprocity, trust, and civic participation [Putnam, 1993]. Researchers have studied the link between social capital and wellbeing of both, communities and individuals.

After comparing measures of social capital and neighbourhood mortality in Chicago, Lochner et al. [2013] concluded that social capital correlated to lower neighbourhood death rates, even after adjustment for material deprivation. Similar results were found in a study carried out in Hungary where mortality rates correlated to levels of mistrust among individuals [Skrabski et al., 2003].

2.7.1 Summary

Social interaction is a fundamental human need. Through social interactions groups develop social capital [Putnam, 1993] and modulate behaviour [Rosenberg, 2011]. Researchers have investigated how facilitating social interactions between groups of people can support the development and persistence of new habits through the use of social factors such as peer pressure [Rosenberg, 2011] and social norms [Consolvo et al., 2009; Schultz et al., 2007]. In HCI, these factors have been explored in civic projects that aimed to reduce energy consumption such as The Tidy Street [Bird & Rogers, 2010] or Reveal-it! [Valkanova et al., 2013], and in a variety of personal informatics projects addressing behaviour change [Fogg, 2002]. In citizen science social interactions have been considered key in the development of community dynamics that can foster engagement and bonding [Corbun, 2005]. Likewise, it has been pointed out that the orchestration of social dynamics and the resources of a community, described as the strategic distribution and assignation of resources and tasks, can make social interactions and collaboration more productive [Dillenbourg et al., 2011].

2.8 Participatory methods and ownership

It has also been argued that communities are more likely to sustain engagement with a technology intervention if they develop a sense of ownership over the tools, the practices and the overall aims. Taylor et al. [2013] discussed the suitability of **participatory methods** to promote a sense of ownership among community participants.

Crabtree et al. [2013] created PlaceBooks, a mobile toolkit aimed at enabling people in rural areas to create and share digital multimedia books based on places they visit. They found that participatory approaches, where the community is involved from the outset supports the development of innovative interventions that people will want to appropriate. This is because involving participants through the entire process of design can help identify design requirements stemming from user needs, which in turn can foster sustained community engagement and facilitate the use and appropriation of technologies. They also highlight the importance for researchers to use ethnographic methods and be embedded in the community as a way to achieve a deeper understanding of the context and the community practices. Finally, they recognise that the efficacy of the PlaceBooks project depended on sustained *engagement*, not a limited period of contact with users.

Following a similar approach, Chamberlain et al. [2013] worked with a rural community in West Wales to design a web portal for a farmers market that is organised once a week. The stallholders at the market wanted to increase footfall and interest in the market, by means of a Market web Portal. They collaborated with researchers to design such portal. The investigation revealed key factors for generating user engagement, such as: building trust; fitting in with the day-to-day life of the stakeholder and demonstrating understanding of the context; working with local community groups (even involving politicians); and using methods that focus on action. It also showed how sometimes researchers collaborating with communities in the wild need to adapt different research methods to meet both academic and communities' requirements [Chamberlain et al., 2013].

Another approach to fostering sustainability in community technology interventions has been referred to as long-term participatory design [Merkel et al., 2004]. It blends ethnography with participatory design. The ethnographic methods are used to understand the user's work practices and identify opportunities for collaboration. The general aim is to engage participants in the design process from the outset so they can take control of the process in terms of both directing what should be done and maintaining the resulting technology infrastructure. As described by the researchers, their ambition is to "*gradually fade away with the participants maintaining and developing the achievement that is produced*" [Merkel et al., 2004: 2].

2.8.1 Summary

Researchers who collaborate with communities to design technologies and achieve sustainable practices tend to follow participatory methods. These methods range from action research [Hayes, 2011; Taylor et al., 2011] to long-term participatory design [Merkel et al., 2004], and often include an ethnographic component [Chamberlain et al., 2013; Crabtree et al., 2013]. There are many benefits associated to using participatory approaches. On the one hand, the researcher becomes embedded in the community, making sense of their culture and practices to identify both collaboration and design opportunities. On the other hand, the community can develop a sense of ownership by setting the goals of the intervention from the outset and developing the mechanisms and skills required to sustain the intervention after the researcher has left. However, while participatory methods can substantially increase the sustainability and appropriation of technologies in hands of the beneficiary communities, this doesn't always necessarily happen. A hand-over strategy should be deliberatively planned and designed to support such aims [Taylor et al., 2014].

2.9 Impact

A final aspect that is considered in this literature review is the importance of measuring and assessing the impact of civic technology interventions.

In many cases, community technology efforts are reported in the literature with a focus on the evaluation of the technology itself rather than whether it achieved the results that motivated its design from the perspective of the participating community. Within academia, the impact of research is quantified through citations and the derivative works of scholars who build on others' research. However, assessing the impact that HCI research has outside academia is not straightforward, especially when consequences ripple after a study has ended and may become evident only in the long-term. In order to suggest that our HCI efforts can be appropriated and lead to the empowerment of communities, methods for impact assessment need to be better integrated within the field [Heyer & Brereton, 2010].

Measuring impact is fundamental to promote accountability, in particular to those who participated and/or funded the intervention; to track progress and make sense of what was or was not achieved; to inform decisions to improve the intervention; to increase motivation; and to increase credibility on the methods implemented and the intervention itself [Gray-Felder & Deane, 1999]. One approach is to use Action Research methods and document, assess and reflect on facts and indicators that demonstrate impact [Hayes, 2011; Kock, 2011].

Although still at an early stage of development, other methodologies for assessing the outputs and the impacts of social innovations include: standard investment appraisal methods, cost-benefit analysis and cost-effectiveness analysis, social accounting methods, quality of life measures, social impact assessment, comparative metrics or benchmarks and user experience surveys [Murray et al., 2010]. However, to date, most of the assessments rely on case studies and qualitative methods, making it difficult to establish means of comparison [Bellini et al., 2016]. Moreover, researchers in the field of ICT4D have argued that traditional research methodologies and impact assessment techniques are often not suitable to promote meaningful participation, and called for the development of impact indicators to measure and understand the consequences of participatory interventions as "*social change is likely to take a long time, this work is very difficult to assess and evaluate*" [Gray-Felder & Deane, 1999: 19].

Researchers working in the field of participatory design are increasingly interested in devising impact assessment methods that are not top-down or exclude target communities from weighing in [Woods et al., 2016]. Such approaches tend to privilege the community's perspective on what needs to be achieved from a group perspective rather than an individual one. *Community level indicators* could be evidence of goal achievement (e.g. reducing noise pollution in a neighbourhood), learning new skills, sustaining number of participants, or scaling up the intervention to reach other groups and communities [Coulton, 1995; Woods et al., 2016].

2.9.1 Summary

A main goal of doing community-based technology projects is that the achieved outputs produce both academic and societal impacts [Hayes, 2011]. While measuring academic impact is quite straightforward, measuring the societal impact of a given project can be more difficult. Moreover, research projects often lack an assessment of the impacts delivered by an intervention from the perspective of the beneficiary communities. An approach to ensuring that the impact of community technology interventions is assessed is to follow an Action Research approach, placing particular focus on the guidance for evidence collection and fact-checking [Hayes, 2011]. Others have advocated the need to collect data over long-term and devise impact assessment methods from the outset [Heyer & Brereton, 2010].

A new approach within participatory design is to collaborate with the community to agree on community level indicators from the bottom-up. This aims to ensure that the collaborative intervention delivers impact deemed valuable to the participating communities [Woods et al., 2016].

2.10 Chapter summary

This chapter has presented a number of related areas of research that are relevant to this thesis. In particular, it has presented a historical overview of the main research on civic and community technologies.

To provide a context for current research on civic technology, the vision of the smart city was presented. This industry vision of the smart city was contrasted with alternative community based approaches that included the Sharing city, the Fab City and the Co-city. The latter are conceptualised as being more citizen-focused that acknowledge the citizen's contributive capacity to participate in the improvement of their localities, with autonomy and creativity. Nevertheless, to date there has been little research reporting the outcome of these newer approaches in terms of whether they have met their goals.

From the reports of research in these domains, it becomes evident that technologies play a big role in facilitating civic engagement, enabling groups and communities to coordinate actions, have a voice and act on their collective environments to effect change. The literature review has also identified that technology alone is not enough to infrastructure and sustain civic participation. Sustaining engagement and collaborating with communities in the wild was found to be problematic across many projects, including issues of technology reliability and robustness, the sustainability of technology usage and emergent practices and behaviours, and a lack of resources and skills required for communities to maintain technology infrastructures.

The aim of the thesis is to explore how successful community-based approaches are initiated, how they develop and sustain, and the impact they have on the community and beyond. It seeks to investigate how notions of sustainability can be addressed by leveraging social interactions, following participatory methodologies and supporting communities to develop skills and infrastructure. It intends to identify what impacts community-led civic technologies can achieve. To conduct this kind of research requires adopting appropriate methodology. A number of methods that have been used in community research were reviewed in this chapter. The next chapter presents the methodology adopted in this thesis and the rationale for the choices of using a general qualitative in the wild approach.

3 Methodological Approach

To successfully study sustained community engagement and the impact of civic technologies naturally requires assessing which combination of methods to use in order:

i. To effectively study naturally occurring social phenomena in authentic settings

ii. To establish partnerships to collaborate with previously existing communities galvanising around matters of concern, thus becoming an active agent in the planning and deployment of genuine bottom-up socio-technical systems

iii. To collect data over extended periods of time in order to assess changes in behaviour and long-term impacts

iv. To explore different community arrangements and socio-technical systems, in varied contexts, to identify general patterns

These set of considerations are deemed fundamental for answering the research questions posed in the thesis. The obvious approach to (i) is to situate the research in-the-wild [Rogers, 2011]. However, an in-the-wild approach can be broad and underspecified. How can one do an in the wild study for an indefinite period of time? Which methods and framings should be used? These include approaches such as technology probes [Hutchinson et al., 2003], research through design [Zimmerman et al., 2007], ethnography [Dourish, 2007; Randall, 2007], participatory design [Schuler & Namioka, 1993], or Action Research [Lewin, 1946; Hayes, 2011; Stringer, 2014].

The methods selected for this thesis are Action Research (AR) and ethnography using a case study framing. (ii) AR allowed partnerships and collaborations with stakeholders to be established on equal footing, letting the researcher become an active member in the collaborative planning and deployment of the intervention. (iii). Ethnographic research enabled both an initial reconnaissance of the setting as well as the collection of user experience data, opinions and observations over prolonged periods of time (iv). The case study approach enables different contexts, technologies and community arrangements to be studied in depth. This combination of methods affords the flexibility of answering the research questions set in this thesis while allowing for the stakeholders to make an equal contribution to the project. These are described below.

3.1 Action Research

Action Research (AR) is an approach that focuses on co-creating technical solutions to real situated needs faced by communities in the wild, while providing a "*mutually acceptable ethical framework*" [Rapaport, 1970: 499].

Additionally, the approach offers a systematic participatory approach that meets both the need for scientific rigour and promotion of sustainable social change [Hayes, 2011]. Moreover, a fundamental aspect of AR, that makes it particularly suitable to interventions that aim to achieve social change and community empowerment, is its focus on fact-finding, impact and assessment.

The goal of an AR project is to understand a given situation and develop a situated, local and specific solution that doesn't need to be generalizable [Hayes, 2011]. In this sense, AR researchers understand that reality is not a given truth but a flux and can be understood as action and critical reflection are simultaneously conducted in the world [Stringer, 2007]. As a result, the method is open ended and generative, involving phases of planning, action, fact-finding and reflection that are conducted iteratively [Lewin, 1946].

It should be noted that AR differs from Research Through Design [Nelson & Stolterman, 2003, Zimmerman et al., 2007]. In the latter the emphasis is on design, as consecutive iterations and evaluations are used to frame the problem and improve some characteristic of the studied phenomenon [Nelson & Stolterman, 2003; Gaver, 2012; Fitzpatrick et al., 1998; Mentis et al., 2014] or achieve a "*desirable and appropriate state of reality*" [Zimmerman et al., 2007: 496]. For example, Gaver et al. followed a Research through Design approach to develop the Prayer Companion, an electronic artefact to support the spiritual practice of a group of cloistered nuns [2010]. They found that following this approach over a 10-month period allowed them to design a technology that is effective and embodies the designers' judgments about valid ways to address the complexity of the deployment context [Gaver et al., 2010: 2055]. However, while this approach requires an active collaboration with communities, it is still the researcher who is in control of the design and production of the technology.

While it has led to the design of very novel technologies, it is not necessarily the most appropriate to ensure the sustainability of the emergent technologies and practices in hands of the beneficiary communities.

3.2 Ethnography

Ethnography is commonly used by HCI researchers that seek to understand the social contexts in which users and technologies are embedded [Dourish, 2007].

It is a qualitative research approach that focuses primarily on the observation of people in naturally occurring settings. Its goal is to present an account of a given situation and context as understood by those who experience it. This happens as a result of becoming directly involved with the situation that it's being studied. While applying ethnographic methods the researcher's job is to observe and listen, and to capture this data by taking field notes, pictures, recordings, etc. This method is appropriate for the work reported here as it enables the design for specific communities, contexts and research groups. However, it requires an immersion, often prolonged, in the setting [Randall, 2007]. Nevertheless, Dourish has warned that if applied lightly, this method can lead to naïve design guidelines and a superficial understanding of complex politically and socially-grounded situations [2007].

In addition, the research adopted the more recent method of *net-ethnography* (or cyber ethnography). This allows for making sense of situations and contexts that occur in the distributed context of the cyberspace. Wittel suggests that the pluralisation of cultures enabled by globalisation and the Internet problematises the notion of "the field" as a geographically defined research space [2000]. The author advocates for a modernisation of the method that enables the process of data collection in the distributed landscape of the cyberspace. Although net-ethnography can be extremely useful when investigating the use and appropriation of Internet enabled civic technologies, research has warned about the challenges of ensuring data accuracy in a context where anonymity and identity play is common [Wittel, 2000].

Others have used this combination of methods, which sometimes comes under the label of *Participatory Action Design Research*. For example, it has been used in urban informatics [Bilandzic & Venable, 2011] and community technologies [Carroll et al. 2011] studies. Tacchi et al. [2009] proposed to add an ethnographic component to Action Research in order to address the gaps between research and the ability to implement its findings and assess impacts while collaborating with communities in the wild. The Ethnographic Action Research (EAR) approach combines participatory techniques and ethnography to guide the research process, in an Action Research framework aimed to link the research back in to the initiative through the development and planning of new activities. The method entails a process that starts with a planning phase, then leads to conducting the research, collecting and documenting data, to later analyse the data in order to inform new planning and action. Using ethnographic action research the researcher aims to learn about an environment while co-developing a technology that is tailored to that particular setting.

While participatory methods are often described as successful paths to empowerment, they don't always lead to the most fruitful outcomes. Researchers studying the various ways in which people can be involved in participatory interventions have highlighted the complex dynamics that emerge between participation and power [Arnstein, 1969; Gurstein, 1999; Arnold & Stillman, 2012, Thakur, 2009]. Finally, Crabtree et al. [2013] and Chamberlain et al. [2013] posit that co-creating technology innovation in the wild entails complex community engagement strategies that are too often overlooked: this includes negotiations with stakeholder communities in the design setting and ethnographic understandings of the site, the social and political context, and the community. They assert that adopting agile methods allowed them to adjust the research requirements to unexpected constraints, and to sustain stakeholder engagement through the provision of a rapid succession of developments in the form of small iterative cycles.

3.3 Approach adopted in thesis

As mentioned above, a general in-the-wild qualitative approach is combined with the methods of Action Research and ethnography.

This combination enables the establishment of long-term collaborations with existing communities to foster sustainable practices and to increase the possibilities of achieving (and assessing) positive social impact. Furthermore, the approach and its associated data collection instruments can be tailored to meet the goals of each case study. In each one, different quantitative and qualitative methods are combined ranging from direct observations, interviews, surveys, and assessment of online data activity and logs. In some cases net-ethnography [Wittel, 2000] is adopted to collect data on users' opinions and on the various impacts of the interventions, such as online media coverage and external appropriations. In all cases, qualitative data is analysed using inductive thematic analysis [Braun & Clarke, 2006]. Specifically, a grounded approach is used to collect evidence and reveal an initial set of themes that are associated with the meaningful engagement, sustainability and impact of community technology interventions.

3.3.1 The case studies

Three case studies are conducted over a 4 year period: *CrowdMemo, Smart Citizen* and the *Dampbusters*. **Table 1** summarised the methods used in each case study.

(i) Crowd Memo study

Chapter 4 presents the assessment of a community technology intervention that achieved sustained community engagement as well as various impacts. In CrowdMemo, a community in Arequito (Argentina) used off-the-shelf technologies such as smartphones, cameras and QR codes to record and share soft data (personal memories) about the village's history. These data were then embedded on the facades of buildings that the community wanted to preserve as they were considered to be fundamental to their collective history. The study explores how heritage preservation was instigated and sustained over a two-year period with an emphasis on outlining the challenges and successful impacts.

In CrowdMemo an AR approach is followed to allow for an equal collaboration between stakeholders and ensure that the community would be able to sustain the intervention after the end of the collaboration. The project was instigated by a group of photographers and the local school in Arequito. They contacted me to help them organise an intervention where technologies could be used to engage the broader community in a heritage preservation effort. I was born in Argentina and have experience working with communities in towns like Arequito. An initial ethnographic reconnaissance was not deemed necessary nor was it possible due to time and resource constraints. Instead, we used Skype, email and shared documents to collaboratively design and plan the intervention. Following this approach, teachers and school children participated in the planning and also in training sessions. I then travelled to Arequito during the deployment and initial evaluation of the intervention. I remained in touch with the community and collected data regarding the impacts of the intervention for over two years.

A qualitative approach to data gathering was followed and the process lasted two years. This included participatory observations, questionnaires with closed and open-ended questions, debriefing sessions, and interviews (both done in person and via Skype). Reports and media coverage were also collected. Data were analysed following a thematic analysis approach, where the resulting themes are discussed with the stakeholder until consensus is reached [Braun & Clarke, 2006].

(ii) Smart Citizen study

Chapter 5 presents the second case study that focuses on community engagement with Smart Citizen, an open source sensor kit and visualisation platform that allows citizens to gather and share urban environmental data, such as humidity, temperature, air quality, and noise. Unlike the CrowdMemo study, where I was involved from the outset in the planning, deployment and evaluation of the intervention, in Smart Citizen an ethnographic approach was adopted to assess community interventions that had been designed *a priori* by external stakeholders. In this sense Action Research was not followed. The focus instead was on adopting an ethnographic approach to assess the uptake and appropriation of the technology by two distinct communities, who had followed different engagement strategies: the community in Barcelona crowdfunded Smart Citizen while the one in Amsterdam was recruited as part of a citizen science initiative championed and orchestrated by the Waag Society, a local cultural institution. This was done over a period of two years. During the first year I studied the communities, becoming familiar with the participants and the project instigators in their respective locations. During the second year I revisited the settings and continued to gather data regarding the evolution and the impacts of the interventions.

A mixed methods approach to data collection [Creswell, 2003] was adopted to assess user experience and participation with Smart Citizen. Quantitative data about participation levels (defined minimally as keeping the sensor kit powered and connected) was collected from the servers of the Smart Citizen platform and through questionnaires. Qualitative data included direct observations, interviews and debriefing sessions. The broader impact of Smart Citizen was assessed after having collected data from interviews, reports and using net-ethnography [Wittel, 2000]. Data were analysed following a thematic analysis approach [Braun & Clarke, 2006].

(iii) Dampbusters study

Chapter 6 reports on a project where I collaborated with a not-for profit organisation, Knowle West Media Centre (KWMC), and the city council in Bristol, UK. Like in CrowdMemo, KWMC contacted me to co-create a framework aimed at guiding the design and deployment of community-led citizen sensing programme. For this project an ethnographic Action Research approach was followed. The first phase of the project comprised using rapid ethnography where I became familiar with the setting and the Media Arts Centre and the city council's work practices, their views and aspirations. Numerous interviews and less formal conversations, Skype calls and emails were conducted. Two co-creation workshops were also organised to design the framework. The second stage of the study focused on the implementation of the framework, which resulted in the community intervention, Dampbusters, which aimed to address the problem of damp housing in two neighbourhoods in Bristol. Throughout this phase, my role was to support the community orchestration processes conducted by the organisation and to complete cycles of documentation, reflection and feedback.

A qualitative approach to data collection was followed. This included direct observation, participation in a sample of the workshops, interviews, Skype and face-to-face conversations, emails, and group debriefing sessions. The outcomes of the intervention were assessed jointly and a summary report was collaboratively written. The scale and diversity of the activities performed and participants engaged meant that decisions had to sometimes be taken on-the-fly. An agile component [Crabtree et al., 2013; Chamberlain et al., 2013] was integrated into the general ethnographic Action Research approach to adapt to this complex scenario.

	Study 1 CrowdMemo	Study 2 Smart Citizen	Study 3 Dampbusters
Approach	• In the wild • Action Research	• In the wild • Ethnography & net-ethnography	• In the wild • Ethnographic Action Research
Data gathering techniques	**Qualitative**: Observations, questionnares with open ended questions and interviews	**Qualitative**: Observations, interviews, internet scraping **Quantitative**: Backend user participation logs and likert-scale based surveys	**Qualitative**: Observations, interviews

Table 1. Methods used in each case study.

3.4 Chapter summary

This chapter has presented and discussed the different approaches to conducting research studies with communities in the wild.

It outlines the existing approaches and the methodological requirements of this thesis. It proposes a qualitative in the wild approach comprising elements of Action Research and ethnography. This overarching methodology was tailored to meet the goals of the three different studies presented in this thesis. Its grounded approach allowed for the initial identification of relevant themes in the CrowdMemo study that where further tested and augmented in the Smart Citizen investigation. The resulting themes led to the co-creation, with stakeholders, of an actionable framework for the design and deployment of community civic technology interventions that was validated in an intervention aimed to use technology to address the problem of damp housing in Bristol.

4 CrowdMemo

4.1 Introduction

A first step towards understanding the factors underlying meaningful community engagement, sustainability and impact of civic technology interventions began with the evaluation of CrowdMemo.

The project was instigated by a community in Arequito, a rural village in Argentina, who were concerned about the preservation of their local heritage. They contacted me to help them plan and deploy a technology intervention that would involve a large group of participants to collaboratively tackle the problem at stake.

Initially, I was interested in following a participatory approach to collaborate with a community in a rural setting, in order to appropriate existing technologies to engage in civic action and effect positive change. The project followed an Action Research approach where research and action occurred simultaneously as I worked with the community [Hayes, 2011]. As the project developed, sustained and achieved a number of impacts, I became interested in further understanding how this had happened and what factors had contributed to the project's success. The evaluation phase then lasted for over two years and focused on understanding the factors underlying sustained community engagement with civic technology interventions and its potential impacts.

This chapter summarises the experience of CrowdMemo, explains the context in which the intervention took place and the issue that the project addressed. It also presents the stakeholders, the impact achieved during and after the deployment and the research findings. The results of this case study revealed four factors that were key to encouraging the sustainability and scalability of CrowdMemo: valued ownership, technology and skills, social interactions, openness, and tensions. These themes were then used to frame the subsequent case studies, therefore contributing to the overall narrative of this thesis

Figure 8. Children learning how to use digital cameras to interview older people.

4.2 Method

The project followed an Action Research approach where research and action occurred simultaneously as I worked with the community to plan, design, deploy and evaluate an intervention that was inclusive and sustainable [Hayes, 2011].

The main research questions that were addressed for this case study were:

1. What factors underlie meaningful community engagement with civic technology interventions?
2. What factors contribute to the sustainability of a community, its practices and the resulting technologies?
3. What kind of societal impacts can bottom-up civic technology interventions have and how should they be assessed?

To answer these questions, data were gathered through interviews, questionnaires and field notes and analysed using thematic analysis [Braun & Clarke, 2006].

4.3 Background

Storytelling is central to how a community preserves its heritage.

Technology has allowed different ways for storytelling to be created and stored, using audio-visual narratives, and digital technologies ranging from cameras to mobile phones. These stories tend to be distributed online, of a short duration and biographical [Lambert, 2013]. A number of community civic technology projects have used portable and handheld devices, such as mobile phones and consumer digital cameras, to document, share and preserve heritage [Bidwell et al., 2010; Lambert, 2013; Tisselli & Seels, 2008]. For example, Bidwell et al. [2010] worked with a rural community in a Xhosa tribal region of South Africa's Eastern Cape to design a mobile storytelling tool. Their goal was to enable users without access to personal computers to preserve, reflect on and share their life experiences using digital media. They found that the Western approach to storytelling differs from practices in rural Africa and that a participatory design approach was beneficial to inform the development of digital storytelling technologies for that context.

In Australia, Klaebe et al. [2007] worked with a community in Brisbane to develop History Lines, a project where citizens used digital tools to create and geotag stories. They found that effectively mediated historical narratives can contribute to identity, authenticity and creating a sense of belonging among community members. In Voice of Kibera citizens of a slum in Nairobi used handheld portable devices and OpenStreetMap to map their neighbourhood and geolocate stories about their daily lives. Hagen concluded that these practices have the potential to represent community opinions and a collective version of truth [Hagen, 2011s].

Three main benefits of using community memories and digital storytelling in a community project have been outlined:

i. they empower underrepresented groups by giving them a voice [Skuse et al., 2007, Klaebe et al., 2007];
ii. they provide a medium for the preservation of memories [Steels & Tiselli, 2008];
iii. they have been successfully used as a teaching tool [Brown & Brown, 2005].

Moreover, there is evidence that interactions between older and younger people can improve children's motivation for learning, and increase their awareness of personal and community culture [Ogozalek,1994]. Druin et al. [2009] and Bonsignore et al. [2013] have applied participatory design methods to design and develop mobile applications for intergenerational storytelling where community elders can play a role in educating the next generation of children. In formal learning settings like schools, digital storytelling has been adopted by many teachers because it combines interesting learning opportunities for students, including: learning how to operate digital tools; working creatively with others in the production of a story; and understanding how visual and textual content may blend to communicate a message. Some authors have referred to this set of knowledge as 'Media Literacy' or '21st Century Literacy' [Hull, 2003; Brown & Brown, 2005].

An ultimate goal for Action Research is to achieve long-term change. This not only requires the community to engage with the project during its initial phases but also when the researchers have left: *"Once research facilitators leave, the community partners should be able to maintain the positive changes that have been made"* [Hayes, 2011; p.13]. However, in HCI there have been few descriptions of ICT interventions that have successfully engaged communities over the long-term.

The contribution of the study presented in this chapter is to reflect on CrowdMemo and highlight the factors that were important in sustaining community engagement.

4.4 Setting

Rural communities in northeastern Argentina have experienced radical socioeconomic and cultural changes over the last three decades.

In the Argentine Pampa, from 1985 to 2010, soybean production increased from 7.1 to 52.7 million tons per year and the cultivated area expanded roughly from 3 to 18 million hectares [Calvo et al., 2011]. This expansion of soybean production was the result of an increase in the price of this commodity on the international market and the introduction of genetically modified seeds.

Arequito, a village of approximately 6,000 inhabitants in the state of Santa Fe, is known for being the 'Capital of Soybean'. Like other towns in the Pampa, Arequito has changed dramatically in the last three decades (Figure 9). As a consequence, some members of the community had a growing concern that failure to document and preserve the architectural heritage of the village could weaken the sense of community and even threaten the preservation of the local identity. Furthermore, many adults worried about the legacy that they will pass on to the younger generation.

A member of a local photography collective ProyectoIntemperie, working on a project documenting the architectural heritage of Arequito, contacted me and enquired about the possibility of running a digital storytelling workshop to address these concerns. Due to my experience with mobile media and film, I had previously been invited by the government of Santa Fe to teach a workshop on how to produce films using mobile phones in the context of an initiative aimed at incorporating the use of ICT at schools. This is how the relationship between the photography collective ProyectoIntemperie and myself was first established.

Figure 9. Comparison of early 20th century Arequito and a current view of the town.

4.5 The creation of CrowdMemo

The goal of CrowdMemo was to collect user-generated micro documentaries that present stories about places that are significant to the community in Arequito.

A number of documentaries (Figure 10) were created by school children based on interviews with elderly people who shared their memories about those places. They were then edited and uploaded to YouTube enabling them to be seen both online and in situ: commemorative plaques with QR codes associated with each documentary were embedded on the facades of the places that they refer to. The website of the project includes a Google Map of all geotags.

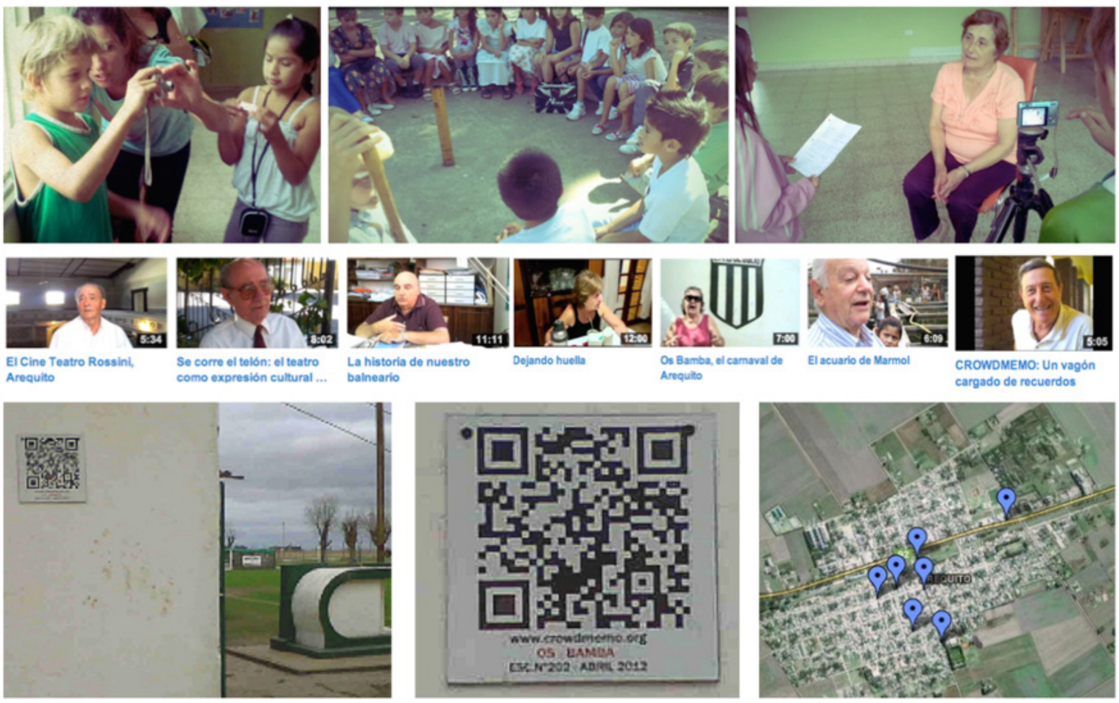


Figure 10. Thumbnails represent the CrowdMemo process.

CrowdMemo was orchestrated collaboratively by myself (sometimes here referred to as the researcher) and two local stakeholders groups in Arequito. First, the elementary school of the town, which had 260 students aged from 6 to 12 who were divided into 7 grades. There were 22 teachers, a headmaster and deputy headmaster, and at the time of the deployment three visiting ICT trainers from the Ministry of Education of the Province of Santa Fe. The second stakeholder group was the photography collective ProyectoIntemperie who have been working on documenting the architectural heritage of Arequito for many years. For four months we collaborated over email and Skype to plan a long term Action Research project that would engage the community and encourage it to reflect on and preserve its heritage.

In addition to this main goal, CrowdMemo had to meet the different priorities and expectations of the stakeholder groups and provide value for each of them.

4.5.1 Stakeholders' motivations

Although all the stakeholders involved with CrowdMemo (Figure 11) shared a common purpose (heritage preservation), they all had different motivations and expectations regarding the project.

- The school was interested in offering a learning experience to its teachers and students, mainly focused on digital literacy.
- Teachers expressed a desire to learn how to use mobile phones and low cost cameras for the production of videos, as they thought it would motivate their students to take an active role in innovative educational activities.
- The students were enthusiastic about being able to use handheld devices to produce short films at school, a type of technology that is typically forbidden in the classroom.

- The photography collective proposed that CrowdMemo should extend beyond the boundaries of the school and into the broader community. They saw this project as part of their initiative to create community awareness of the need for heritage preservation. In addition, they valued the idea of children using ubiquitous and affordable technologies to document locations in the town.
- Initially, I was interested in using action research to collaborate with a community in a rural setting to appropriate assemblages of existing technologies to engage in civic action and effect positive change. As the project developed and sustained, I became interested in further understanding how this had happened and what factors had contributed to the project’s success. The evaluation phase then extended through to over two years and focused on understanding the factors underlying sustained community engagement with civic technology and their potential impacts.

Local school: 260 kids (ages 7 to 12), 22 teachers, head master and deputy head master

Photography collective “ProyectoIntemperie”

Researcher

Figure 11. The stakeholders involved from the beginning.

It is important to emphasise the very active role that the stakeholder groups took in the project. Not only did they initiate the project but also representatives from the local school and the photography collective raised the funds to support CrowdMemo by persuading local enterprises, the village council and individuals to finance it. Furthermore, stakeholder groups were also responsible for organising public events associated with the project: a film premiere launch, and two subsequent events, Cafe Literario and Encuentro en la Llanura (all of which are described in more detail later).

4.5.2 Project conception and initial training

During the four months of project conception, we (myself and the project instigators) organised online and offline workshops to engage the different stakeholders involved in the project. An Action Research approach of democratically and inclusively involving stakeholders in project conception was followed from the outset [Foth & Axup, 2006].

Following a number of conversations over email, we then conducted a framing and design workshop on Skype where a representative from the photography collective, the teachers, the headmaster and vice headmaster and the researcher discussed the goals of the project and the deployment strategy. We defined a roadmap for the execution of the initial phase of CrowdMemo.

In a series of workshops in Arequito, teachers explained the project to students and led discussion about the history of the village and the places that were important to the community. As homework, students were asked to discuss with their parents what places were relevant to the community and learn about their history.

In a third workshop, two representatives from the photography collective taught students the theory and practice of filmmaking using low cost cameras. They also presented a slide show showing how Arequito had changed over the last century. In the last workshop, teachers worked with students to select the locations that each grade was going to document in their videos. For several weeks they conducted research about the history of those places and found out which members of the community could share memories and anecdotes about them. The output of this process was a selection of 9 locations, a list of people to be interviewed, photos (Figure 12), songs, videos and media related to those places. They then created one script for each selected location.

Figure 12. Historical pictures of cars in Arequito collected by the children.

4.5.3 Deployment

I visited Arequito for the week-long deployment phase. Before each class filmed their script they received an additional half day workshop, conducted by myself, where they learnt how to film documentaries using mobile phones and low cost digital cameras. Nine micro documentaries were filmed (Figure 10) following the scripts defined in the previous phase. The students from first and second grade did not film documentaries but participated in creating their own videos. First grade used mobile phones and digital cameras to make footage of the plants and trees in the village and second graders acted in a micro telenovela (soap opera) representing what life in Arequito was like in the beginning of the 20th century.

Below, the titles and descriptions of some of the documentaries produced by students are presented, each of which involved interviewing elderly people in the town:

- **The Rossini theatre** (5th grade) The Cine Teatro Rossini was opened in 1932 and was considered one of the most important theatres in the province for its architecture, its dimensions and the wonderful acoustics. During the deployment of CrowdMemo the theatre was temporarily out of use.
- **The history of our riverside resort** (7th grade) The Balneario Arequito riverside resort used to hold social gatherings every summer. It has been abandoned for decades.
- **A wagon full of memories** (6th grade) The first train arrived in Arequito in 1887 but stopped being used by passengers many years ago. The documentary explains how the train changed people's lives in Arequito and the neighbouring villages.
- **The aquarium of Mr Marmol** (4th grade) Mr Marmol created an aquarium in his backyard and it now contains thousands of fish species from all over the world. In the documentary Mr Marmol explains how he started his aquarium and shows hundreds of species of fish that he takes care of. His concern is that someone in the village learns how to take care of the aquarium after his death.

4.5.4 Project launch and blog

CrowdMemo was launched at a public premiere that was advertised in the media. Refreshments were served and all nine micro documentaries were shown on a big screen. 600 people attended the event (Figure 13). During the premiere we also displayed the QR codes that enabled the videos to be watched online. Because many people in the village did not have previous experience of QR codes, a group of community members volunteered to train people on how to download QR code scanners on their phones and how to use them to view the videos. Children were also very keen to teach adults how to access the documentaries by scanning the codes. Elderly people were moved when their stories appeared on the screens.

Figure 13. People learn how to use QR codes (left) and attendees at the CrowMemo premiere (right).

A blog (CrowdMemo.org) was created and regularly updated during the process of deployment. This online resource allowed the community to track the evolution of the intervention and see pictures of the interviews and documentary locations. It also enabled students and other stakeholders to leave comments.

Importantly, it also communicated the project to other communities outside Arequito, which led to the external appropriation of the project. This was a desired outcome and the blog clearly stated that the project was open and available to be replicated and gave step-by-step instructions on how to do so.

4.5.5 Data collection

The process of assessment was conducted in collaboration with the stakeholders. A qualitative approach combining participatory observations, questionnaires with closed and open-ended questions and interviews covering all the phases of the intervention was adopted. In addition, a debriefing session was carried out with the school teachers, headmaster and deputy headmaster, representatives of the photography collective and two of the ICT trainers from the Ministry of Education of the Province of Santa Fe who had visited the school.

A questionnaire (in annex 1) was designed to collect data and interviews conducted to gather information about participants' experiences and opinions with regards to:

- the deployment of CrowdMemo, in particular the strengths and weaknesses of its different phases;
- community engagement;
- reflection and awareness about heritage preservation; and
- sustainability of the project.

Questionnaires were answered by 22 participants from the school, the photography collective, the Ministry of Education and members of the community who took part in the project, 12 months after the researcher left the field. The researcher also interviewed the coordinator of the first external appropriation of CrowdMemo, which took place in a neighbouring town, Pujato.

Assessing sustained engagement and impact is challenging because data collection needs to cover extended periods of time. Therefore, the evaluation continued through emails and the researcher and the stakeholders discussed the results iteratively. All interviews where conducted in Spanish and quotes from the respondents have been translated to English.

Participants' answers to the open ended questions were analysed by using thematic analysis [Braun & Clarke, 2006]. Themes emerging from the analysis were discussed with stakeholders until consensus was reached. Two overarching themes were identified: **impact indicators** and **engagement**. Quantitative data extracted from the fieldnotes have been used to further validate the analysis.

4.6 Findings

In this section the findings from the thematic analysis are presented. Initials and their role in the project identify the interviewees.

4.6.1 Impact

The community kept the project going after the researcher left the field, renaming it 'Natives and immigrants at the 202 of Arequito' in reference to the cooperation between children (digital natives) and old people (digital immigrants) and the name of the school (202). A number of other indicators (Figure 14) were also found to demonstrate the sustained impact that CrowdMemo achieved. They are described in the following subsections.

Figure 14. Impact indicators associated to CrowdMemo.

4.6.1.1 Media coverage

The project launch received media coverage in the local newspaper, a radio station and on regional TV. A few months after the intervention, there was a local TV show about the story of the village and its characters building on the interviews created during CrowdMemo.

4.6.1.2 Attendance at public events

CrowdMemo was launched at a public premiere organised by the school, which over 600 people attended, a large proportion of the town: *"the day we organised the premiere everyone was there!"* [S.A.G., school teacher]. Many attendees found the event surprisingly moving: *"The emotion, the tears and other samples of appreciation were unexpected. We didn't imagine that this project would be so moving to people"* [M.J.G., school teacher].

After the intervention, the school and the photography collective organised two social gatherings around the problem of heritage preservation: the Cafe Literario (7 months after), attended by 400 people; and the Encuentro en la Llanura (14 months later), attended by 250. In both cases, the community discussed CrowdMemo and its legacy:

> *"Participants continued to talk about the process and about the premiere at the Cafe Literario...about the huge number of people who came together that day!" [M.M., school teacher].*

4.6.1.3 External appropriation

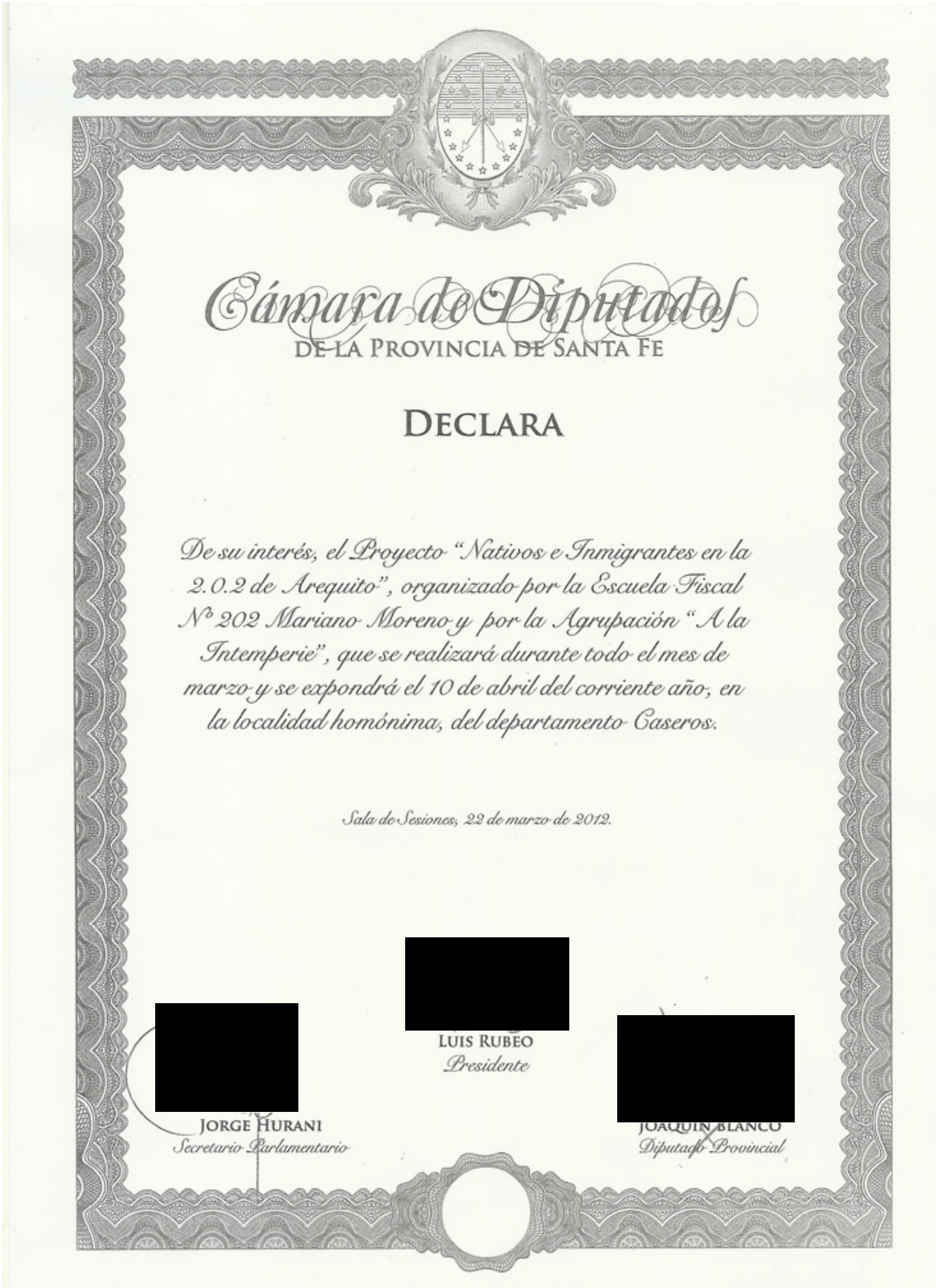
CrowdMemo's impact extended beyond Arequito and the project's approach has been appropriated by other communities in the state of Santa Fe. An ICT facilitator from the Ministry of Education explained:

> *"This project has been a real 'social mobiliser', as it not only captured the collective memory of the village but it also inspired other projects within the local school and other external institutions".*

For example, a few months after the deployment, Pujato, located 43 km away, launched Replay (nuestroreplay.wordpress.com/), their own version of CrowdMemo. School 227 of Pujato was celebrating its 125th year anniversary and invited people to the school to be interviewed by the students following the CrowdMemo approach.

As well as capturing digital stories, they also created an e-book and a photography exhibition. Moreover, they organised a public event where the micro-documentaries were shared and showed them at different science fairs in the province.

This appropriation was led by a member of the community who learnt about CrowdMemo through the project's website. For over two years, their initiative was sustained by the community with regular blog postings and creation of new microdocumentaries. In addition, in San Jose de la Esquina, a rural community 30 km away from Arequito, the local school appropriated CrowdMemo (at a smaller scale) to commemorate the 150th anniversary of the founding of their town.



Cámara de Diputados
DE LA PROVINCIA DE SANTA FE

DECLARA

De su interés, el Proyecto "Nativos e Inmigrantes en la 2.0.2 de Arequito", organizado por la Escuela Fiscal Nº 202 Mariano Moreno y por la Agrupación "A la Intemperie", que se realizará durante todo el mes de marzo y se expondrá el 10 de abril del corriente año, en la localidad homónima, del departamento Caseros.

Sala de Sesiones, 22 de marzo de 2012.

[redacted]
LUIS RUBEO
Presidente

[redacted]
JORGE HURANI
Secretario Parlamentario

[redacted]
JOAQUIN BLANCO
Diputado Provincial

Figure 15. CrowdMemo was awarded 'project of interest' by the Chamber of Deputies

4.6.1.4 Recognition by state government and impact on public policy

CrowdMemo was awarded 'project of interest' recognition by the Chamber of Deputies of the province of Santa Fe (Figure 15). Furthermore, during the deployment, three ICT trainers from Santa Fe Ministry of Education visited the school to observe the project. They reported on the techniques used to train the school community in digital storytelling.

As a result, the Ministry of Education created a new training course called 'Make and narrate with ICT', which has so far been delivered to 1,500 teachers and students from 288 institutions across the state. When interviewed, the coordinator for ICT in the Ministry of Education explained: "*It will be difficult to replicate the experience of CrowdMemo but we are trying to spread it in different ways*".

4.6.1.5 Impact on architectural heritage preservation

Three of the locations captured in digital stories in CrowdMemo have undergone, or are undergoing, refurbishment as a result of the project. First, the Cine Teatro Rossini has been restored and is now open to the community. Second, the local council launched an initiative to collaborate with students at the Faculty of Architecture (National University of Rosario, Santa Fe) in order to redesign the Balneario Arequito riverside resort. The council received five project proposals and is now carrying out a technical assessment to choose and develop one. Third, restoration works were carried out at the train station. Finally, one of the members of the photography collective worked on a research project named 'Conformation of the Historical Centre of Arequito'. The aim is to investigate whether Arequito can be recognised as having a historical centre in accordance with the UNESCO norms of Quito.

4.6.1.6 Integration into the school curriculum

Teachers and students have continued using mobile and low cost cameras phones to film new content:

> *"At school they use the short movies for reflective coursework and they still use the mobile phones" [M.B., school teacher];*

> *"This year (2013), 5th grade created a blog and students in 7th grade filmed interviews with mobile phones and little cameras for their language course" [M.M, school teacher];*

> *"Fourth grade students continued with the project and we presented a short film with interviews honouring seamstresses from the village along with an exhibition that shows how fashions have evolved and a parade with bridal gowns made by dressmakers from different years" [J.R., school teacher].*

4.6.2 Engagement

One of the key factors leading to the sustained success of CrowdMemo was the strong community engagement that it generated among the different groups involved in the project. This included commitment, emotional involvement, feeling of belonging and identity with the project. One example was the positive emotions expressed by individuals from all of the stakeholder groups when they described their experience of CrowdMemo [Kahn, 1990]:

> *"To see the students, teachers and a lot of people from the village conversing, remembering worthy anecdotes about the town...their faces, voices, expressions and even silences denoted the strong emotional impact that the project generated" [G.F., photography collective];*

"The excitement, tears and hugs of thanks [by members of the community] was something we did not expect. We did not think that it would affect people so much" [J.R., school teacher];

"...this project allowed for the participation of the community, which was full with emotion" [deputy headmaster]; "We had fun, we learnt and made really nice works" [group comment by students on the project blog].

A second piece of evidence for engagement was the reflection CrowdMemo engendered about belonging to the community:

"I felt that the whole community was engaged with the project and that we were all working to transcend the walls of the school" [A.M.C., school teacher];

"The community's response was wonderful, all the people were talking about what the students were developing. The response was incredible, very positive! I learned a lot and the students have shown great interest, participation, emotion, habits, behaviours, and vocabulary. It has been a wonderful project, an excellent motivator to get to know the history, architecture, and people in our town" [C.B., school teacher].

A group of students commented:

"It was really nice to learn anecdotes about our village and those stories that are not written in any books".

These forms of strong engagement with CrowdMemo can be analysed further in terms of **recognition** and **pride, social encounters**, and **technology** and **skills**.

4.6.3 Recognition and pride

A key factor in the community's engagement with the project was that they felt recognised and valued. This recognition came from both inside and outside the community. Being interviewed engaged elderly members of the community in the project (Figure 16): *"People who were interviewed by the students expressed enthusiasm and excitement because they were being recognised again for what they had done"* [J.R., school teacher]. Having their stories recorded and shared led to their contributions being appreciated by the wider community: *"It allowed me to better value what we have and what our grandparents, mainly immigrants, built, their work ethic and perseverance"* [T.Z., member of the photography collective].

The community also valued the fact that their personal histories would persist as digital stories: "*Knowing that people I know are and will always be portrayed telling our story fills us up with pride!"* [M.A.V., school teacher]. Other respondents clearly expressed how seeing the digital stories led them to appreciate other members of the community:

> *"The community was surprised to know about the experience of neighbours. It was great to remember those events and learn about the places in our village from a different perspective" [school deputy headmaster].*

Memories are imbued with features of the local identity and publicly displaying them led to reflection on locations in the village and why they are relevant to the community's heritage:

> *"[CrowdMemo] made me reflect on the history of the local community but from a novel perspective. It's not only about our material achievements but through learning our ways of having fun, our achievements as a human group through our stories (...) It's not about some texts and paragraphs put together by a historian, it's about the testimony of those who gave life to many of the situations [in our heritage]." [T.Z., member of the photography collective].*

Figure 16. Older members of the community show the first theatre play of Arequito (left) and one of the first cars in the village (right).

One source of outside recognition was the wide media coverage, which the community frequently discussed: “In the village people are still talking about CrowdMemo, the local TV channel created a show telling the story of the village and its characters” [C.B., school teacher]. Others were the award from the Chamber of Deputies of the State of Santa Fe and the creation of the course ‘Narrate and make with ICT’ by the Ministry of Education (both mentioned in Impact indicators):

> *“I think this novel experience gave a lot of prestige to our institution ... I feel very proud of my school and the school principals because they are always looking for positive innovation for our community...I am thankful to have been part of it” [M.A.V., school teacher]*

> *“Those involved have been very excited and grateful to have contributed to the reconstruction of those stories. Everybody spoke about the impact of the project both here and in nearby towns” [school deputy headmaster].*

The fact that the researcher came from Europe to Arequito to participate in the deployment was a source of community pride.

In sum, the main consequences for the community of these different forms of recognition were a sense of ’having their voice heard’ and more generally feeling pride in the project, both of which resulted in sustained engagement. Another key factor was the opportunity for social encounters engendered by CrowdMemo.

4.6.4 Social encounters

CrowdMemo generated social encounters in three ways, each of which strengthened community engagement with the project and contributed to the sustainability of the project:

- enabling interactions between children and the elderly;
- organising public events that fostered shared experiences among members of the community; and
- creating triggers for conversation in public spaces.

According to 90 percent of the participants, enabling conversation between children and older people was one of the most valuable aspects of CrowdMemo:

> *"People interviewed were emotionally engaged because they could revisit and transmit their experiences to the youngsters" [S.A.G., school teacher];*

> *"Seeing my father in law and my son together remembering the old days, in front of the church and next to the old family car. Emotion and pride at the same time!" [A.M.C., school teacher].*

There were several public events in CrowdMemo that created opportunities for face-to-face social encounters:

> *"I think that CrowdMemo was useful because it enabled dialogue between different community members about the town's heritage. Each group of participants visited the places where their stories had taken place...At the premiere and the Cafe Literario people were very excited to converse and reveal their memories to others" [deputy headmaster].*

Public events also enabled sustained reflection. When asked about what happened within the next 12 months after the deployment of the intervention, respondents explained:

“Participants continue to talk about the process and the premiere at the Cafe Literario. About the huge number of people who came together the day of the premiere!” [M.M, school teacher].

Moreover, the QR code plaques (Figure 17) on the building facades facilitated conversation in public spaces:

“People who come to the village ask about the QR codes” [school deputy head]; “We use them as a tool for cultural promotion available at all times for locals and visitors. TV programs show those places and interview the people who have been related to them” [T.Z., member of the photography collective].

The following section describes how the other technologies deployed in the project facilitated engagement.

Figure 17. The QR code plaques on the building facades became talking points.

4.6.5 Technology and skills

The combination of mobile phones, digital storytelling and QR codes represents a novel assemblage of technologies, rarely used in Argentinian schools. Participants often referred to the novelty of the technological approach, which generated a positive attitude to the project:

> *"I think this novel experience gave a lot of prestige to our institution... I feel very proud of my school and the school principals because they are always looking for positive innovation for our community...I am thankful to have been part of it." [M.A.V., school teacher]*

and

> *"The community feels motivated by this type of activity as it contributes to an innovative education" [M.N.M., school teacher].*

The project also created opportunities for teachers and students to learn new technical skills, which they found to be valuable and engaging: 70 per cent of the respondents agreed that one of the most important aspects of CrowdMemo was that students learnt how to produce content using mobile phones. Students commented on the blog that they had fun learning how to film with phones and were grateful for having acquired such skills.

4.6.6 Tensions, complaints and challenges

While the project was successful in galvanising the community and achieving its purpose, tensions and challenges arose throughout and after the deployment. There were two key complaints that created tensions among participants: time for training and contested narratives.

Firstly, half the teachers retrospectively complained about the time had been assigned for them to learn how to film, edit and publish the micro-documentaries. For example:

> *"It was too little time to learn so much!" [J.R., school teacher].*

Many of them had low digital media literacy and felt like the students were sometimes faster than they were in using the technology and producing content:

> *"One weakness was the lack of time and, personally, my lack of knowledge of some technological resources to work more confidently with the students." [M.J.G., school teacher].*

However, the teachers did not directly blame the project for this limitation but rather considered it to be a consequence of the education system itself, for example:

> *"I think this weakness is related to the times of the school, which does not allow us to do everything we plan." [M.M., school teacher].*

Moreover, the community's enthusiasm to go out and film the memories created a sense of urgency and much of the content was filmed before the teachers and students could master the technology and incorporate the basics of cinematography. On a few occasions, this naturally led to the production of content that was technically poor. As this teacher commented:

> *"I think the greatest weakness of the project was the lack of time because in my case I would have liked to repeat one of the interviews that could not be used in the final work due to poor image and sound quality". [M.B., school teacher].*

Secondly, a source of tensions was the fact that memory is subjective and shared narratives are prone to be contested. Those who were interviewed had the power to share their side of the town's story, without it necessarily being accepted by others. For example, when sharing the story of the riverside resort, an interviewee described how one summer they celebrated a beauty pageant to choose the prettiest girl in town. Both, the event and the winner were discussed during the interview. As the story of the interview circulated around the town, rumours emerged condemning the fairness of the contest. A lady, who had participated in the beauty peasant but was awarded second place, visited the school to share her story. The students agreed to film her and she used the opportunity to describe how, in her view, the winner of the contest was chosen due to favouritism rather than merit. She also disclosed the names of those who were involved in the case, and her explanation for how they had acted in such way. The students and the teachers believed that the lady's story was biased due to the fact that she had lost the contest and that it was not fair to include her video in the micro-documentary as townspeople had been named and defamed.

While the children and teachers would have liked to involve as many interviewees as possible, they had to be selective due to time and resource constraints. Choosing who should be interviewed and who should be left out was a hard process, involving many discussions, primarily among adults (teachers and parents). In some cases they prioritised the stories shared by their relatives, which was viewed as unfair by other community members who expressed their disappointment after the public screening.

4.7 Discussion

The goal of CrowdMemo was to create sustained community engagement to ensure long term heritage preservation.

The project was successful in this regard: two locations in the village have already been refurbished (the theatre and the train station) and there are plans to do the same with the riverside resort. Since the deployment, there have been two public events independently organised by the community that have sustained interest in heritage preservation in Arequito.

The novel ways of using mobile phones and low cost cameras, as well as the skills learnt during the deployment, have been integrated into the local school curriculum and students regularly use digital storytelling at school. Furthermore, CrowdMemo has had a wider impact: two neighbouring villages, which were not initially involved in the project, appropriated it; it was recognised by the regional government; and influenced regional educational policy. The findings drawn from CrowdMemo suggest the following factors were important for the impact of the intervention and its success in terms of sustained community engagement:

- valued ownership;
- technology and skills;
- social interactions;
- openness; and
- tensions.

4.7.1 Valued ownership

The findings support Taylor et al.'s assertion that a crucial part of sustainably integrating technologies into community life is encouraging the community to feel a sense of ownership of the project [Taylor et al., 2013]. People in Arequito involved with CrowdMemo had a strong sense of ownership, which was a consequence of several factors. They instigated the project by contacting the researcher with a request to collaborate. The stakeholders were involved from the outset in the organisation and logistics of the project. They not only set the goals of the intervention in collaboration with the researcher, but also organised interviews between children and old people, as well as public social events such as the premiere. The importance of these factors for sustained engagement has also been recognised in the action research literature [Hayes, 2011]. Significantly, the community also raised all of the funds to support the project, which enhanced their sense of ownership.

Another significant aspect is that participants owned the technology that was used in the project and were trained in the skills necessary to use it in novel ways, for example, making digital stories with mobile phones. These skills were embedded in the community through their incorporation in the school curriculum. However, although necessary, ownership is not sufficient for sustained engagement. For example, many people own a technology that they do not use because it no longer has value for them, such as an old mobile phone left in a drawer or a forgotten gadget at the back of the kitchen cupboard.

Importantly, CrowdMemo provided value for all of the stakeholder groups that were involved. Children were excited about using the technologies and curious about the stories they were told by the old people they interviewed. Elderly participants felt valued and useful and enjoyed sharing their memories with the children and having them preserved as digital stories. Members of the photography collective valued CrowdMemo because it encouraged the community to reflect about the architectural heritage of Arequito. Teachers valued learning new technology skills that enhanced their classroom practice. The school management found value in being able to play a significant role at the heart of the community. CrowdMemo suggests that a sense of valued ownership can be facilitated by following action research principles: involving community stakeholders in the conception and running of the intervention and ensuring that the project provides value for each stakeholder.

4.7.2 Technology and skills

CrowdMemo facilitated a number of different technology encounters that deepened community engagement: students with mobile phones; teachers with digital storytelling tools; and townspeople and visitors with QR codes. Importantly, the technologies themselves were off-the-shelf rather than prototypes but the way they were used was novel. The combination of mobile phones, digital storytelling and QR codes represent a novel assemblage of technologies, rarely used in Argentinian schools. Participants often referred to the novelty of the technological approach, which generated a positive attitude to the project: *"The community feels motivated by this type of activity as it contributes to an innovative education"* [M.N.M., school teacher].

In Argentina there were more than 50 million active mobile phones in 2012, among the highest rate in Latin America [Retegui & Perea, 2012] and many students owned a handset. However, they are usually banned from classrooms as they can be distracting. In contrast, CrowdMemo legitimised mobile phone use at school by training students to use them, along with low cost cameras, to produce digital stories. Students were excited about this opportunity to use them in a new way. Kolb highlights the benefits of introducing mobile devices into the classroom because most students know how to use them and enjoy doing it [2011]. Furthermore, they enable teachers to plan technology-based activities that can take place outside the classroom. CrowdMemo introduced teachers to using mobile phones for digital storytelling. They learned new skills in order to create content using low cost devices, simple video editing software and QR codes. Using digital tools to produce pedagogical material allowed them to innovate their classroom practices.

In the context of CrowdMemo, it was significant that participants owned the technologies that were used in the project and were trained in the skills necessary to use them in novel ways, for example, making digital stories with mobile phones. These skills were embedded in the community through their incorporation in the school curriculum. As discussed by Taylor et al. [2013], using off-the-shelf technologies bypasses many of the challenges associated with handovers of experimental technology prototypes to communities. Specifically, off-the-shelf technologies, such as mobile phones, and established infrastructures, such as 3G networks, are far more robust than research prototypes, generally require less maintenance, and if they do fail can easily be fixed or replaced. Furthermore, many people in the community are familiar with, and have the basic skills to use, off-the-shelf technologies like mobile phones and low cost cameras. CrowdMemo built on these existing skills, for example, by training community members in how to install and use QR code readers. Merkel el al. have also identified the importance of developing participatory processes that take advantage of a community's skills in order to develop and sustain an intervention [2004].

The findings from CrowdMemo suggest that using off-the-shelf technologies in novel ways rather than using novel technologies (that often respond to a researcher's own agenda), for the context of digital storytelling played an important role in sustainability and scalability. Had a novel technology been introduced it may have provoked interest in the beginning but would have been unlikely to have sustained the same level of engagement. This is because low level of digital literacy, would have hindered the community's capacity to appropriate the intervention and continue contributing to it.

4.7.3 Social interactions

A key reason underlying the community's sustained interest in CrowdMemo was that it facilitated a range of social interactions that led to face-to-face conversations between different community members and thereby increased their engagement with project. The interaction between children and the elderly members of the community was identified by interviewees as one of the most important aspects of the project. The digital stories produced by the children meant that the old people knew that their life stories were recognised and valued by the community. The children also benefited from finding out about their heritage and by playing an important role in a project that was widely valued by their community. Steels & Tisselli [2008] argue that face-to-face meetings between community members are essential to the success of an intervention because they create the necessary trust and engagement for collective action.

A second type of social interaction was facilitated by the three public events: the premiere; 'Cafe Literario'; and the 'Encuentro en la Llanura'. At these gatherings community members could share experiences and discuss the digital stories, and more generally the heritage of the town, in a group context. Previous studies have highlighted the importance of celebrating milestones [Hayes, 2011] and capitalizing on public events [Carroll & Rosson, 2013] to engage participants in a project. CrowdMemo demonstrates that increased community identity and social change, in particular heritage preservation, can come about by facilitating social interactions.

4.7.4 Openness

CrowdMemo was designed to be open source in the widest sense. The approach was to use widely available and low cost off-the-shelf technologies, provide clear step-by-step instructions on the project website, and explicitly encourage appropriation. For these reasons, CrowdMemo provided an attractive opportunity for other schools striving for ICT training and learning activities using readily available technologies. Coincidentally, both additional schools 'opportunistically' appropriated the intervention because they were celebrating anniversaries, which provided an opportunity for the use of digital storytelling to recover the heritage of the communities.

Furthermore, the openness and low cost were crucial factors in the Ministry of Education's decision to scale up the digital storytelling aspect and train large numbers of teachers in this technique. Finally, media coverage played a strong role both in creating a sense of pride in the community that strengthened internal appropriation, and also in enabling the external appropriation of the project. Both local media coverage and the project blog raised awareness of the project inside and outside of Arequito. For example, CrowdMemo was appropriated by schools in the towns of Pujato and San Jose de la Esquina, neither of whom were initially involved with the project. This external recognition, as well as the local government recognising CrowdMemo as a 'project of interest' generated community pride in the project, which in turn facilitated sustained engagement. The intervention highlighted that it is possible to design for appropriation by: first, providing clear instructions on how to conduct the project; and second, using off-the-shelf technologies which are readily available to participants and which many will have the necessary skills to use. Leveraging media coverage is also useful.

4.7.5 Tensions

Tensions emerged during the process of collecting the memories to assemble the micro-documentary and a perceived lack of time for the teachers to develop the skills necessary to proficiently work with the students to produce digital storytelling. While these were unexpected hurdles that emerged after CrowdMemo was planned, the community discussed ways to overcome them. With regards to the time needed to better learn how to produce audiovisual content, the community agreed to continue developing their skills by adapting the practice of digital storytelling into the school curriculum. They also organised more events to discuss the history of the town, inviting people who did not participate in the filmed interviews to voice their views on the shared stories. The local TV show also played an important role in producing content that presented different voices and anecdotes. However, projects like CrowdMemo naturally reveal how narratives are contested and there is not one truth about how things occurred but rather different views on past facts. The distributed nature of digital platforms can help address this by providing opportunities for people to record and share their own views.

4.8 Conclusions

One of the primary reasons for the success of CrowdMemo is that it used locally available everyday technologies.

It was instigated by the community rather than by a researcher and delivered value for all the stakeholders involved. This meant that that community had a strong sense of valued ownership from the outset. A sense of valued ownership can be facilitated in projects that are research- rather than community-led by following an Action Research approach that aims to involve the community in the conception and running of the project. Another distinctive aspect of CrowdMemo was that it was funded by the community itself. This is unlikely to be the case in research-led projects. Unless a community has instigated a project then requesting them to contribute to the running costs is more likely to disengage the community than engage them.

This chapter described CrowdMemo, an Action Research project for heritage preservation in Argentina that not only had long-term impact but has successfully engaged the local and wider community over a prolonged period (18 months) and continues to do so. The methodology was effective in this context because it enabled a fruitful collaboration among stakeholders, who shared a sense of ownership and autonomy. The method meant that the goals were agreed upon from the outset and the project delivered value for each of the stakeholders. There were no power tensions and the intervention was effectively continued after the researcher had left. The data gathering methods provided opportunities to collect varied types of information during an extended period of time, leading to the assessment of impact indicators that demonstrated the effectiveness of the intervention.

In terms of answering research question one (*What are the factors underlying meaningful community engagement through civic technology interventions?)* the CrowdMemo case study showed that starting with a matter of concern, namely heritage preservation, that galvanises the community can foster strong engagement and a shared sense of purpose. It demonstrated that using off-the-shelf technologies in ways that were novel to the community also fostered engagement. Different stakeholders profited from learning something new, which was useful and enhanced their daily practices. The children were allowed to use mobile phones at school and learnt how to make movies using them in combination with other tools that they hadn't used before. The teachers also learnt about new tools and developed skills that could then be applied to improve their teaching practice. The older people in the community felt engaged and valuable as their stories were turned into micro-documentaries and then screened to hundred of people at public events. The fact that their memories were also "immortalised" gave them a sense of pride and joy.

In terms of question two (*What are the factors that contribute to the sustainability of a community, its practices and the resulting technologies?)* CrowdMemo showed that creating a sense of valued ownership in all of the project stakeholders by following an Action Research approach was crucial to the uptake and sustainability of the intervention. After the researcher left they changed the name of the intervention to make it easier for everybody to make sense of and communicate it, and applied the concepts learnt to other activities and to achieve different goals. Also, the fact that the intervention leveraged technologies that were owned by participants meant that they could easily sustain the intervention. The case study also demonstrates that facilitating a range of social encounters contributed to sustaining engagement with the project: people felt connected and part of a collective endeavour. The events became community gatherings that people wanted to attend to socialise and mingle. Moreover, the community champions from the photography collective and the school had a key role in sustaining engagement by promoting the organisation of more community gatherings and acting as contact points for people who wanted to join the initiative.

In terms of question three (*What kind of societal impacts can bottom-up civic technology interventions have and how should they be assessed?)* the research demonstrated that initiatives like CrowdMemo can achieve both internal and external impacts. Its direct impacts can be described in terms of:

- **Effectiveness**: CrowdMemo achieved its goal of tackling a heritage preservation problem. Places that were valued by the community and had been abandoned were refurbished and there was increased awareness regarding heritage preservation in the broader community.
- **Social collaboration:** CrowdMemo enabled new collaborations between groups of people that united to tackle an issue together. Children and older people, teachers and the students' families, the photography collective and the school community, and later the town hall and the CrowdMemo community. These new collaborations not only made the project possible but also accelerated the effectiveness of the intervention. Without the elderly there would have been no stories, and without the teachers and students these would have not been recorded and shared. Without the town hall becoming involved public funds would not have been allocated to refurbishing the abandoned places. Without the TV journalists who engaged with the stakeholders the projects probably wouldn't have had broader exposure. These new social collaborations helped *make things happen* to an extent that would have been difficult for the stakeholders alone to achieve.
- **Social capital:** the new collaborations contributed to building and/or strengthening community ties that fostered processes of bonding [Putnam, 2002]. This was also observed in the Blacksburg Electronic Village project, where new capital in terms of community bonds, the development of local skills and capacities created infrastructures that were then adapted and appropriated in other community ventures [Carroll & Rosson, 2013]. In Arequito, new social capital in the form of ties, skills and commons were developed. CrowdMemo facilitated the co-production of a community memory, *a medium for recording and archiving information relevant to a community and for distributing this information among members* [Steels & Tisselli, 2008].

Secondly, the fact that CrowdMemo achieved a number of external impacts, namely:

- **Communication outreach:** The project received wide media coverage, which fostered community pride but also contributed to fostering external appropriations and the state recognition. The initiative was further developed in neighbouring communities and the Ministry of Education adapted it to become a state-wide learning programme. This occurred partly due to the fact that CrowdMemo was addressing a local concern (heritage preservation), and it was doing it in a novel way: using technology in ways that had not been used before, and enabling new social collaborations (e.g. school children and older residents). Familiarity and novelty are well known characteristics of newsworthiness [Bell, 1991]. Having impact in the media significantly expanded the project and its impact.
- **Openness:** CrowdMemo was designed to be open in the widest sense of the concept, which made it possible for external parties to appropriate it for their own goals. The project delivered documentation, in the form of a clear step –by-step guide, enabling others to understand how the process was run, what was required to make it possible and which tools needed to be used. The project demonstrates that following an open approach where documentation is made available can increase engagement with the project [Teli et al., 2015], foster its scalability [Marttila & Botero, 2013], shareability [Lessig, 2004] and forkability [Balka, 2011].

In sum, CrowdMemo demonstrates that if researchers adopt a participatory approach that aims to empower communities, then a project can be appropriated in unanticipated ways and result in positive long-term impact. Using off the shelf technologies was key. However, for other contexts, new technologies may play an instrumental role. For example, how can a community learn more about its environment? In this case, new sensing technologies can play a central role. To investigate if this is the case, the next chapter addresses the research questions from a novel technology intervention perspective. The goal was again to assess how communities emerge and appropriate civic technologies. In particular, it aimed to determine how they were appropriated and used by people not familiar with the technology *a priori*, as well as the factors underlying meaningful engagement, sustainability and impact of such tools.

4.9 Summary

This chapter described CrowdMemo, an action research project for heritage preservation in rural Argentina that not only had short term impact, but successfully engaged the local and wider community over a prolonged period (18 months) and continues to do so.

The goal was to investigate the factors that made this project a success. Previous studies had identified some of the challenges faced by researchers when collaborating with communities in the wild, such as: the need to manage expectations; the challenge of maintaining and supporting novel technologies [Taylor et al., 2013]; and how to facilitate the appropriation of technologies by stakeholders [Crabtree et al., 2013].

CrowdMemo shows that creating a sense of valued ownership in all of the project stakeholders, using off-the-shelf technologies owned by participants, facilitating a range of social encounters, designing for appropriation and aiming for broad media coverage were positively related to sustained long-term engagement in CrowdMemo. Although following these themes may not be a recipe for guaranteed sustained community engagement; CrowdMemo does demonstrate that if researchers adopt a participatory approach that aims to empower communities, then a project can be appropriated in unanticipated ways and result in positive long-term impact.

5 Smart Citizen

5.1 Introduction

In the previous chapter, the CrowdMemo case study revealed that off-the-shelf technology used in novel ways, social interactions and conversation can facilitate engagement and foster sustained participation with a civic technology.

Moreover, it supported previous findings suggesting that involving the community from the outset in setting up the goals of the intervention, as well as using off-the-shelf technologies that people already own and providing skills contributed to a sense of ownership. This helped to support community engagement over a long period.

In this case study instead of examining the use of off-the-shelf technologies, I explored how a novel sensing technology, which was developed by entrepreneurs working at a Fab Lab was taken up and used by different communities (Figure 18). To begin, the technology was developed as part of a research and development experimental project, inspired by technologies such as Safecast that was used by communities to engage in civic action. It then became available for the general public to acquire and use through crowdfunding. This is quite a different approach from that used in CrowdMemo. The question that arises is: *is this kind of new technology useful for and usable by another community? Is it in a form that many people will see its value and be able to use it over sustained periods of time? Or is it a device that someone obtains through crowdfunding, tries it out for a while and then for various reasons discontinues using it?*

Figure 18. Two users setting up a Smart Citizen Kit.

This chapter explores these questions in the context of a new sensing technology – Smart Citizen that was designed to help communities measure aspects of their local environment and use the data collected, if they felt strongly about it, to raise a concern for their local council. It asks what are the factors associated with meaningful engagement, sustainability and impact of a novel technology intervention? What do citizens actually do with it? How might it empower a community and what impacts can they achieve?

From a research perspective, it is also of interest to determine the effectiveness of crowdfunded technology development intended for community use. Do communities have a higher level of buy-in and commitment to using it – having contributed financially to its development? Do they understand how to collect data using it, what the data represents, how reliable it is and what it can provide them with to pursue new policies or changes to existing ones?

The specific aims of the study were:

i. to examine user participation patterns of using Smart Citizen for a sustained period of time

ii. to identify any differences in community participation associated with engagement strategies;

iii. to understand the users' experiences with using it and the factors underlying community engagement.

5.2 Methodology

A long-term ethnographic study was conducted to examine how the sensing platform, Smart Citizen, was deployed, taken up and appropriated by two different communities over a period of three years, from April 2013 until April 2016.

Qualitative data were also collected using online surveys, semi-structured online interviews, face-to-face open interviews in Spanish, Dutch and English, and direct observations at project meetups and workshops. As much of the data analysed was online, a form of 'net' ethnography [Wittel, 2000] was used to analyze the uptake. Action research was not used for this study because the technology design and pilot deployments were undertaken prior to the research conducted here.

The data collected was analysed following a thematic analysis approach [Braun & Clarke, 2006]. In some cases, follow up interviews were carried out to collect more data pertaining to the emergent themes. In this study, the quantitative findings complement the qualitative data by providing a baseline of participation in the communities studied.

5.3 Background

While researchers have studied many aspects of community sensing systems, including the role of different design features in user engagement [Eveleigh et al., 2014; Kuznetsov et al., 2009; Gaver et al., 2014; Willett et al., 2010], data quality and reliability [Sheppard & Terveen, 2011; Stevens & D'Hondt, 2010], novel forms of data visualisation [Kim & Paulos, 2009; Willett et al., 2010], new perspectives on materiality [Kuznetsov et al., 2013], and the need to support orchestration for data gathering campaigns [D'Hondt et al., 2014], there is little work exploring long term user participation with crowdfunded participatory sensing initiatives.

Furthermore, the kinds of impacts that these technologies can achieve have not been assessed.

Motivations to participate, issues around data reliability, and aims and organisational aspects are normally different in citizen science projects than in crowdfunded IoT crowdsensing interventions. While the former usually stem from research goals or specific community needs, the latter tend to be initially inspired by technical possibilities (c.f. [Rogers et al., 2002]). It is worth understanding how these approaches differ to better frame the research contribution of the study presented in this chapter.

Data quality is a pressing issue in most citizen science projects [Nicholson et al., 2002] because experts use these contributions in scientific enquiry or make assessments that result in policy decisions [Snyder et al., 2013]. Experts often question the validity of the data provided by citizens who have varying levels of skills and knowledge [Sheppard & Terveen, 2011]. Consequently, various studies have sought to address data quality and reliability issues [Aoki et al., 2009; Mun et al., 2009, Stevens, M., & D'Hondt, 2010]. While researchers have also raised concerns about the reliability of the data provided by crowdfunded crowdsensing tools such as AQE [Snyder et al., 2013], the instigators of these novel technologies propose that data quality is less important than the volume of data produced by large crowds:

> *"Safecast supports the idea that more data – freely available data – is better. Our goal is not to single out any individual source of data as untrustworthy, but rather to contribute to the existing measurement data and make it more robust. Multiple sources of data are always better and more accurate when aggregated. [Safecast, 2015]"*

This kind of statements demonstrates a prioritisation of their mission to engage the public in political action. For example:

> *"Without real air quality data, people can be easily brushed aside, or worse, ignored. But nothing screams, "Take action!" like a link to a datastream updating in real-time showing how people are being affected at this very moment" [Air quality egg, 2015].*

Studies evaluating SafeCast and RadiationWatch have supported the vision that crowdfunded participatory sensing initiatives can empower self-organising citizen movements, but have provided little description of the mechanisms involved in such auspicious goals [Kera et al., 2013; Bria et al., 2015]. There is a need to further understand how communities use and appropriate these technologies in the long term, as well as how this novel approach compares to more documented ones in the citizen science literature.

5.4 The sensing technology: Smart Citizen

Smart Citizen (Figure 19) was developed as a research project and made available by crowdfunding. The project was launched in 2012, instigated by Tomas Diez, director at the Fab Lab Barcelona, at the Institute for Advanced Architecture of Catalonia (IAAC), and Alex Posada from Hangar Art Production Centre.

The first version was funded via Goteo crowdfunding, and raised almost 14,000 euro from 159 backers in 2012 and led to the production of 200 units. One year later, a second campaign, via Kickstarter, raised 68,000 U.S dollars from 517 backers and helped fund a further development of 520 Smart Citizen devices [Diez & Posada, 2013].

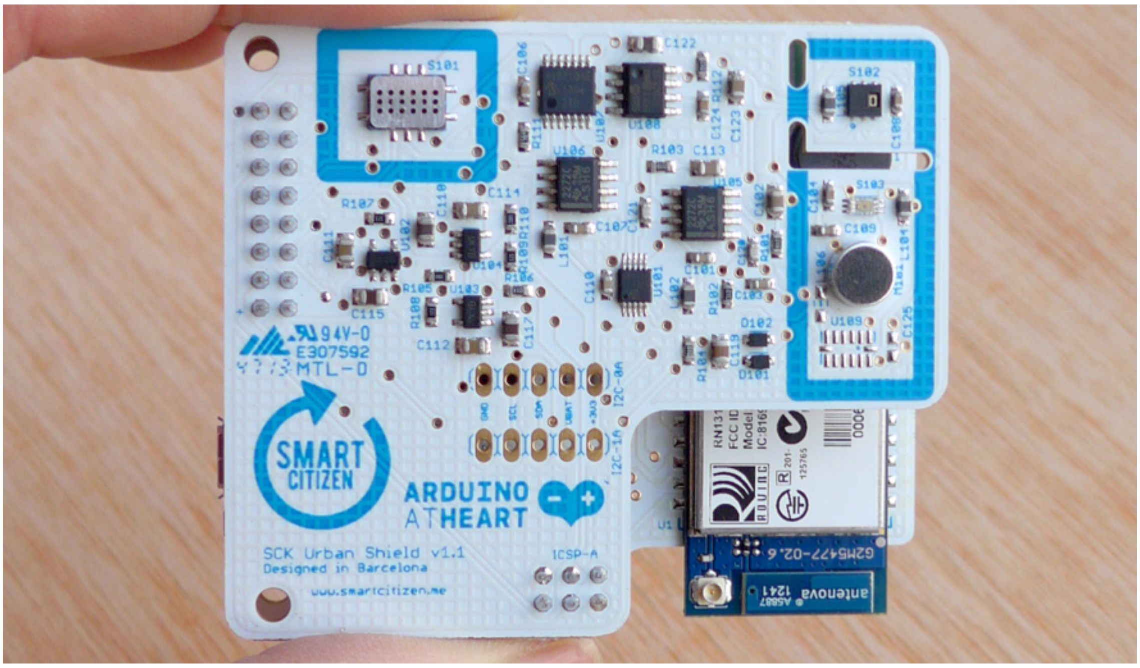


Figure 19. The Smart Citizen Kit sensor board.

Smart Citizen was initially developed with very limited resources and it was the crowdfunding campaign that made the production of units possible. However, the project was still in its infancy and the pressure to develop the sensors quickly to release them to the community who had crowdfunded them meant that the development team had to cut corners. The prototypes had minimal user testing and although advertised as "plug & play" it was considered to be at level six in the Technology Readiness Level Index[56], which is based on a scale from 1 to 9 with 9 being the most mature technology.

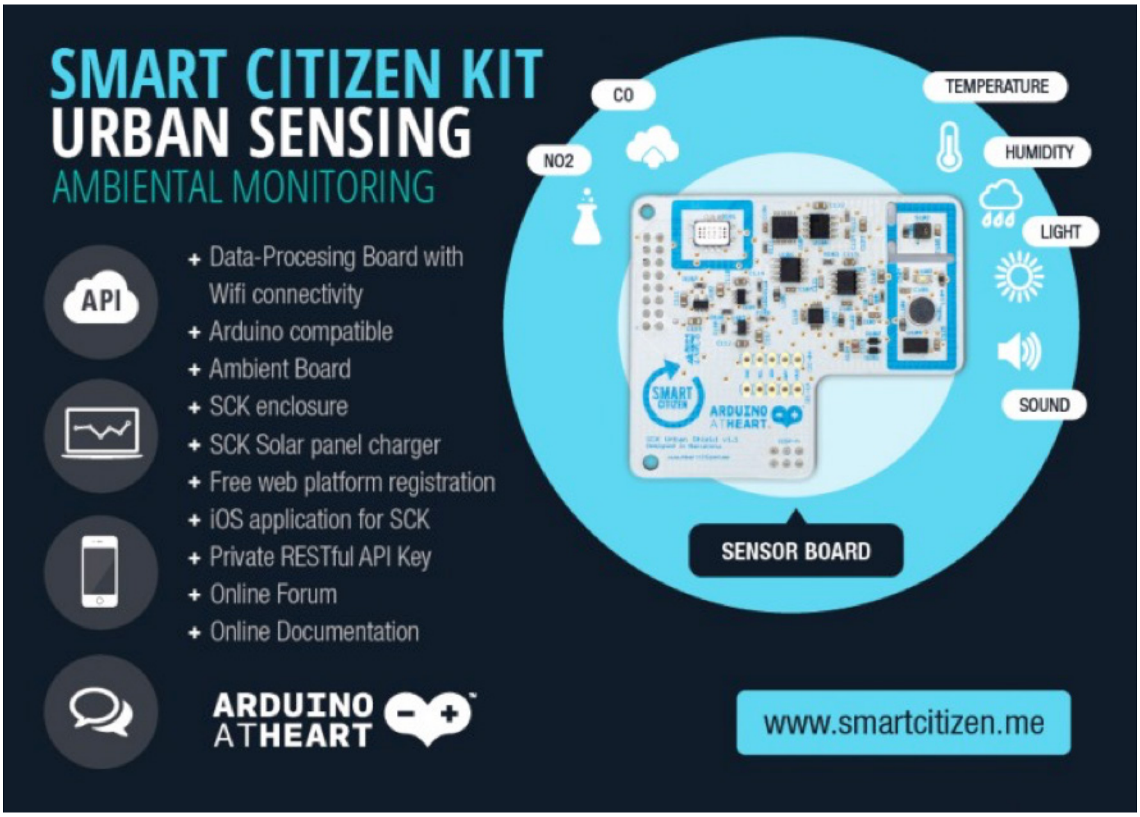


Figure 20. Components in the Smart Citizen Kit.

56 A technology readiness level 6 (on a scale from 1 to 9) is defined as "Representative model or prototype system, which is (...) tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment."

The Smart Citizen[57] (SCK) system provides a sensor kit, an online platform and a mobile application that enable collective sensing and sharing of environmental data. It consists of an electronic board and shield based on Arduino; a battery; a Wi-Fi antenna; and a set of sensors to monitor humidity, temperature, NO2, CO, sound pollution, solar radiation (using a solar panel as a sensor), Wi-Fi spots (using the Wi-Fi antenna as a sensor) and battery charge level. It was designed to be easy to set up and programmable by people with some technical knowledge. The kit can record offline data on a MicroSD card, in case a Wi-Fi connection is not available (Figure 20).

According to its creators, the kit has been designed using open source tools to incentivise advanced users to extend the existing infrastructure by programming new features and adding capabilities in order to meet their own purposes [Diez & Posada, 2013]. A key feature in the project was its commitment to providing an online platform that allows users to upload data from their own device, share them through social networks and make them available to everyone online for free. The website provides an interactive map showing other Smart Citizen Kits that have been logged in and the data they are collecting. The reason this was considered to be important was that it enabled users to visualise data collected and shared by others.

Figure 21. The complete Smart Citizen ecosystem.

57 https://smartcitizen.me/

The system also included an Android based mobile app that uses geolocation to retrieve data from the devices in the area where the user is located at the moment of opening the application (Figure 21). Additionally, users can download the digital file of a 3D printable open source plastic enclosure that protects the SCK from environmental conditions such as rain when deployed outdoors.

5.5 Researcher involvement

I participated in the Smart Citizen project initially as a backer and user, and subsequently as researcher. I found out about the crowdfunding campaign via Goteo and decided to support the project as it was aligned with my interest in civic and open source technology.

This enabled me to have initially participant observer status to begin with, while later to step back and observe from a more objective perspective how the communities engaged with the technology.

5.6 Context for study

To date, around 1600 SCKs have been rolled out to cities around the world. However, from April 2013 to July 2014 when the user participation assessment reported here took place, fewer than 1000 SCKs had been deployed.

The study focused on how the device was taken up initially in Barcelona (Spain) and Amsterdam (Netherlands), which were the two largest geographically bounded communities of Smart Citizen users at the time of the study. These communities emerged following different deployment strategies. While the former comprises the Barcelona community of users who backed the project via crowdfunding the latter followed from a three month-long deployment led by local institutions with a group of 73 users who signed up to participate in the pilot. The kits that have been distributed to users in other cities have been clustered under a “Rest of The World” category.

5.7 Findings

The findings are presented below. Firstly, a quantitative assessment of participation levels, measured in terms of setting up the device successfully and recording data on the online platform is presented.

This is followed by an assessment of the geographic distribution of participation, which identifies the two largest active communities of participants using Smart Citizen Kits in Barcelona and in Amsterdam. Finally, qualitative studies of user experience and community engagement in Barcelona and Amsterdam are presented.

To study user participation patterns in Smart Citizen, an initial quantitative analysis was conducted focusing on the participation levels (defined minimally as keeping the sensor kit powered and connected) of the SCKs from April 2013 when the first batch of devices was delivered to users, until July 2014. Two data sets were analysed to examine the initial uptake of the devices (i) a database dump from SmartCitizen.me, which contains metadata about registered SCK devices and time series data of all postings generated by the devices, and (ii) the shipping data provided by the project leaders, showing when the kits were dispatched to users.

5.7.1 Participation patterns

Figure 22 shows, within the timeframe specified above, the number of SCK devices that were shipped to users and the number of devices that were registered and sent data at least once to SmartCitizen.me. It shows that until the end of July 2014, 73% of the devices were successfully connected to the platform.

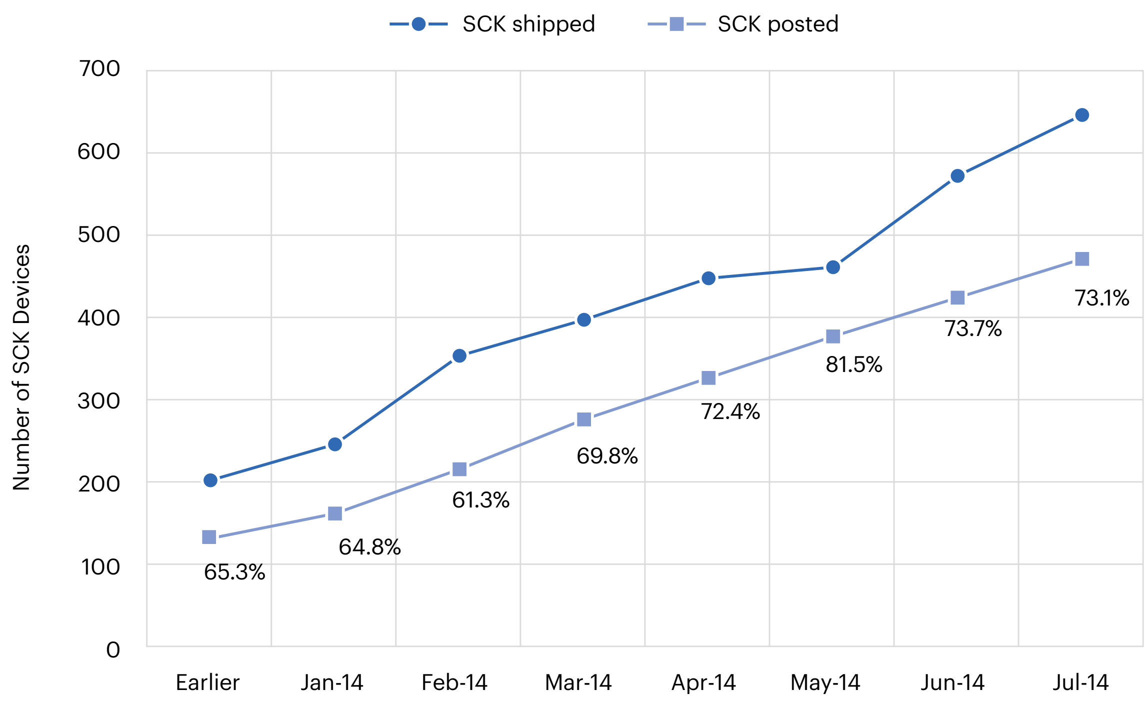


Figure 22. SCK device adoption showing monthly shipping figures and successful device connections.

Figure 23 shows the detailed breakdown of the population of successfully connected devices population across the Barcelona and Amsterdam communities and the remaining SCK devices in the Rest of the World (ROTW). The Barcelona community shows the largest geographic device population with nearly 90 SCKs. The first device in the Amsterdam community appeared in December 2013. From March 2014 the community grew rapidly. The Amsterdam study was different from the other two contexts, in that an orchestrated deployment campaign was set up by community members.

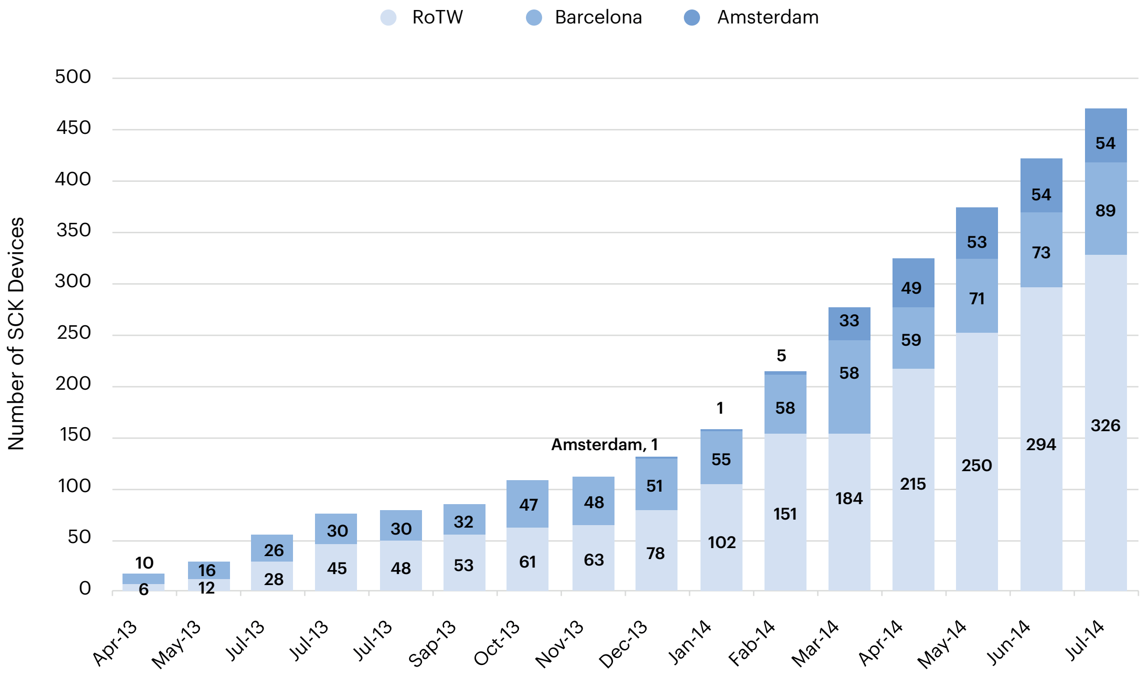


Figure 23. Breakdown of the SCK population.

5.7.2 Geographic distribution of participation

In order to assess participation levels of connected devices in the communities, their level of utilisation was measured. In an ideal case, once an SCK device is successfully connected to the platform, it will continuously report data at its configured reporting frequency, which is chosen by the user at the moment of the setup. However, packet losses due to intermittent connectivity and varying reporting frequencies make it difficult to compare utilisation levels between devices based merely on the counts of successfully received reporting records.

To address this issue and prevent inconsistencies in the data, each monthly period was divided into hourly timeslots and examined in how many of these timeslots a post from a SCK had been successfully received. A SCK that posted in every timeslot was considered to have 100% of utilisation, while SCKs that reported in none of the timeslot have 0% utilisation. The remaining devices were grouped in four other categories between the two extremes.

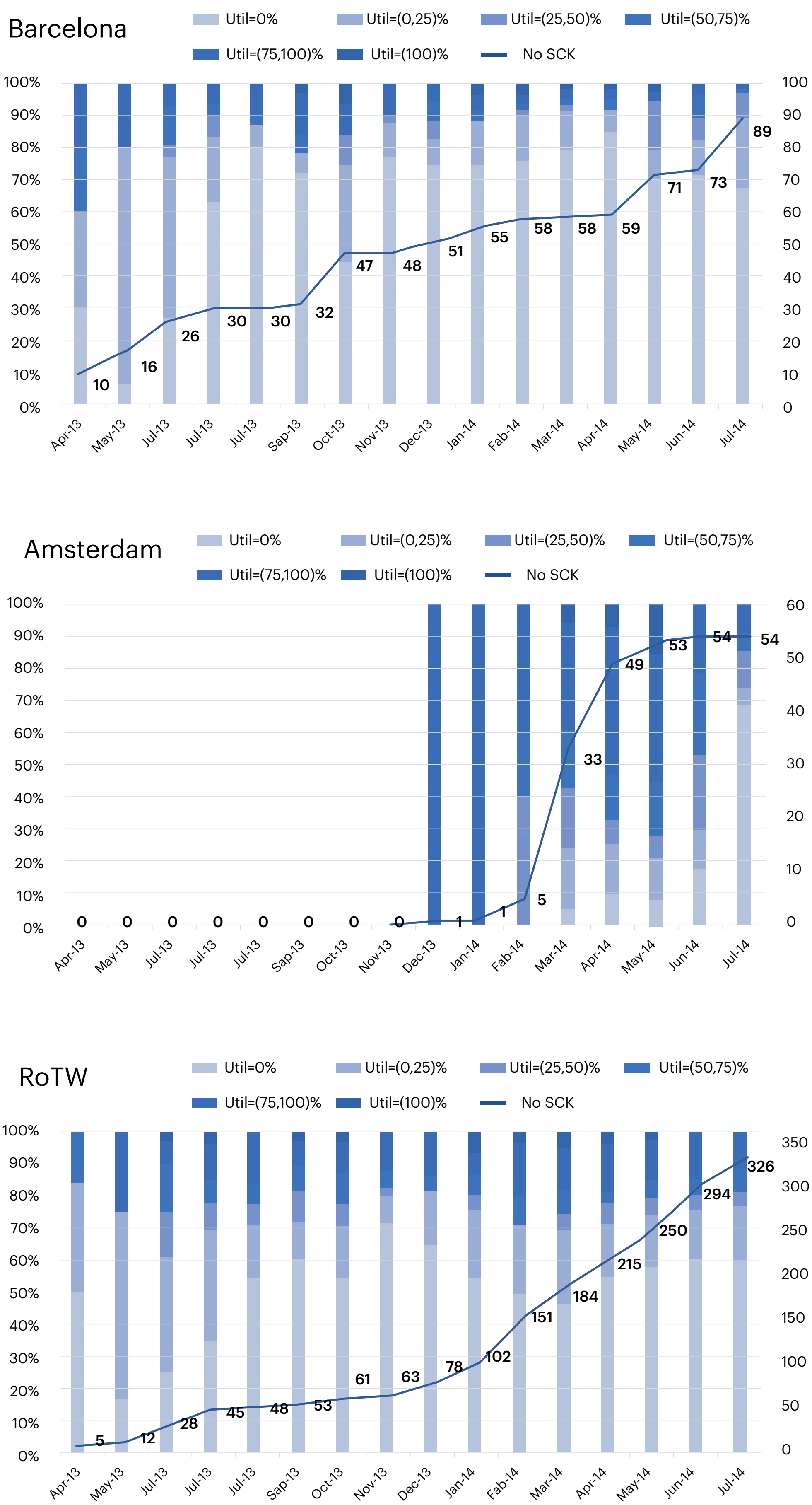


Figure 24. SCK utilisation across geographic areas.

Figure 24 represents the levels of utilisation of SCKs across the three settings. The figure shows the percentage of devices in the respective utilisation categories for each community (a darker colour shading represents larger levels of utilisation). The Amsterdam community shows the highest levels of participation, especially from March to June 2014 (an average of 50 activated sensors of which nearly three forth reported at least at 50%). This coincides with the orchestrated deployment organised in Amsterdam.

The Barcelona community and ROTW group of sensors are characterized by an initial phase of higher device utilisation that drops after June 2013. However, in Barcelona there are some intermediate utilisation peaks during October 2013 and July 2014, which correspond to large events where the Smart Citizen Project was showcased. These events were the IoT Forum[58] and 10th International Fab Lab Conference[59], both in Barcelona. In the ROTW figure similar peaks are visible between January and March 2014, which correspond to the dates during which the SCKs were shipped to those who backed the project via Kickstarter. In both communities there are a high number of SCK devices that did not report any data.

The data shows that uptake of Smart Citizen grew at a steady pace, a high percentage of users (~50%) failed to login their SCKs and therefore did not participate in contributing data to the platform. While specific local events around Smart Citizen led to peaks in participation, the highest levels of participation were recorded in Amsterdam from March to June 2014 (Figure 24). In the next section, we look in more detail at participation patterns for each context of use: Barcelona and Amsterdam. Informants are identified with letters and numbers.

58 https://www.iotwf.com/about/inaugural

59 Fab10 https://www.fab10.org/en/home

5.7.3 The Barcelona Community

Figure 25. A screenshot of the crowdfunding page of Smart Citizen in Goteo.

The crowdfunding platform used in Barcelona is especially dedicated to helping open source projects that find funding from contributors that are primarily Spanish (Figure 25). In the case of Smart Citizen, 159 people (117 males, 28 females and 14 anonymous or organisations) backed the project by making a financial contribution. 125 contributed enough to receive a SCK (98 males, 13 females and 14 anonymous or organisations). Following the campaign, the Barcelona Fab Lab organised a meetup for those who had backed the project to come together and receive their SCKs. Around 20 participants attended. A second event was organised a year later to connect the Barcelona community group with the Amsterdam community using Google Hangouts and around 38 users (8 from Barcelona and ~30 from Amsterdam) participated. No other events were organised during the period of this study.

In the context of this study, the 125 users in Barcelona are considered the "early cohort". With the aim to learn more about the demographics of the users, what their motivations to support the project were and how their experience with the technology had been so far, an online survey was sent via email to all the Goteo backers (who had registered an address in Barcelona) one year after the launch of the project. 36 anonymous responses were received. 72% respondents were male and 28% were female. Almost 80% were aged 32-45, 8% were aged 26-31, and the rest (12%) were aged 46-59. Three months after this initial contact, ten of the most active users were sent a questionnaire with open-ended questions to gather more in-depth opinions about their experiences with Smart Citizen.

When asked about their interest about the Smart Citizen project, all users reported having an interest in technology: 53% considered themselves "technology savvy" (passionate about technologies with programming skills and experience hacking electronics); 28% stated they were "technology newbie" (just started to program and play with different tools); and 19% said they were curious about technology. They also stated having an interest in open data (20%); tools for developers (4%); open hardware (14%); smart cities (20%); Internet of Things (20%); and citizen science (12%). Only 9% indicated being interested in environmentalism (9%), and others (1%).

Furthermore, a number of participants explained that they had contributed to funding the project due to sympathy for the Smart Citizen leaders. For example:

> *"The truth is that I contributed to the crowdfunding campaign because Alex [one of the project leaders] is my friend and I wanted to help even if only symbolically" [P6].*

37% of those surveyed indicated that they knew at least one of the project instigators, and many might have not intended to actively participate by contributing data to the platform (cf. [Belleflamme et al., 2010; Mollick, 2014]). For example:

> *"I supported the project because I thought it was a cool idea coming from people I know. I like having the SCK but never had time to configure and use it" [P10]*

Users' feedback highlighted a number of issues hindering their sustained participation in the project. These are presented in terms of four key themes:

i. Technology set-up;
ii. Data reliability;
iii. Social interactions;
iv. Sense of purpose.

5.7.3.1 Technology set-up

Despite their strong interest in the technology and the fact that SCKs are publicised as being "plug & play", when asked if their sensors were active, 72% of the respondents declared having them offline. They also provided a number of reasons to explain this. For example, users highlighted having faced difficulties while trying to set up the devices and criticised the troubleshooting advice provided in the Smart Citizen platform:

> *"I haven't used the kit yet...and that is because I still don't have it online (...) because the process is too long (even if not difficult but still too many steps for the time I have available)" [P3].*

Another user stated:

> *"It's hard to set up the kit, it crashed many times and I haven't been able to get it to work again. That's why it's offline: I got tired of trying to configure it" [P12].*

Even for those who managed to complete the setup, the process was more complicated than expected or took more time than they had available for the task:

> *"Honestly, I have only started using the device recently (...) the fact that I had many issues during the installation and it took me a while to solve them didn't help." [P16]*

Members of the Barcelona community manifested a desire for SCKs to be more like plug & play devices than they actually were – and that required no extra work and little maintenance, as indicated by this participant:

> *"I have it [the sensor] online, on top of my desk. It is waiting for me to put it in an adequate box and set it outdoors (...) But this is not easy because I don't have time to take care of it, and it needs to be protected from the cold, the rain, etc." [P20]*

Other user suggested that Smart Citizen designers:

> *"...Manage to make sensors that can connect to any type of Wi-Fi and configure without intervention from the user. The configuration (...) through the Arduino software requires technical skills that many don't have." [P5]*

5.7.3.2 Data Reliability

Some people supported the Smart Citizen project because they believed that having access to tools to produce free and open environmental data was empowering:

> *"Sharing these data and having access to it in an open and free way is a totally different concept that didn't exist until now. Some public and private institutions who had access to this information used to distribute it in a limited and closed way" [P20].*

However, a perceived lack of quality of these data attenuated their engagement:

> *"I participated because I think that having access to information helps us take action regarding issues (....) [But] I've checked several times my sensor data compared to that in the surrounding area to see if there were patterns but it is complicated because of the lack of consistency of some of the metrics." [P14]*

One of the problems with the Smart Citizen Kit is that it requires users to calibrate the sensors in order to obtain reliable measures. However most of users did not do this – it could have been because they did not know how to, did not have the time or did not understand its importance. This meant that much of the data collected was not reliable and led to the users not trusting it. When users distrusted the data they tended to disengage with the project, for example:

> *"I think that we are storing a lot of data, but this data have a great inaccuracy. For the moment, I would not use the kit in projects that need some functionality". [P8]*

Furthermore, none of the users declared having used the data collected by SCKs for their own purposes because they felt like they were unreliable. This means that they paid little attention to the overall project:

> *"In the beginning, during the setup and configuration I experimented more with the device (…) but now that it is fully operational I just monitor the readings sometimes". [P21]*

5.7.3.3 Social interactions

When asked about how frequently they interacted with other members of the Smart Citizen Community through the project's website or outside of it, 85% of users answered that they hardly ever or never did it; 10% said they did it once a week; and the remanding did it once a month. However, many of them recognised the value in being in touch with members of the SCK community, especially to share and compare the data, to learn how to setup and maintain the devices, or to plan joint actions based on data collection.

One user [P21] indicated that he would like it if there had been "workshops in key cities to learn more about how to set up and maintain the device, see what others are doing with it…etc.". Another participant [P8] asked for "Higher interaction among users, developers such as meetings or 'webinars'". Along these lines, Participant 21 highlighted: *"I think that more interaction among participants would enrich and improve this project in all of its aspects"*.

Although they did refer to "the community" when talking about other SCKs users, some participants felt that more interactions were needed to promote bonding and collaboration. For example, P21 commented:

"The experience with the community that participates in the project is poor. The online platform helps us stay connected but it would be better if we had more contact, for example, as we did during the Google Hangout with Amsterdam (...) that would enrich the project."

5.7.3.4 Sense of purpose

Participants also raised issues with regards to the overall purpose of collecting and sharing data and even regretted there were no means to reward users who contributed. The lack of a clear goal or a set of incentives to keep the sensors up and running also resulted in disengagement. As P17 and P11 said:

"To incentivise users to keep their sensors uploading data Smart Citizen should enable more applications with practical uses and features (...) and find a way to reward those who contribute the most". [P17]

[The platform should] "reward users with tokens or points because we are producing open data which could be valuable to third parties as well". [P11]

5.7.3.5 Summary

The findings from the survey data, analysing the early adopter group in Barcelona highlighted a number of issues preventing sustained engagement with Smart Citizen. While the users backed the project because they were interested in exploring the technology, collecting open data and supporting the project instigators, their participation was minimal. This occurred because many of them were unable to setup their SCKs to begin with. They mentioned that they had received little help from the Smart Citizen team. Furthermore, those who did manage to set up their devices, subsequently did not trust the data collected and stopped using them. There was also a lack of social interactions among community members (both online and offline), which prevented them from helping each other with technical difficulties, discussing and making sense of the data, and even planning joint actions to further develop the project. They expected the Smart Citizen team to champion events to both improve social connectedness among users and to improve the device's robustness.

Next the findings from the Amsterdam community are presented, which had quite a different context regarding how the members were recruited, helped in setting up the devices and using them. The findings are strikingly different in terms of participation patterns and views about the perceived value of the technology in their community.

5.7.4 The Amsterdam Community

The Amsterdam deployment ran from March 2014 to June 2014. It was organised, paid for and championed by Waag Society (a cultural institution) in collaboration with Amsterdam Smart City, Amsterdam Economic Board and Smart Citizen. The aim of the deployment was to recruit 100 citizens to explore how they might collect environmental data using affordable sensors, with a particular focus on air quality. The Waag Society hosts a Fab Lab and has been collaborating on the development of projects within the Fab Lab Network. In 2013 the Amsterdam Economic Board and the Amsterdam Smart City project delegations visited the Fab Lab Barcelona and expressed their interest in running a participatory sensing intervention in Amsterdam using the Smart Citizen Kit. Although they knew the technology was not as robust as a consumer product, they were unaware of the challenges faced by local users to set up and use the kits.

For this study, the data gathering process comprised approximately 10 hours of observations and eight interviews with users and staff from Waag Society at three Smart Citizen events in Amsterdam. Additionally, the Waag facilitated access to project reports containing survey data and opinions from the stakeholders. Data from four blog posts published by Waag Society at different stages of the deployment were also analysed.

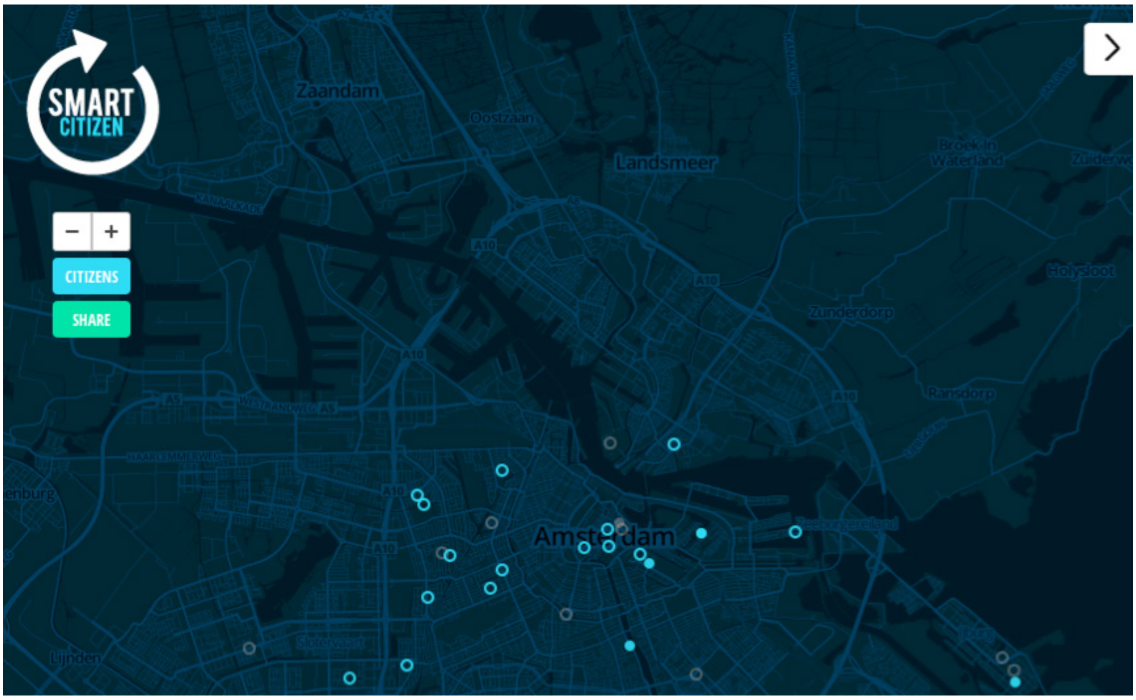


Figure 26. SCKs in the Amsterdam community.

5.7.4.1 Championing and orchestration

In Amsterdam the Waag Society championed the intervention. With extensive experience in community engagement with technology interventions, the Waag organised and coordinated a series of actions that are described in the next sections. These actions, which were facilitated by a group of experienced Waag community coordinators had a marked impact. In particular, they enabled many things to happen that did not in the Barcelona setting, including: (i) social interactions among members; (ii) discussion around data quality and sensing practices; and (iii) development of resources and skills in the community to help overcome technical challenges.

5.7.4.2 Participant recruitment

To engage community members, the Waag initially put out a call in a widely read local newspaper, asking people if they would like to receive a SCK to measure and learn about pollution in their environment, in particular air quality. To take part, volunteers had to commit to keeping their sensors online over a three-month period. They were also told that at the end of the intervention, they could purchase the SCKs for €50 or return them. This acted as an incentive – again absent in the Barcelona setting. One hundred applicants were selected based on the location where they lived (or would place the sensor) in order to ensure a geographically bounded community.

The stakeholders purchased 100 SCKs. However, 13 SCKs broke down, 6 people dropped out prematurely, and 8 never collected their sensors. Overall, 73 users received working SCKs, 30% were female and 70% were male, although many of them were representing a family or an institution. However, not all sensors provided data: 8% dropped out during the deployment and 29% never managed to provide data. Overall 46 sensors posted data sustainably.

5.7.4.3 Participant's motivations

Unlike the Barcelona community, participants in Amsterdam had fewer technical skills but a more focused interest in sensing the environment. Only 12% considered themselves "tech savvy", and among their motivations to take part in the project, they indicated interests such as air pollution (55%); the technology (20%); crowdsensing as a social experiment (18%); and others (7%). Apart from the Waag Society staff members, who personally knew the Smart Citizen developers, the participants who signed up for the trial did not know the project leaders but were motivated to participate in a participatory sensing initiative to reveal local environmental issues. It is important to note that over half of the participants had a specific environmental concern, namely air quality. This issue was a strong driver for participation, even stronger than their interest in the technology per se (20%).

5.7.4.4 Engagement

As shown in the quantitative assessment, and in particular in figures 24 & 26, the Amsterdam community was significantly more active that the Barcelona community, with an average of 50 activated sensors of which nearly three quarters reported at least at 50%, of the period from March to June 2014. Nevertheless, the qualitative evaluation of user experience demonstrated that, similar to Barcelona, users faced technology issues, lacked skills to proficiently use the SCKs, distrusted the collected data or struggled to make sense of it. However, the orchestration actions conducted by the Waag Society helped participants overcome these problems. Next, the participants' feedback is presented building on the same themes as in the Barcelona case study.

5.7.4.5 Technology and skills

The vast majority of the participants initially experienced technical issues; struggling with setting up the SCKs, especially those who were using Windows OS. They had to separately download and install the Arduino drivers, a task that was reportedly confusing for many of them. However, The Waag carried a set of actions and produced resources to help them overcome these difficulties. These were:

- adapting the technology to be more robust and suitable for the intervention by using industrial electrical boxes to protect the sensors from weather conditions, making them suitable for outdoors monitoring;
- helping the users to acquire technical skills by organising an 'install party' where community members received assistance and information on how to set up their sensors;
- producing a user manual in Dutch because all Smart Citizen documentation was in English and *"was difficult to understand by people with little technical skill"* [Waag Society community coordinator];
- enabling a process of peer-to-peer technical assistance by matching tech-savvy participants with those who faced technical difficulties. As explained by a community coordinator [Pa4]:

> *"We took note of the contact details of those who volunteered to help, and mediated: if someone needed help, first we matched them with a volunteer via email and if they still couldn't work things out we scheduled a visit between them".*

By April 2014, most users had their kits installed and were contributing data to the online platform. At the end of the deployment around 13 users purchased the SCKs and kept them online. The effect of having their sensors active for a period of time, led to some of the Amsterdam participants identifying more complex technology issues. For example, some noted the carbon monoxide and nitrogen dioxide sensors were not as suitable for measuring outdoor air quality as had been expected. In fact, compared to professional equipment, SCK carbon monoxide is very accurate. However, the nitrogen dioxide sensors have sometimes tended to retrieve inaccurate data. Others noted how the casing provided by the Waag Society to enclose the SCK in could have influenced the reliability of the measurements. The Wi-Fi module was also found to not always operate properly. As explained by participant Pa6:

> *"The air pollution sensor was the biggest problem because it only measures extremes (….) it measures high concentrations and that is not always present or interesting in cities."*

5.7.4.6 Data reliability

The participants also did not always trust the collected data. They highlighted that data provided by SCKs was "unreliable" both due to the characteristics of the sensors and their lack of knowledge about calibration and environmental monitoring. However, this only led to disengagement by a small number of users (8%). Instead, the Waag Society took actions when discovering this to help alleviate the situation:

> *"We decided to organise a lecture and invited an air quality specialist working for the government. He explained how they measure air quality, what data means and how different sensors work. After this meetup it became more apparent that SCKs were not a reliable technology" [Pa4].*

Having learnt about the complexities involved with sensing technologies and practices, the Amsterdam community thought of ways to overcome data reliability issues: "It's essential to measure under more controlled circumstances", and valued the possibility of collaborating with domain experts:

"Maybe we could cooperate with environmental organisations who have more experience with measuring" [Pa10].

5.7.4.7 Data meaningfulness

Figure 27. Air quality data displayed on the Smart Citizen online platform.

The Smart Citizen online platform displays real time streams of data accompanied by numeric figures (Figure 27). Furthermore, it is important to note that the air quality sensors retrieve data to the platform in KOhms values. This raw sensor data still requires to be converted to ppm for participants to make sense of. For the participants in the Amsterdam community, this form of representation seemed confusing and not able to support their sensemaking. Moreover, they struggled to make sense of the data due to the lack of features for "data comparison" and "annotation". One of the tech-savvy participants indicated that he was initially "charmed" with the looks of the Smart Citizen website but the lack of tools for annotating data was a burden:

"... when I needed to make notes next to measurements to make sense of them... I realised that I didn't find the site to be useful". [Pa5]

A member of The Waag also suggested that if the measurements provided by the sensors are not accurate then the platform *"should provide visualisations for users to at least observe changes in patterns" [Pa7].*

However, the findings showed that when people are able to make sense of the data it has the potential to produce actionable insights, for example, Pa6 noted:

> *"Sound measures are good. People in my neighbourhood rely on my sensor kit to monitor that. We could do visualisations of these data because finding silence is important for people and might define where they want to live".*

She also suggested that these data "could help citizens put pressure on the government to better control how bars and cafes impact the quality of life in certain areas".

5.7.4.8 Social interactions

Within a three-month period there were four occasions where community members met up: the initial "install party[60]", the Smart Citizen café[61] an air quality workshop with experts[62] and a final debriefing session. It was apparent from these meet ups that the social interactions among participants in the Amsterdam community fostered engagement, for example, Pa3 said:

> *"I am enthusiastic about the drive and expertise of other participants and I think that it is essential to create this dialogue between citizens and institutions."*

Waag also reflected on how they managed to help create a sense of community that fostered participation:

> *"This all led to discussions and we didn't positioned ourselves as if we knew everything but rather as 'we are in this together and we are also learning" [Pa4].*

60 https://waag.org/en/event/smart-citizen-kit-install-party

61 http://waag.org/en/event/smart-citizen-cafe

62 http://waag.org/en/blog/measuring-air-quality

Additionally, an improvised peer-to-peer technical assistance system was developed, which consisted of matching tech-savvy users with others facing technical issues, fostered social connectedness and commitment among the community. As an example, one of the tech-savvy users became a champion by not only providing technical assistance to others with fewer skills, but also organising a meetup (the 'Smart Citizen café') to further discuss technical aspects of the project and the collected data.

5.7.4.9 Sense of purpose

The experience of the Amsterdam community showed that a sense of meaningful participation can foster engagement when the community feels like their efforts contribute to a novel venture that produced learning and can have a positive impact: "*Despite the difficulties, the deployment was a positive experience*" [Pa4]. The community learnt about technology and environmental monitoring: *"We now know more about hardware, sensors, sensing and housing*...." [Pa3]. Secondly, they engaged in fruitful discussions about how citizens might harness the potential of technology to participate in civic life. In her own words:

> *"Official institutions now have more interest in working with citizens to measure data… [This deployment showed that] there are a lot of citizens who are concerned about the city and have motivation to participate in citizen science. But official institutions also notice that the data citizens are collecting is not correct…the technology is cheap and affordable but the data is not good. We need to continue working on this." [Pa6]*

Participants also suggested that other citizens be involved, for example,:

> *"We should give these sensors to art students so they can produce data visualisation projects." [Pa3]*

The level of engagement often led to participants feeling part of something novel and worthy. They valued the project and especially their local community of users. As one participant [Pa10] said:

> *"I am enthusiastic about the drive and expertise of other participants and I think that it is essential to create this dialogue between citizens and institutions"*.

5.8 Discussion

The results of the investigation presented in this chapter reveal key aspects underlying user experience and community engagement with the Smart Citizen.

Although most community sensing systems have tended to be presented as enablers of successful bottom-up movements due to the large number of people who contributed to them financially [Kera et al., 2013], the findings presented here showed that providing the technology, even when affordable and open source, was not enough to foster the emergence of self-organising and sustainable sensing communities. The findings are discussed in terms of ownership, social interactions, skills and training, and participatory orchestration.

5.8.1 Ownership

The study analysing the early cohort group in Barcelona highlighted a number of issues that prevented sustained and meaningful engagement with Smart Citizen. While these users crowdfunded the project their participation has been limited. This occurred because, on the one hand, a third knew the developers of Smart Citizen and wanted to support them and be part of a like-minded community of people but possibly didn't intend to actively use their devices (c.f. [Hui et al., 2014]).

The study revealed that funding and owning the technology does not necessarily translate into active participation, a fundamental issue that has been largely overlooked in previous reports that equate the success of a crowdfunding campaign with the active use of the participatory sensing technologies [Abe et al., 2014; Kera et al., 2013, AirQuality Egg, SafeCast]. Those in the Amsterdam community were loaned devices in exchange for participation and proved to be more engaged than those in Barcelona. They felt a sense of ownership over the intervention itself, as they shared goals and galvanised around a set of activities, felt responsible for the data they produced and could envision how it might translate into collective action (mapping noise levels in an area to revise legislation for bars and cafes, for example).

While crowdfunding may be a satisfactory way to attract users and enable the development of technologies for civic action, what makes participatory sensing work in practice comprises more aspects that simply owning the technology. Unlike other IoT technologies that have become very successful, such as the Nest smart thermostat[63], participatory sensing technologies are unlikely to become useful tools for civic action unless there is a community of users contributing data or galvanised around a shared purpose [Latour, 2004] (e.g. measuring air quality in Amsterdam). A sense of ownership seemed to be achieved by following participatory methods to involve people in the setup and implementation [Taylor et al., 2014; Hayes, 2011] of the sensing intervention, by collaboratively agreeing on the goals of the collaboration and galvanising around a shared matter of concern [Teli et al., 2015; LeDantec & DiSalvo, 2013].

5.8.2 Meaningful engagement

The experience in Barcelona demonstrated that participants struggled to engage with sensing in the absence of a shared goal or purpose. In contrast, the experience in Amsterdam highlighted that it is possible to foster meaningful engagement when there is a shared motivation and the community feels like their efforts contribute to a novel venture, produce learning and could lead to positive change. This is consistent with previous studies that highlight a growing motivation for citizens to engage in citizen sensing without necessarily being recruited by scientists to contribute to research projects [Bria et al., 2015; Jiang et al., 2016, Townsend & Chisholm, 2015] and that this bottom-up participation tends to emerge when citizens share a matter of concern and the purpose to effect collective action [Le

63 https://nest.com/

Dantec & DiSalvo, 2013]. Moreover, the findings presented here suggest that to support meaningful participation, participatory sensing platforms could help users make sense of the data better by providing features for data comparison and annotation. Local champions should catalyse community dialogues to produce actionable insights that can create a sense of empowerment in the community.

Additionally, designers of participatory sensing platforms and organisers of deployments could devise different roles for different skillsets. While most of the Smart Citizen users had an interest in technology, their skills varied widely. From the moment the crowdfunding campaign is launched and throughout the deployment, the instigators of participatory sensing platforms should provide opportunities for users to contribute their skills knowing that their participation matters and is valued by the rest of the users. Profiting from open source tools and providing users with an open-ended device means that the most advanced community members can collaborate with the project developers to extend or improve the system's features. Finally, participatory sensing initiatives should carefully consider how they reward users' contributions [Kawajiri et al., 2014]. As users become more aware of the value of data they expect to be rewarded for their efforts as data contributors. Designing features that can effectively quantify data provision and translate it to "points" or "tokens" that represent a form of value may support sustained engagement and a sense of meaningfulness.

5.8.3 Social interactions

The participants in Barcelona agreed that poor community building actions hindered engagement; the lack of social interactions among users (both online and offline) prevented them from helping each other with technical difficulties, discussing and making sense of the data, and even planning joint activities to further develop the project. They expected the Smart Citizen team to organise events to foster community connectedness and to improve the device's robustness. On the contrary, the participants in Amsterdam enjoyed a wide range of social interactions that strengthened community engagement.

They meet at workshops and meetups; they discussed issues and even helped each other to overcome technical challenges by meeting face to face.

While citizen science projects increasingly harness the potential of Internet technologies to crowdsource data with the help of distributed users who don't need to meet in face-to-face settings, such as in the case of virtual initiatives [Crowston & wiggins] like the SETI@Home[64] project, environmental monitoring and citizen sensing requires more situated approaches. In citizen sensing people measure phenomena and collect data to understand the causes of something that directly affects them. In this regard, data is situated and contextually bounded; it comes from somewhere, and it has purpose for the actors involved in *making data matter* [Taylor et al., 2015]. It is here suggested that fostering social interactions between community members can strengthen community engagement, support data sensemaking and knowledge and skills transfer.

5.8.4 Skills and training

About 70% of the Barcelona cohort did not set up their SCKs and would have liked more help in doing so (e.g. better troubleshooting advice and documentation). Participants in Amsterdam also faced difficulties while trying to set up their sensors and make sense of the data collected. This is consistent with previous research that demonstrate how citizen sensing campaigns can be hindered because people often lack the skills required to configure, use and maintain sensing technologies [DiSalvo et al., 2009], and struggle to make sense of the data collected [Willet et al., 2010].

Nevertheless, the experiences in Amsterdam demonstrate that the challenges associated with participants' lack of skills can be overcome with orchestrated actions led by community champions and participants. For example, technology designers and champions can embed skills in the community by providing troubleshooting advice and documentation, possibly in the form of video tutorials. They can also incentivise users to post

64 http://setiathome.ssl.berkeley.edu/

questions in the platform's forum and motivate others to provide answers. Furthermore, the experience with Smart Citizen has shown that processes of learning can take place within the community, when members with more technical skills help others to overcome issues. Enabling peer-to-peer assistance and group workshops can strengthen social interactions among participants and the overall sense of community, possibly fostering the sustainability of the participation. This type of orchestration resembles that proposed by Crabtree and Benford [Crabtree et al., 2004] where the community creates a conducive environment for cooperation among members, augmenting the shared resources of the community to collectively tackle difficulties.

5.8.5 Participatory orchestration

While many community projects are publicised as grassroots and self-organising [e.g. Kera et al., 2013], the studies presented here show how participatory orchestration matters. Projects that evolve around concrete championing provided by groups or institutions may have higher chances of achieving sustained participation, where a key part of this involves establishing the goals of the project.

The study around the Amsterdam community indicated that a more orchestrated deployment led by local champions could significantly foster community participation. Waag Society orchestrated the Smart Citizen pilot by engaging a group of users with diverse interests and skillsets, adapting the technology and providing skills, and facilitating social interactions and peer to peer assistance, that in turn fostered community engagement throughout the intervention. These actions helped the community overcome challenges associated with the technology and the lack of experience with participatory sensing, enabled discussion around data quality and sensing practices, and embedded resources and skills in the community. Their participation revealed issues with Smart Citizen, such as the quality and suitability of the sensors, the perceived unreliability of the data, and the lack of tools supporting data sensemaking.

Champions and orchestrators can foster social interactions by organising frequent meetups and workshops that will keep participants engaged. They may also identify different skillsets among users and enable processes by which each can perform roles that might enrich the community. They can also intervene in crisis situations by contacting experts and helping to channel discussions as well as enabling collaboration with stakeholders to assist with data validation. In addition, champions who are knowledgeable about local issues can help focus community efforts to make sense of the data collectively and make it actionable [Corburn, 2005]. If users cannot get their sensors to start producing data they will progressively disengage with the project. Additionally, once users manage to start gathering data they can disengage if they cannot make sense of it or trust it. However, while system developers typically focus their efforts on increasing the robustness of the technology, champions can follow participatory approaches to help manage users' expectations by properly communicating the weaknesses of these novel technologies and making them feel part of an on-going development process.

Participatory methods have been repeatedly recommended in the literature on community technologies as an approach to help manage expectations [Taylor et al., 2013, Crabtree et al., 2013]. Furthermore, the deployment highlighted the potential of orchestrated participatory sensing interventions to trigger processes of dialogue between citizens and official institutions, enabling the emergence of new social dynamics and networks than can potentially lead to change.

5.8.6 Summary

The study around the Amsterdam community indicated that an orchestrated deployment led by local champions was able to foster much community participation. By engaging a group of users with diverse interests and skillsets; where over half were concerned about a specific problem (air quality), adapting the technology and providing skills, and facilitating social interactions and peer to peer assistance, the Amsterdam community overcame a number of challenges associated with the technology and the lack of experience with sensing. That they were able to do so highlights the potential of novel sensing technologies to facilitate dialogue between citizens and official institutions - provided there is sufficient support to help out. Without this it is unlikely that the technology can be empowering – as was seen in Barcelona. Next, a follow up analysis is presented. It aims to identify the impacts achieved by Smart Citizen in the long-term and after the community engagement pilots.

5.9 Follow up analysis

The Barcelona and Amsterdam trials with the Smart Citizen technology demonstrated that it was far from straightforward for people to use the technology in order to take any kind of 'action' in their local community.

In particular, the findings showed how a number of developments needed to be put into place in order for communities to use sensor devices and to sustainably contribute data. These include training support, social interactions, and participatory orchestration.

Since the initial study in Barcelona and Amsterdam, a wide range of stakeholders have engaged with the Smart Citizen project and appropriated the devices, sometimes to meet purposes that had not been previously envisioned by the project instigators. To assess the sustainability of the Smart Citizen project and communities, and to monitor their impacts, a further qualitative study was conducted for two years. Methods to monitoring the impact of ICT in social change remain largely underexplored. In particular because the thing that aims to be measured defines the tools that ought to be used, this means that a one-size-fits-all approach would not be appropriate [Gray-Felder & Deane, 1999].

Towards this end, a lightweight approach to data collection was implemented. It consisted of developing a template based on the kinds of impacts achieved in CrowdMemo, and using a form of quick & dirty ethnography [Norman, 1998] to gather information by: regularly monitoring the media, attending events, and keeping in touch with the project instigators and communities to track for indicators of effectiveness of the technology, external appropriations, and awards and recognitions.

The data collected was then analysed using a deductive approach [Braun & Clarke, 2006], where the data is coded and clustered following a specific research question, in this case what type of impacts did Smart Citizen achieve?, and based on a pre-existing set of themes (those resulting from the CrowdMemo study). Five types of impact were identified:

- Urban participatory sensing
- Research and innovation
- Media coverage
- Creative appropriations
- Technology development

5.9.1 Impact 1: Urban participatory sensing

Apart from the initial interventions in Amsterdam and in Barcelona, other deployments have been reported organised in Manchester (UK), Lima (Peru), Montevideo (Uruguay), Santiago (Chile) and Pristina (Kosovo). These deployments typically involve acquiring or developing between 10 and 50 sensors and engaging citizens to collaboratively collect and share data about urban environmental factors. While the groups in Lima, Montevideo and Santiago learnt about Smart Citizen because they all host Fab Labs that are part of the larger Fab Lab Network, that includes the Fab Lab Barcelona, the communities in Manchester and Pristina followed different paths.

In Manchester, the Smart Citizen pilot[65] was led by Future Everything (FE), a Community Interest enterprise, and supported by Intel. It was launched in March 2014 to investigate how citizens can acquire, analyse, store, and use data collected using low cost and open source

65 http://futureeverything.org/news/futureeverything-bringing-smart-citizen-uk-intel/

environmental sensors. The Manchester deployment was influenced by the experience in Amsterdam. An open call was launched through the FutureEverything Festival and Fab Lab Barcelona websites to identify potential users. The selection criteria were based on the applicants' stated level of technical skills and topics of interests. The stakeholders agreed to deploy 15 sensors only in an initial phase with selected participants who were asked to keep the sensors online for a 6-month period. Three workshops were organised for users to learn how to set up and maintain the sensors and to discuss data sensemaking processes and activities.

FutureEverything had been working in grassroots environmental awareness projects since 2006 and found that Smart Citizen strongly aligned with their aims:

> *"In 2006 we started the programme Environment 2.0 that was interested in the potential of citizens and distributed platforms to help to sense the environment. But we did not have technology platforms to make it happen. We saw great potential in Smart Citizen to provide a platform and a community to involve people and organisations in making sense of their environment and building bottom up infrastructure. Although the technology was not completely ready yet, we saw it as a 'critical artefact' that supported our narrative that citizens should have a leading role in making cities smarter" [Director of FutureEverything].*

This idea of a critical artefact did not emerge from the first study but appears to be central to the uptake of Smart Citizen. The technology appears to be associated to a narrative of bottom-up empowerment that contests the top-down smart city vision. In this direction, it supports the goals of institutions and groups who organise and lead community engagement programmes. Nevertheless, users faced similar technical difficulties and lack of engagement as found in the Amsterdam and Barcelona case studies. For example, they struggled to set up and keep the sensors connected, their enthusiasm waned as less community events were organised. It was also unclear to them what the collected data could be used for or how to do it. The initiative lost traction two months after it launched and the project instigators decided to focus on a new intervention in schools.

The intervention in Prishtina (Kosovo) followed a different approach, in particular because it used assemblages of different sensors and it relied on a previously existing community that is heavily invested in measuring air quality, an issue that has been identified as problematic after the installation of power plants near a residential area. Smart Citizen Kits were used in the context of the first year of Science for Change Kosovo[66], a collaboration instigated by the local NGO PEN (Peer Educators Network), Unicef Innovations Lab Kosovo, the Czech NGO Transitions and the UK-based practitioners InternetArtizans. The aim of Science for Change Kosovo is to drive positive environmental and social change by empowering young people to make sense of their environment using accessible sensing technology and scientific methods. Moreover, their participatory approach combines capacity building and experiential environmental education for bottom-up citizen science research and advocacy. They aim to enable young citizens to understand, reflect, learn and take actions on environmental and air quality-related issues. 12 Smart Citizen Kits were deployed alongside diffusion tubes for nitrogen dioxide (NO2) and sulphur dioxide (SO2), to provide digital readings that could be calibrated against results from the laboratory. The participants included young people from the Roma community living nearby Kosovo's lignite power plants, just outside Prishtina. This area was identified in a report by the World Bank [World Bank, 2013] as one of the region's worst single sources of air pollution.

Despite some technical challenges (e.g. abnormal spikes in the readings) with the Smart Citizen Kits, the project was able to demonstrate that levels of NO2 at hotspots in Prishtina exceeded the EU safety limits. This appeared to be a time when the use of the Smart Citizen led to positive change regarding environmental awareness and policy. The results were presented by project participants at events that also included speakers from the Kosovo Environmental Protection Agency and the National Institute for Public Health. The project is still on going with frequent gatherings and meetings such as the Science for Change Festival, workshops aimed at volunteers aged 16 to 27, and activities at schools.

66 http://www.citizenscienceks.org/

In Chile, the Smart Citizen deployment emerged from a connection between Fab Labs. People involved with the Fab Lab Santiago, who is a member of the Fab Lab network, connected with the project leaders at Smart Citizen and expressed their will to plan a citizen sensing intervention in the city. The application has been successful and they received public funding to deploy 50 SCKs with the aim to "*build a laboratory in situ and an online platform, to generate and visualise environmental data in real time, involving in the process the respective authorities and most importantly the citizens*" [from their funding application]. Following recommendations from the Smart Citizen team, they plan to orchestrate the pilot by running workshops and meetups, liaise with policy makers at the city council and experts in environmental issues.

A similar approach was followed in Lima and Montevideo, where the local Fab Lab communities received guidance from the project instigators in Santiago and the Smart Citizen team to write their funding applications and structure the pilots. This suggests how important helping each other is to scale up and sustain engagement. All these interventions are planned to take place in 2016 and 2017. It is important to mention that, unlike the community in Kosovo, none of the interventions are focusing on a specific issue that has been identified as relevant by the communities. Their goal was to explore how citizens may use low cost sensors to contribute data about general environmental phenomena and engage in "multisectoral urban planning":

"*This unprecedented programme in the country will allow you to view multiple data on a single platform, providing key information to analyse patterns of urban behaviours...*" [from Santiago's funding application].

Additionally, groups engaged with Fab Labs in Copenhagen (Demark) and San José (Costa Rica) have been in touch with the Smart Citizen team as they plan to soon start deployments in their cities. Finally, in Australia, the mayor of Rockhampton Regional Council has purchased a number of SCKs to test how this technology could enable participatory processes in the region. She has had no previous connections with the Smart Citizen team or the Fab Lab Barcelona and little information regarding the project's aims and strategies has been disclosed.

5.9.2 Impact 2: Research and innovation

To date, 18 universities have been in touch with Smart Citizen as they conduct research using the platform. A list provided by the project leaders included the following institutions: University of Antwerp, Pontifical Bolivarian University (UPB), Pompeu Fabra University (UPF), Girona University (UG), Ramon Llull University (URL), Ionian University, Open Schoolgemeenschap Bijlmer, Slovak University of Technology (STU), Middle East Technical University (METU), University of Manchester, Liverpool John Moore's University (JMU), University College London (UCL), University of Glasgow, Architectural Association, Century College, Massachusetts Institute of Technology (MIT), Kent State University, and California State University Long Beach (CSULB).

At least 13 published papers (see below) that report on research using Smart Citizen have been published. An analysis of these articles demonstrates that the Smart Citizen platform and the sensing devices have been used by researchers to investigate a variety of topics. These were categorised according to the following 4 themes: *(i) Bottom-up citizen engagement in smart cities, (ii) Technical development in the Internet of Things, (iii) Data sensemaking and (iv) European research and innovation projects*.

Citizen engagement in smart cities

Three papers have used Smart Citizen as a case study to understand how new low-cost and distributed sensing technologies can foster citizen engagement with urban issues. Nijman [2014] and Jiang et al [2015] have evaluated the deployments in Amsterdam, organised by the Waag Society. Their findings support those presented in this chapter. For example, Nijman found that citizens using the Smart Citizen Kit faced several technical challenges in trying to set up and use the sensors but that the openness of the technology meant that they could appropriate it to meet their goals and to help each other:

> *"The open hardware/open software approach of the FabLab Smart Citizen Team allowed the project team and citizens to adapt the kit" and "Citizens appropriated roles as tester of and tinkerer with the kit, and as helper acting as helpdesk for other citizens" [2014:34].*

Jiang et al [2015] discussed the limitations of SCKs to measure air quality and proposed avenues to overcome them. In particular, the authors highlight the need to enable cooperation and collaboration among participants to foster community building in lab environments such as maker spaces and fab labs, as well as enabling different types of support provided by experts.

Two other papers explored different case studies of urban participatory sensing. Costa el al. [2015] used Smart Citizen in the context of a study aimed to explore the use of metropolitan buses equipped with sensors as "urban data collectors". This approach can reportedly help to overcome the challenges of traditional top-down urban sensing approaches such as power supply, maintenance and operation, among others. Ekstrand & Åsberg [2015] installed SCKs at an office building to collect data on indoors air quality. These data were then represented in a website and aimed to empower office workers to make better choices when booking meeting rooms at the office premises. They found that more work needs to be done in terms of representing the collected data to support sensemaking and choice.

Technical development in the Internet of Things

Other projects have used Smart Citizen to advance and investigate technical developments in the field of the Internet of Things and urban sensing. For example, The Array of Things (AoT[67]), a network of open source modular sensor boxes that will be installed around Chicago to collect real-time data on the city's environment and activity, is testing the viability of integrating Smart Citizen Kits within the modules. 250 AoT nodes will be mounted on streetlight traffic signal poles and lampposts around the city by 2017. The raw data will be posted to the City of Chicago's open data network and Plenario, a web-based portal that supports open data search, exploration, and downloading. Three studies have specifically investigated how to advance and improve the Smart Citizen infrastructure. Anguera [2015] has worked on the design and implementation of a system that aims to support the calibration of SCK, while Barco & Peiró [2015] have developed new firmware for SCK. Casas [2015] and Heras Gómez [2015] have designed and implemented systems to support SCK data management. Finally, Carbajales et al. [2015] have used SCKs to develop a platform that allows users who deploy sensors at home to have better control of who accesses their

67 https://arrayofthings.github.io/

data once they have been uploaded to the cloud. The authors argue that while sensors in public spaces are already widely used, users are reluctant to deploy sensors for shared data at their homes. Their system could help users overcome trust concerns by giving them more control over their shared data.

Data sensemaking

Research using Smart Citizen has also explored new graphical and tangible interfaces to support data use and sensemaking. For example, Sánchez [2015] has studied Smart Citizen as part of the Smart CEIM platform, an open experimentation platform for Smart City services located in the Moncloa Campus of the Universidad Politécnica de Madrid. It aims to facilitate research and development activities done by the university, companies, and public bodies. The author developed a web application based on HTML5 that allows real-time graphical display of the status of the various services and networks of sensors.

The Physikit project, Houben et al. [2016] comprises a set of four tangible actuation modules (the light, vibe, move, and air cubes) and a user-friendly drag-and-drop web interface that allows these components to be linked to Smart Citizen data. Once linked to the sensor data, the cubes can show how sensor readings, for example air quality, temperature, and noise levels within the household, change over time. Moreover, the user can configure alerts to indicate when a sensor reading crosses a chosen threshold. Valdivia [2015] also developed a noise data visualisation and identification web tool that harnesses existing noise data sets (including Smart Citizen data) and can be used by city planners to identify the areas that have the highest levels of noise pollution, and by normal users to find quiet zones within the city.

European research and innovation projects

The following table Table 2) presents key information about the five European research projects that were and are currently being conducted in collaboration with Smart Citizen. These projects investigate citizen engagement in smart cities, participatory sensing and open data.

Name & date	URL	Budget	Partners	Aim
iCity project 2012-01 to 2015-09	http://www.icityproject.eu/	€5.2m	Cities of Barcelona, Genoa, Bologna, and London	Develop and deploy an approach to allow interested third parties to create, deploy, operate and exploit services based in the use of available public information, digital assets and Open data.
OrganiCity 2015-01 to 2018-06	http://organicity.eu/	€7.2m	Aarhus, London, and Santander + 15 partners such as Intel, Imperial College, Future Cities catapult and IAAC	Develop and offer a multidisciplinary research facility that citizens can engage with to create data intensive services, research, initiatives, etc., for Smart Cities
Making Sense 2015-11 to 2017-10	http://making-sense.eu/	€1.3m	Waag Society, IAAC, Dundee, JCR, and PEN	Seeks to empower citizens through personal digital manufacturing applied to the design and deployment of environmental sensors
iScape 2016-09 to 2019-08	http://cordis.europa.eu/project/rcn/202639_en.html	€5.8m	13 partners led by Trinity College, Ireland	Aims to integrate and advance the control of air quality and carbon emissions in European cities in the context of climate change through the development of sustainable and passive air pollution remediation strategies, policy interventions and behavioural change initiatives.
Grow 2016-11 to 2019-10	http://cordis.europa.eu/project/rcn/203271_en.html	€5.7m	19 partners, led by University of Dundee	aims to create a sustainable citizen platform and community to generate, share and utilise information on land, soil and water resource at a resolution hitherto not previously considered.

Table 2. European research and innovation projects using Smart Citizen.

5.9.3 Impact 3: Media coverage

The third theme refers to the way media picked up on the Smart Citizen projects since its inception. The coverage has grown exponentially from a few small reports at the start to multiple reports worldwide. This includes reports on the technology, the crowdfunding campaigns and its leaders, which have been published in well-known media outlets such as Wired, TechCrunch, Guardian, El Pais, among others. It has also been featured in television (the Spanish RTVe and the Dutch public TV, for example). Also, an independent full-length documentary has produced to report on how citizens engaged with Smart Citizen[68].

In all these media reports Smart Citizen is presented as an enabler of bottom up citizen empowerment in cities and an alternative to the top down approach to the smart city. For example, an article in The Guardian describes it as *"an initiative that empowers citizens to improve urban life through capturing and analysing real-time environmental data.*[69] " This media coverage would appear to have contributed to more communities appropriating the technology all over the world. This is remarkable considering its small scale beginnings. Moreover, it has consolidated and validated the Smart Citizen narrative as being an instrumental technology in the empowerment of grassroots communities.

5.9.4 Impact 4: Creative appropriations

The 4th theme is the creative appropriation of the SC device. By this is meant when external stakeholders have used the technology for purposed not envisioned by the developers. It was found that 4 projects appropriated Smart Citizen.

68 https://vimeo.com/91615297

69 https://www.theguardian.com/media-network/media-network-blog/2014/feb/28/ten-digital-social-innovators-online

Firstly, in Amsterdam, the Waag society launched the Smart Citizens Lab Amsterdam[70], a series of meetups, workshops and interventions where citizens engage with community champions to use SCKs combined with other tools and applications to map the environment. Along with citizens, scientists, and designers, they focus on themes ranging from air quality to the conditions of bathing water to noise pollution. The openness of the approach was key in their decision to use Smart Citizen and to believe that the project provided powerful tools for citizen engagement. As explain by one of the project instigators:

> *"The reason we started to work with SC again is that it's an integrated platform, providing a lot of sensors that together make a powerful tool for citizen sensing, provided that they take into consideration the limitations of the these sensors; an interesting visualization tool, being the website; a relatively easy way to collect the data. Furthermore, it is open source, which allows both the sensor kit & the platform to be extended and forked; which is in line with our mission [...] The opportunities for extending & tweaking the kit, and using API's to approach the platform, is key."*

As part of this lab, in 2015 a group of citizens used SCK data to produce a noise visualisation tool (Figure 28). The web tool[71] (Amsterdam Noise map) aimed to provide awareness with regards to sound levels in Amsterdam by representing data in an engaging and understandable way.

70 https://waag.org/en/lab/amsterdam-smart-citizens-lab

71 https://waag.org/en/news/measuring-noise-amsterdam.

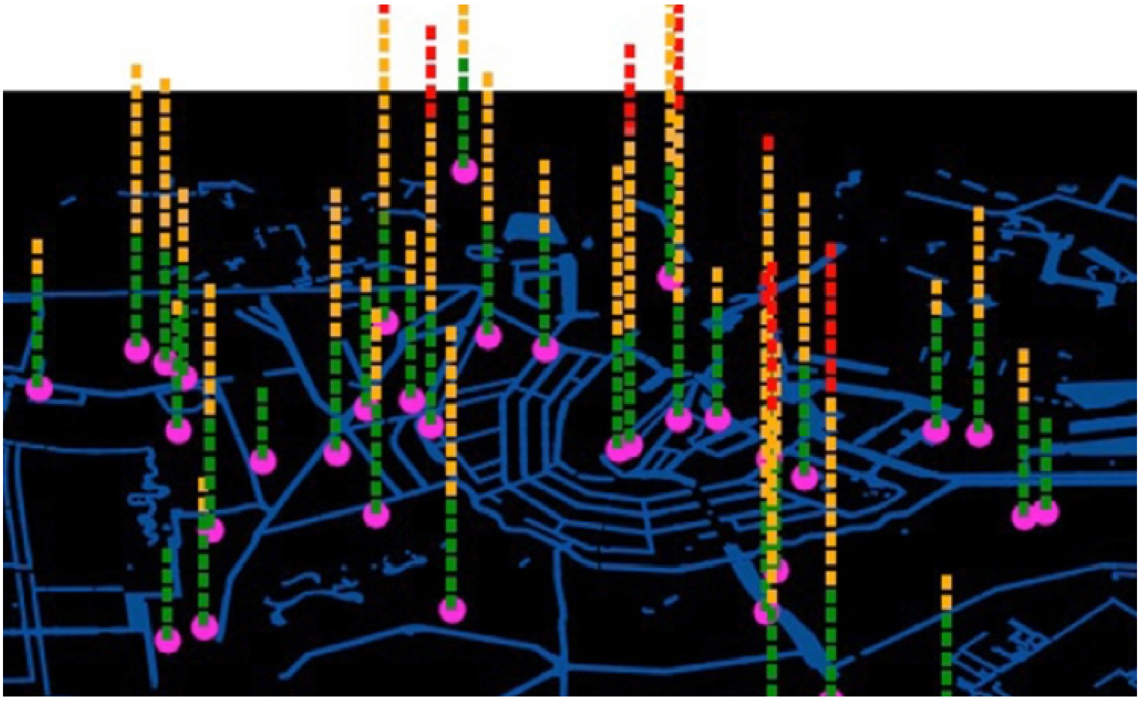


Figure 28. A data visualisation project using noise pollution data from SCKs.

Secondly, a similar approach was followed in the project Dynamic Noise and Pollution Campus Map[72] Project, produced by a student at the University of Glasgow. The aim of the project was to produce an awareness tool for students and staff at the university to learn about the air quality and noise levels at the campus for them to know where the most appropriate places to walk and study are. To collect and map the data, the system uses a SCK as a portable device paired with a mobile device's GPS sensor, and a mobile web application.

Thirdly, a number of data driven installations have used Smart Citizen. For example, the creative project FABMOB: 3d printing atmosphere used SCKs to produce tangible 3D printed representations of environmental data. The system comprises a SCK attached to an Ultimaker 3D printer that can print the sensor data in the form of small tiles called ATMOStags. The device[73] was produced in the context of an international contest for functional prototypes related to digital manufacturing and the Internet of Things. At a larger

72 UGmap.me

73 http://3dprintingindustry.com/2014/03/03/fabmob-3d-prints-atmosphere/

scale, another project called Balls[74]! used SCK data to guide the movement of an array of 42 suspended glowing spheres that were individually controlled by a software programme that can convert data into movement, colour and form. The installation was deployed at the atrium of the office building of the consultancy firm Arup in London. The deployment lasted for a month, where the balls responded to different factors such as sound levels within the building. The technology company Cisco used 25 SCKs to run a large-scale data visualisation installation that was featured at the international event IoT World Forum, in 2013 in Barcelona.

Fourthly, as part of the Open Source Beehives[75] project, SCKs have been used to monitor bee colonies in cities. This initiative was crowdfunded via Kickstarter and is promoted by a group of makers and social entrepreneurs that aim to use sensors and open source tools to discover why bee populations are declining throughout the world. The OSBH sensor is designed to monitor honeybee-health indicating factors inside a beehive, and share the collected data on the Internet using the Smart Citizen platform. An initial prototype is currently being tested at the Green Fab Lab in Barcelona.

5.9.5 Impact 5: Technology development

During 2015 and 2016, and following the results of the studies presented in this chapter, the Smart Citizen technology evolved, making both the sensors and the data platform more robust and easier to use. On the one hand, a new version of the sensor kit (SCK 1.5) has been launched, which includes a more powerful board and a new plugin compatible with Alphasense CO and NO2 sensors (and with other 1200 existing sensors), which are more reliable and sold pre-calibrated. On the other hand, the new data platform is faster and more robust. It provides an extended and more detailed API, which allows for better control of the features available in the platform. Three more features have been developed:

74 http://www.bartlett.ucl.ac.uk/architecture/events/balls

75 http://opensourcebeehives.net/

- **Data comparison**. A new feature supports data comparison between pairs of sensors. This is very useful if participants want to compare measurements coming from sensors deployed in different locations or to check for deviations in specific sensors.
- **Data sensemaking**. A new data conversion feature supports air quality data sense making. It retrieve values in parts per million,- ppm (CO) and ppb (NO2).
- **Tags**. A new feature enables the creation of tags, which creates opportunities to group sensors enabling easier exploration, identification and comparison. For example, #AirQualityAmsterdam

5.9.6 Summary

This section presented a number of other projects that have demonstrated how Smart Citizen has been taken up and used in a variety of ways - not always for urban participatory sensing. The technology has proved useful to researchers pursuing developments in the nascent field of the Internet of Things, has been used to prototype and deploy new visualisation interfaces from web apps to tangible modules, and it has been appropriated by designers (Balls!) and activists (OSBH). In many cases, these appropriations have been possible because SCKs are cheap compared to more professional sensors but still provide relatively reliable data. Moreover, the fact that the technology is open source and uses the broadly known Arduino infrastructure has supported its appropriation by advanced users who have software and hardware skills. Finally, the technology has evolved to become more robust and easier to use. Five European funded projects use Smart Citizen as a tool for civic engagement and open data for cities.

5.10 Discussion

The follow up analysis of how Smart Citizen has since been taken up demonstrated that although sustained community engagement with the technology has been challenging, the project itself has achieved impact in various areas, from fostering academic research on the Internet of Things to becoming instrumental to the design of creative installations.

It has enabled a diverse group of users to explore how the technology can be appropriated in a variety of ways, including for civic action. The findings are discussed around the emergent themes openness and narratives.

5.10.1 Openness

The lack of reliability of the Smart Citizen Kit and the challenges encountered by communities trying to measure environmental phenomena with it did not prevent the project from growing. During the time studied, it received large amounts of funding and media coverage, and organisations have started their own pilot interventions using the Smart Citizen technology. Moreover, different stakeholders appropriated the SCKs for their own purposes. This entailed using the sensors to power creative installations, produce novel interventions and catalyse research endeavours, such as the Arup Balls, the Open Source Beehives or the Physikits. This approach to advancing civic tech through the use of open source technologies has been investigated by Teli et al. [2015] who suggested that it increased participation and innovation in the co-creation of solutions to urban challenges.

The experience of Smart Citizen also demonstrates that an open source project can scale up by leveraging existing networks. For example, many of the appropriations reported here occurred because stakeholders were connected to the Fab Lab network, which facilitated the sharing of know how and advice between actors. This investigation demonstrates that leveraging existing networks and following an open approach can catalyse the scalability of civic technologies. Nevertheless, there are still no indicators of communities that have effectively been able to tackle environmental concerns or effect civic change using this technology. Until now, it seems like the project has instead fostered an ecosystem of technological innovation.

5.10.2 Narrative

There is a common pattern across the projects associated with Smart Citizen: most of the organisations that pursued citizen sensing interventions in research and innovation projects strongly advocated a narrative of bottom-up participation in smart cities. For example, as the director of FutureEverything said:

> *"We saw great potential in Smart Citizen to provide a platform and a community to involve people and organisations in making sense of their environment and building bottom up infrastructure (...) we saw it as a 'critical artifact' that supported our narrative that citizens should have a leading role in making cities smarter"*.

As a "critical artefact", Smart Citizen supports a narrative that is associated with values such as openness, bottom-up and empowerment. It emerged at the right time, when organisations at the grassroots level were galvanising to contest the dominant top-down and corporation driven narrative of the smart city. The low-cost and open source Smart Citizen Kits contest the discourse of the big tech companies, they can empower citizens to play a leading role in the smart city.

Narratives and visions are known to be powerful drivers for engagement, galvanising people around a shared vision that evokes joy and empowerment [Ruddick, 2010]. Narratives have been used as a means to compel individuals to think and behave in ways that will contribute to the collective good and to motivate individuals in challenging situations (i.e. [Redman, 2005]). While this phenomenon has been largely studied in the social sciences, it remains underexplored in computer science.

5.11 Conclusions

This chapter presented a long-term evaluation of user experience, community engagement with, and impact of Smart Citizen, a crowdfunded sensing platform that aims to empower citizens to take a more active role in improving their cities by contributing data on environmental phenomena.

By comparing two communities, which engaged with the project following different strategies (crowdfunding versus orchestrated deployment), it was observed that while crowdfunding might be an effective way to fund these tools and attract users, participatory orchestration provided by local champions is key to encourage participation. The studies show how community participation in sensing projects could be supported by enabling orchestration provided by local champions, embedding external skills and fostering internal learning, and enabling meaningful participation by supporting data sensemaking. Finally, the impact assessment showed how the openness of the technology and the fact that, as a "critical artefact" it is associated to a narrative of bottom-up civic empowerment, has contributed to its sustainability by fostering external appropriation (particularly promoted by organisations who are keen to develop an agenda of community participation) and collaborations that attracted funding.

The study on Smart Citizen expands themes previously investigated in CrowdMemo, and reveals new insights. Following, these themes are discussed in relation to the research questions:

In terms of answering research question one (*What are the factors underlying meaningful community engagement through civic technology interventions?*) it was found that, again, **novelty** was a driver for engagement. However, while in CrowdMemo the novelty came about from how off-the-shelf technologies were combined and used, in Smart Citizen what is novel is the technology per se. This novelty attracted people who were willing to contribute via crowdfunding platforms to the development of the project. However, unfamiliarity with the sensors [DiSalvo et al., 2009] and the data platform meant that people lacked the skills to appropriate them, which in turn ended up hindering engagement. Moreover, the participants experienced difficulties around data reliability and sensemaking that hindered engagement with the technology.

With regards to **ownership**, it was found that crowdfunding doesn't necessarily translate into active participation since those who had purchased and owned a sensor kit were not more engaged that those who were lent devices as part of the orchestrated crowdsensing experience. Again, it was found that a sense of **meaningfulness** could come about from supporting the development of technical **skills** for people to be able to operate the technology and to make sense of the data, a factor that was present in the Amsterdam community but absent in the Barcelona cohort.

Finally, the fact that Smart Citizen was associated with a **narrative** that advocates bottom-up civic empowerment also had a positive impact on engagement, supporting external appropriation, and increasing the scalability of the project. Unlike CrowdMemo where the community galvanised around a **matter of concern** (heritage preservation), in the Smart Citizen communities the purpose of the interventions was ill defined. In Barcelona half of the participants were interested in the technology but not so much in specific matters that could be tackled through it. This translated to a sense of lack of **purpose** that hindered the formation of a public. In Amsterdam, 55% of the participants were concerned about air quality, which on the one hand supported the formation of the community but, on the other hand, increased tensions when the technology didn't respond as expected to address the problem.

In terms of question two *(What are the factors that contribute to the sustainability of a community, its practices and the resulting technologies?)* it was found that novel sensor technologies, if left to their own devices, are unlikely to be taken up by individuals and be transformed into successful community tools. Human agency and how it is played out over time at a civic level is central to their uptake and route to empowerment. **Participatory orchestration** appeared central to the success of the SmartCitizen community efforts, by supporting a number of processes that infrastructured the community [LeDantec & DiSalvo, 2013]: embedding external **skills** and fostering internal **learning**, and enabling **meaningful participation** by supporting data sensemaking and reward mechanisms. Moreover, the findings supported that social interactions, among community participants and with external experts and networks, are crucial to sustaining community engagement, leading to the formation of ties and bonds, and capacities that increase the **community capital.**

In terms of question three (*What kind of societal impacts can bottom-up civic technology interventions have and how should they be assessed?),* it was found that Smart Citizen was taken up and used in a variety of ways, even beyond participatory sensing. The technology has proved useful to researchers investigating the Internet of Things and civic engagement, and it has been appropriated by designers and social entrepreneurs to develop their own systems.

Finally, the technology has evolved to become more robust and easier to use. Five European funded projects use Smart Citizen as a tool for civic engagement and open data for cities. There are two main reasons why Smart Citizen contributed to these impacts. Firstly, like other *digital commons,* the technology is affordable and open source, which fosters its *opportunistic appropriation* and use for a variety of purposes. In fact, Smart Citizen builds on the Arduino infrastructure, which is broadly known by advanced users who have software and hardware skills. Secondly, the project is inserted in the framework of a larger narrative, which relates citizen empowerment to attributes of open access, commons and collaboration. In the context of new emergent paradigms that contest the top-down vision of the smart city, groups and communities who advocate for approaches that assure a leading role for citizens in the smartening of their cities (e.g. sharing city, co-city, Fab City) seem to find in Smart Citizen a promising vehicle.

In sum, this chapter has shown how the role of participatory orchestration in civic tech interventions is crucial to foster and sustain community engagement. It has also shed some light to the relative impact of notions of openness and narratives in creating engagement opportunities. But how can orchestrators be supported to plan, organise and deploy participatory sensing campaigns at the grassroots level? How can galvanising narratives and notions of openness be purposely leveraged to foster engagement and impact? One well-known approach is to provide guidance in the form of a framework that researchers can adopt. What would it take to develop a framework that community members could use? What form would it take to be accessible and usable by different parties?

Clearly, most will not have the time or inclination to read an academic paper, and as we have seen, groups of citizens at Fab Labs, cultural organisations and crowdfunding platforms are galvanising to take civic action without much contact with academia. The challenge is to develop a communication vehicle that is intuitive, shareable and serves the purpose of coordinating multiple activities among different stakeholders. The next chapter explores how the themes resulting from the CrowdMemo and Smart Citizen investigations could inform strategies to help community orchestrators design, orchestrate and deploy participatory civic tech interventions from the bottom-up to achieve sustainability and impact.

5.12 Summary

This chapter presented a long-term evaluation of user experience, community engagement with and impact of Smart Citizen, a participatory sensing technology.

The results demonstrate that difficulties around data reliability and sensemaking, lack of technical skills and incentives can hinder sustained engagement with this kind of civic intervention. It was found that while crowdfunding might be an effective way to fund these tools and attract users, it is not enough to ensure participation. The discussion focuses on how the deployment of this kind of civic technology needs a level of participatory orchestration if it is to foster and sustain successful community engagement. It has also showed the impacts that Smart Citizen has achieved, such as fostering research and innovation, the development of novel appropriations and the organisation of new participatory sensing interventions in different cities. These impacts are partly due to the openness of the approach and the technology, and its association with a narrative that advocates civic empowerment from the bottom up.

6 A City Commons Approach to Citizen Sensing

6.1 Introduction

The CrowdMemo study presented in chapter 4 highlighted how starting from a matter of concern, creating a sense of ownership by following participatory approaches and using off-the-shelf technologies can lead to community engagement with civic technology.

The Smart Citizen study in chapter 5 demonstrated the importance of the orchestrated championing provided by the Waag Society in facilitating community engagement, helping individuals to form bonds and overcome challenges associated to the lack of technical skills and data reliability.

However, the Waag society's staff is highly experienced in the practicalities involved in building and sustaining communities, and have planned and implemented numerous citizen engagement programmes. How other groups might plan the orchestration of civic tech interventions to increase the likelihood that they will sustain in hands of communities and deliver positive impact is unclear. A challenge seems to be how to transfer learning and expertise into a model that can aid the process of planning, designing and deploying interventions. One of the problems with existing approaches is that they can be piecemeal and rely too heavily on researcher-led projects (i.e. [D'Hondt et al., 2014; Reddy et al., 2010]).

This often constraints the sustainability and societal impact of the interventions, which may depend on research funds and agendas making it difficult for communities to sustain and appropriate the resulting tools and practices [Taylor et al., 2014].

Figure 29. A leaflet describing The Bristol Approach to Citizen Sensing.

This chapter presents an Action Research project where a strategic framework was designed and applied in collaboration with stakeholders in Bristol (UK). The City Commons framework was developed to help communities, researchers, and/or city councils plan and run innovative interventions to tackle local issues. While the framework aims to be generally applicable to civic technology interventions, following on from the Smart Citizen study the focus is on how citizen sensing can be appropriated at the grassroots level and for the common good. In particular, it is on how citizens can participate both in the creation of citizen sensing interventions and the collection, sharing and use of data to tackle issues of their own concern, including noise pollution, housing conditions, the decay of wildlife in urban parks or social isolation. The question this raises is whether it is possible for communities to co-produce solutions to the challenges that they face, develop technology skills and data literacy to take a leading role in imagining and designing their localities.

The framework was developed in two phases. The first involved synthesising the findings from the CrowdMemo and Smart Citizen studies into a new approach to citizen sensing. This entails, starting with matters of concern, supporting the development of technical skills and data literacy in communities, developing a sense of valued ownership, and conveying a galvanising a narrative based on openness and collaboration. A second phase followed an Action Research approach in collaboration with stakeholders [Hayes, 2011], a not for profit charity and company named Knowle West Media Centre (KWMC[76]) and Bristol City Council. During this phase the findings were organised into a strategic model for the design and implementation of community-centred civic tech, ensuring that they made sense and were useful to community orchestrators.

This chapter also describes the application of the City Commons framework in a project called *Dampbusters*, where sensing technologies were co-designed and used to address the problem of damp homes in two neighbourhoods in Bristol (Figure 29).

The contribution of this chapter is twofold. On the one hand it presents the framework, its underling rationale and how it was developed. On the other hand, it describes how the framework was implemented with communities facing a real challenge. This application allows for a more nuanced understanding of how each phase of the framework can be enacted and reveals learnings and tensions that are relevant to the planning and delivery of complex socio-technical participatory interventions.

76 http://kwmc.org.uk/

6.2 Motivation

Citizen sensing is viewed as an important technological enabler for smart cities.

While most citizen science projects continue to strongly focus on the validity of the collected data, in citizen sensing the measurement itself can be considered a political act [Pine & Liboiron, 2015]. In citizen sensing people measure phenomena, and collect data to understand the causes of something that affects them. In this regard, data is situated and contextually bounded [Ribes & Jackson, 2013]; it comes from somewhere, and it has purpose for the actors involved in capturing and making sense of "data-in-place" [Taylor et al., 2015: 2863].

However, there are challenges associated with the scalability and sustainability of citizen sensing. Like in the Smart Citizen study, research has shown that citizen sensing campaigns can be hindered because people often lack the skills required to configure, use and maintain sensing technologies [DiSalvo et al., 2009], and struggle to make sense of the data collected [Willet et al., 2010]. Promoting the sustainability of bottom-up citizen sensing interventions goes beyond the design of technologies and the organisation of deployment pilots. There is a need to have an approach that galvanises people around a shared purpose, fosters capacity building [Krishnaswamy, 2004] and the development of technical skills [Merkel et al., 2004]; as well as a sense of ownership [Taylor et al., 2014; Crabtree et al., 2013]. Additionally, community championing and participatory orchestration are fundamental to sustain engagement in such interventions.

A number of frameworks have been proposed to help steer and design participatory sensing applications. But most of this research has focused on the technical aspects of the systems (e.g. [Agarwal et al., 2013; Cornelius et al., 2008; D'Hondt et al., 2014; Reddy et al., 2010]) rather than on delivering frameworks that address the orchestrational and strategic aspects involved in planning and deploying citizen sensing interventions, and embedding their associated practices and outcomes into the wider socio-economical context of localities.

An alternative approach is to decentralise the control over the intervention and the resulting data and technologies. On the one hand, researchers can contribute know-how and advice to communities [Johnson et al., 2016] by handing over toolkits and methods that they can readily adopt [Rogers & Marsden, 2013]. On the other hand, data and technologies can be made open to use and reappropriate by diverse stakeholders [Lessig, 1999; Benkler, 2006]. As Cuff et al. point out a centralised model in which the data is processed and controlled by the scientists, who plan the deployments, cannot scale well to the city [Cuff, 2008]. The bottom-up approach presented here aims to create an accessible and actionable framework to support communities in designing and building their own tools while helping them produce and manage their resources in terms of a commons (cf. [Ostrom, 2015]).

6.3 Research context

Bristol is a city of approximately 428,000 citizens located in South West England. The city has been named by the first UK's Smart Cities Index as the leading smart city outside London and a leader in the UK for digital innovation[77].

Some of the council leaders recognise that a key objective of their city planning needs to address exclusion and social injustice alongside efficiency priorities; two notions that are considered to be central to the vision of the city as commons (cf. [Iaione & Foster, 2016; Sassen, 2001; Lefebvre, 1996]). To this end, they have supported the work of local

77 http://www.bristol.ac.uk/news/2016/may/bristol-smart-city.html

community organisations notably Knowle West Media Centre to deliver digital inclusion and future city projects that focus on citizen engagement.

KWMC is based in Knowle West, a community that experiences challenges such as low education attainment, poor heath, under employment, and fuel poverty. Since 1996 KWMC has been working with residents, local organisations and young people to develop new and creative models for achieving positive social change. A distinctive factor that differentiates KWMC's approach to those followed by other community organisations is their focus on media arts, creativity and activism in the pursue of socially engaged practice and empowerment.

In early 2015 KWMC contacted the researcher to collaborate on the design and delivery of a citizen-sensing programme, which should be inclusive and sustainable (survive beyond a pilot intervention). The motivation behind delivering this programme stemmed from their understanding that citizen sensing is a socio-technical enabler for smart cities. In this sense, citizen sensing puts people at the centre of data collection, and can create a conducive environment where people make sense of IoT, sensors and data, and discuss pressing issues around data ownership, access and use.

KWMC has developed their ideas around the smart city in collaboration with Bristol Futures, a department at the city council. They were concerned that many programmes emphasise technology development rather than focusing on citizen needs, and don't necessarily address the real situated challenges of local communities. They aspired to deliver a citizen centred programme that if successful would be replicable and scalable. They recognised that, to achieve these goals, any programme they devised needed to be understandable and allow for learning to develop and be shared, including the questions that they asked of smart city leaders and technology designers: who owns the data? What should be openly shared and what protected? How do you ensure citizens can fully be part of the design of their city and contribute to decision-making?

Moreover, they wanted to conceive a programme that would grow, develop and be driven by communities. As described by the director of KWMC:

> *"We live in times of frightening austerity e.g. Bristol City Council must make savings of around £44m by April 2017, and another £60m for the years 2017 – 2020. Services are going to be cut and the most vulnerable in our society will be at risk. We have to build sustainability and inclusion into our work or the gap between those doing well and those not will grow". [CH]*

6.4 Development of the framework

The framework was developed over two stages. An initial stage comprised synthesising the findings from the CrowdMemo and Smart Citizen studies to distil key factors associated with the sustainability and scalability of participatory technology interventions.

These were:

- support meaningful engagement and a sense of purpose by focusing on local matters of concern (chapter 4);
- enable participatory dynamics to foster community ownership (chapter 4);
- support the development of technology skills and data literacy among communities of non-experts (chapter 5);
- enable collaboration among diverse stakeholders (chapter 4 and 5); and
- support community champions who can orchestrate complex collaborations throughout (chapter 5);
- follow an open approach to increase impact and appropriation (chapter 4 and 5).

A second stage of development ran from May to September 2015, with Knowle West Media Centre (KWMC), to deliver an inclusive and sustainable citizen sensing programme in Bristol. The stakeholders were:

i. the community organisation,
ii. the Bristol City Council and
iii. the researcher

The stakeholders engaged in a 16-month long Action Research project. The first cycle consisted of planning action, taking action, evaluating and reflecting [Coghlan & Brannick, 2009]. This chapter describes the planning phase, which included an ethnographic reconnaissance [Crabtree et al., 2013], co-creation and strategy workshops, and the design of the framework and its delivery strategy. It also describes the implementation of the framework and the results of the reflection and evaluation phases.

6.4.1 Methodology

The planning phase comprised three key stages. First, a three-week ethnographic reconnaissance was conducted by the researcher to become familiar with Bristol, Knowle West, KWMC and the Futures department at Bristol City Council. Like in [Crabtree et al., 2013] this procedure allowed for the identification of different community groups and people in order to extend the network of participants. This included communities that collaborated with KWMC and the City Council, and others who were interested in data and technology, and in addressing local challenges. The process comprised 24 hours of direct observation, 14 interviews, calls, emails and skype conversations with KWMC staff, local entrepreneurs, city council officials, and community engagement workers. The aim was to learn about their attitudes towards technology, innovation, citizen engagement, inclusion, sustainability and collaboration.

Second, a “Design and strategy” workshop (Figure 30) was organised by the researcher, with help from the think tank Ideas for Change, where a number of stakeholders, resulting from the ethnographic reconnaissance, were invited. This included:

- KWMC core team, including the two directors, the media arts producers, the environmental media coordinator, and community engagement manager;
- KWMC extended network of collaborators, including researchers from the University of Bristol and University of West of England, the director of the digital creativity centre Watershed, and the director of the local business incubator Engine Shed;
- and representatives from the Bristol City Council, including the director of Bristol Futures, the Strategic Resilience Officer, the City Innovation Manager, and the Director of Neighbourhoods and Communities.

At the workshop the themes derived from phase one were presented. This comprised an overview of citizen sensing initiatives, and a discussion of the themes that were found to be associated to the meaningful engagement, sustainability and impact of community-led technology interventions (i.e. ownership, purpose, technology skills and data literacy, championing and orchestration, openness, etc.).

Additionally, building on the methods described by Sanders & Stappers in the Convivial Toolbox [Sanders & Stappers, 2012] and the IDEO’s Design[78] kit, user-centred design and futures design methodologies [Müllert & Jungk, 1987; Kensing & Madsen, 1992; Bødker et al., 2004] were combined to deliver a co-creation activity to foster the collaborative development of new solutions to social problems. The aim was to collaborate with the stakeholders to identify local issues of concern, attitudes towards collaboration and innovation, and explore capacities and opportunities to inform the design of a sustainable and scalable citizen-centred sensing programme for the city.

78 http://www.designkit.org/methods

Figure 30. Co-creation workshop held in Bristol.

During the activity, the themes were discussed and clustered using post-it notes (Figure 30). The participants unpacked notions of ownership, data, sensors, value, participation, engagement, empowerment, and innovation by clustering descriptions of specific actions and ideas. For example, they conveyed that enabling trust in a citizen sensing programme required tackling people's fear of technology by supporting the development of skills and discussing data ownership. And that the latter could be achieved by creating opportunities for people to connect, share knowledge and collaborate. Notions of creativity and innovation were particularly salient, possibly due to the nature of KWMC, as described before. They also used the post-its to map local matters of concern that they thought could be addressed though a citizen sensing programme. The mapped issues were: housing, transport, local production of food, the need to foster entrepreneurship, and the need to strengthen local communities.

Using a future newspaper dated 2020 (Figure 31), the workshop participants were asked to organise these themes into a cohesive strategy that showed how they could tackle the local issues taking the discussed themes and their associated actions on board. The newspaper task (a template is presented in Annex 3) also included two key features: the need to identify the ecosystem of agents required to address the issues ensuring that the intervention was inclusive and participatory, and the need to identify how the solution was implemented and evolved throughout time.

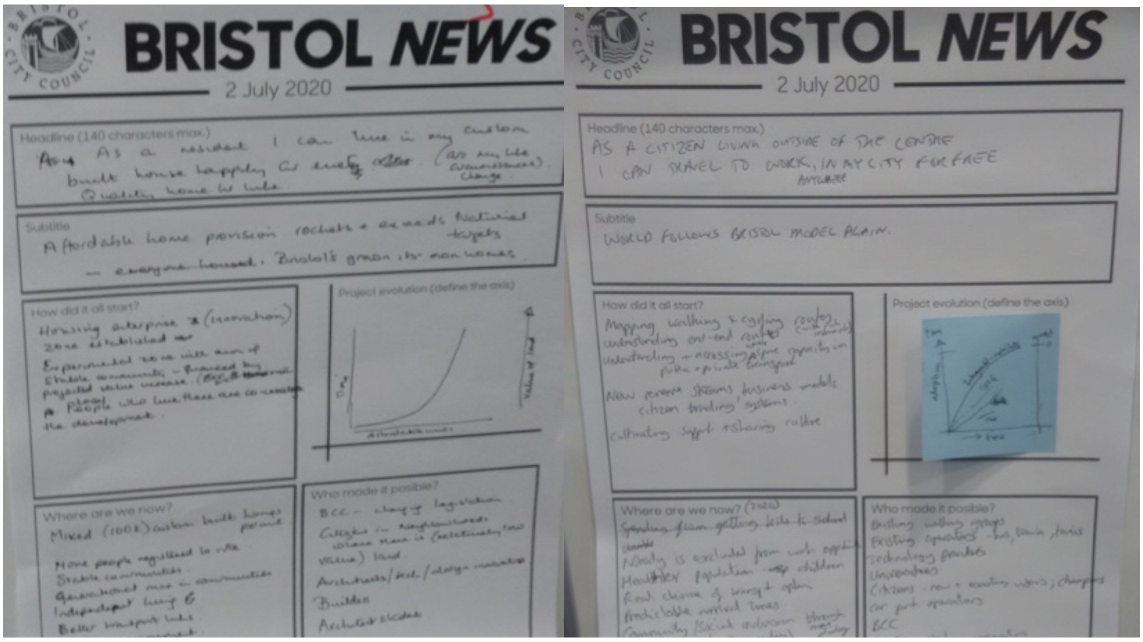


Figure 31. Newspaper template used during the workshop.

In a third stage, the researcher analysed the data collected during the workshop using inductive analysis [Thomas, 2006]. These data were combined with the themes emerging from the CrowdMemo and Smart Citizen studies, and further augmented with a literature review [Braun & Clarke, 2006]. The findings showed that there was a need to develop an actionable framework that would enable KWMC to run the citizen sensing programme in collaboration with stakeholders, communicating stages of development and requirements to a wide range of actors. It emerged that the framework should achieve the following goals:

- draw engagement from identified matters of concern and a network of communities of interest;
- follow participatory methods to create a sense of ownership among participants;
- foster community capital by supporting the development of bonds, technical skills and data literacy to increase participation on, appropriation and sustainability of the intervention;
- produce open and shared resources (i.e. data, technology, skills and know-how),
- encourage discussions on data privacy, ownership and governance; and
- foster entrepreneurial opportunities.

As a result, a preliminary strategic framework for a sustainable and impactful citizen sensing programme was proposed, building on the key phases comprised in well documented participatory models such as Action Research [Hayes, 2011] and Participatory Action Design Research [Bilandzic & Venable, 2011]. The latter, for example, includes: diagnosis and problem formulation, action planning, action taking (design), impact evaluation, and reflection and learning.

Additionally, the resulting City Commons approach comprised two novel attributes. First, a delivery plan that took into account the need to develop expertise and thinking in relation to data sensemaking, citizen privacy and data security, and a proposal for project management (application of the framework). Second, a narrative that conveyed the vision of the commons (placed at the centre of the framework). This vision was chosen as it emerged from the workshop that there was a need to foster sustainability, inclusiveness and participation in the governance and ownership of data and technology for public use. As described in the literature review of this thesis, a commons is an alternative to the traditional private/public forms of ownership and management of resources, and is characterised by attributes such as community governance and openness [Foster & Iaione, 2016], altruism and prosociality [Ostrom, 2015; Blenkler, 2011, Benkler & Nissenbaum, 2006].

This vision is inspired by the open source ethos and builds on the broader city as commons movement [Foster & Iaione, 2016], which contests the increasing privatisation of public spaces, services and assets [Sassen, 2001] arguing for policymakers to provide more opportunities for people to access or even change existing urban resources [Lefebvre, 1996] in an effort to prevent inequality, alienation and social injustice [Harvey, 2003]. Aligned with these principles, the framework promotes the development of a city commons – broadly accessible capital (ranging from assets like data and technology, to skills, knowledge and social relations) that is managed by a community of contributors. The vision of the commons provides a narrative that aims to galvanise people under a shared action plan.

The preliminary framework (Figure 32) was presented back to the rest of the stakeholders at a second co-creation workshop where each phase was discussed until reaching agreement. During this workshop the vision of the city commons was unpacked and explained using examples of commons and sharing best practice such as the Co-city model implemented in Bologna [Iaione, 2016].

The resulting model comprises six cyclical phases: firstly, identification, followed by framing, design, deployment, orchestration and outcome. While well known in the HCI and participatory design communities, their rationale and sequencing needs to be understood by those who are to follow them. To aid this process of adoption, a diagram (Figure 33) was iteratively developed. The goal was to achieve an object that could be used to easily follow and communicate the why and how of the intervention without relying on complex terminology. Simple and memorable shapes (triangle and circles) were used [Scaife & Rogers, 1996] to highlight the three core phases that produce city commons (i.e. a map of issues, open source technologies and data, and skills and know-how) and three sets of actions that are required to achieve each phase.

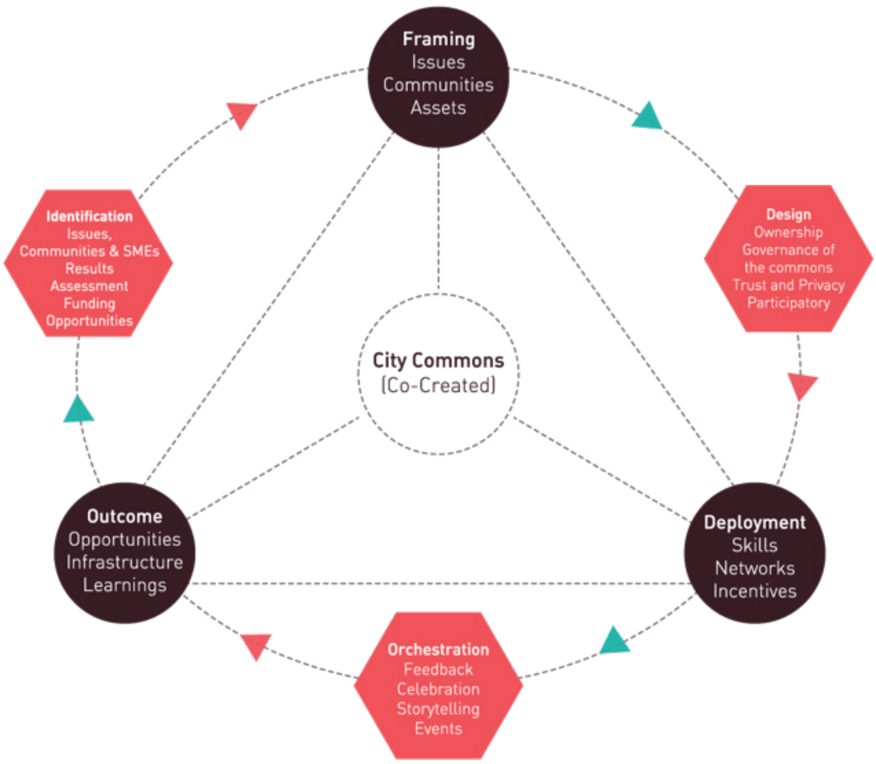


Figure 32. Preliminary version of a city-commons approach to citizen sensing.

In subsequent working sessions, KWMC and the researcher collaborated with professional graphic designers to improve the design of the framework, making it more accessible to non-experts and visually engaging. Based on the experience of the community champions working at KWMC, it was agreed that the phases needed to be identified with unique icons that could aid the coordination of the processes, allowing community champions and participants to easily recognise and communicate the phases.

A set of icons was iteratively developed using human hands to convey the centrality of the human factor in the process. Finally, we chose salient colours that are inclusive in terms of gender and cultures.

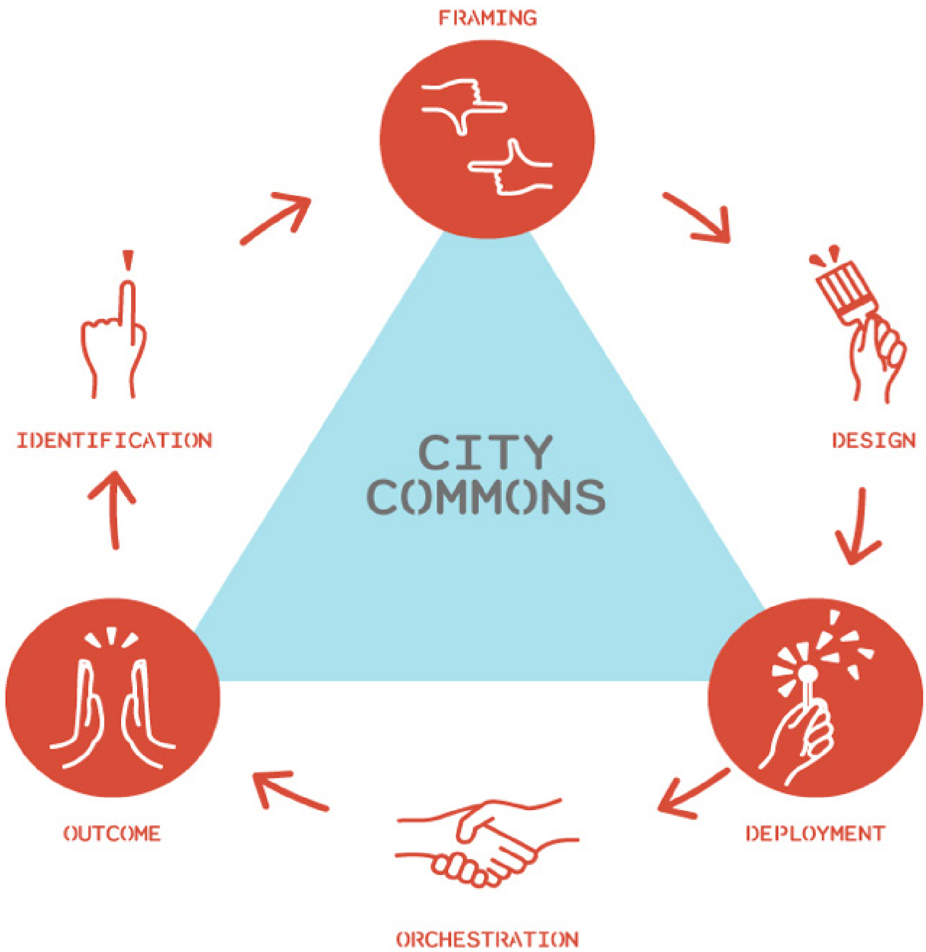


Figure 33. A city-commons approach to citizen sensing.

6.5 The framework

The framework comprises two critical components chosen to instrument the **why** and **how** of civic engagement.

The why is given by the focus on the city commons as a narrative and on matters of concern as a purpose to galvanise people and foster engagement and pro-social behaviour [Blenkler, 2011; Benkler & Nissenbaum, 2006]. The how is facilitated by breaking down a complex process of technology co-design and deployment into a sequence of actions that are easy to follow. The six key phases are: identification, framing, design, deployment, orchestration and outcome. The model ensures that participants are supported to make sense of technology and data by including training, technology design and data sensemaking sessions. It aims to achieve impact and scalability by ensuring that the produced resources are commons that, although being co-governed by the contributing community can be appropriated by external stakeholders.

In this sense, the framework describes the means by which groups can organise and work together in ways they see fit, rather than being managed by the researcher. The role of the researcher is therefore to explain, firefight and help, but not to control or manage [Johnson et al., 2016]. Below, each phase of the framework is described in more detail.

6.5.1 Identification

The first phase involves identifying matters of concern [Latour, 2007] that citizens care about and are prepared to give their time and energy to address and/or communities that already have well established matters of concern. This includes mapping out communities, organisations, businesses and other bodies that are affected by the issues and who might be interested in working together towards a solution [Le Dantec & DiSalvo, 2013]. In this case, this phase was done primarily by KWMC in coordination with stakeholders such as neighbourhood associations, community groups and residents. The role of the researcher is to suggest methods for engagement and documentation.

6.5.2 Framing

The second phase involves exploring the resulting issues in more detail: identifying how technology and data can be utilised to help tackle it, uncovering existing commons and resources that can be drawn upon, and noting if there are any gaps in resources or knowledge that need to be filled. Framing a matter of concern helps to identify what really can be done to solve the issue and to manage expectations, which is known to be crucial in fostering engagement with participatory projects [Hayes, 2011]. The role of the researcher here is to provide guidance [Johnson et al., 2016] based on existing suitable tools and interventions and to suggest methods to frame the issue.

It is important that a group of stakeholders, coordinated by the media centre can come together at this stage to share the sense of ownership over the intervention [Taylor et al., 2013], and that they can agree on its overall goals and timeframe, and discuss what results are expected and how the outcomes will be assessed, as well as to consider any funds that might be needed [Hayes, 2011]. The contribution of this phase to the city commons is a map of framed matters of concern by the community groups.

6.5.3 Design

The third phase involves designing the tools and interactions that are needed to tackle the issue at stake. To ensure that people can effectively contribute to the intervention, the stakeholders need to identify the skills that are necessary for communities to develop, maintain or use the technologies and then design the actions that are necessary to enable such learning [Merkel et al., 2004].

Additionally, this stage may require the creation of a governance and management protocol [Ostrom, 2015]. If so, opportunities will be created for stakeholders to negotiate and agree the ownership of the data generated and the governance of the resulting technologies. The role of the researcher is to support the co-design process by recommending methods and tools, signposting skills that may be required and helping negotiate design tensions.

6.5.4 Deployment

The fourth phase involves the deployment of technologies to be tested in situ, iterated and improved. Testing technologies in the wild means that participants can collect data on how people interact with the tools in their natural environments and without instructions [Crabtree & Chamberlain, 2013]. They can also identify security and privacy concerns, and address them taking into consideration the needs and views of the community.

The researcher can provide advice on how to test the tools, collect data and make sense of the findings. Key to this phase is the organisation of events to enable social interactions between community members with different levels of expertise. The goal is to support social cohesion and the development of skills to ensure that the participants in the intervention are more likely to remain engaged. This phase contributes to the city commons documentation on open source technologies, open data, and new know-how and skills.

6.5.5 Orchestration

The fifth phase involves sustaining the engagement of the contributing community as well as scaling it up to engage a broader group of people. As revealed by the CrowdMemo and Smart Citizen studies, this can be done by organising events (i.e. data jams, hackathons or meet-ups) where participants with diverse skills can meet face-to-face and use the data that has been collected during the deployment to create visualisations, tell news stories or discover correlations.

This phase aims to fuel a sense of meaningfulness by demonstrating the usefulness of the co-created resources. The role of the researcher is to suggest engagement strategies, support the development of tech skills, and to help expand the network of stakeholders by raising awareness about the intervention.

6.5.6 Outcome

The sixth phase involves reflecting on the intervention and assessing if and how the goals that were outlined from the outset were achieved. It includes finding out what participants have learned, and sharing insights gained from using the framework [Hayes, 2011]. It also involves ensuring that the resulting technologies and collected data are accessible to third parties [Teli et al., 2015]. The aim is to support external appropriation [Marttila & Botero, 2013] leading to the creation of new solutions for the issue at stake, the identification of entrepreneurial opportunities, and or changes to the available infrastructure.

For example, if the community wants to address a problem in mobility and shares open pedestrian navigation data, the Council could use it to plan new public transportation routes while car owners could make earnings by covering non serviced trajectories using a ridesharing platform. Here, the role of the researcher is to support the process of data collection and analysis to assess the experience and impact of the intervention. This phase contributes to the city commons open source and community managed solutions to local issues, new social collaborations and relationships, skills and know-how on how to apply the framework.

6.6 Summary

This section has presented the two-phased development of a framework with the objective to support the participatory orchestration of civic technology interventions, in particular citizen sensing.

The framework aims to play an integrating role; outlining the processes and mechanisms for ensuring sensing technologies are co-designed by citizens to address their concerns. At the heart of the framework is the idea of a city commons: a pool of community-managed resources that are accessible to all. The framework is informed by the themes that emerged from the studies investigating community engagement with CrowdMemo and Smart Citizen. In a second stage, these themes were synthesised in a model, which was developed in collaboration with stakeholders following an Action Research approach. The following section presents how the framework was used by various local communities in Bristol that enabled them to collectively measure and monitor the problem of damp housing in an area of their city.

6.7 Application of the Framework: The Dampbusters

The application of the framework was focused in two areas of Bristol, Easton and Lawrence Hill where a large proportion of residents face challenges such as fuel poverty, low education attainment and unemployment.

It was coordinated by KWMC through its media arts producers (here sometimes referred to as community coordinators). 45 events and workshops were run, with over 717 participants aged 13-80. The large number reflects the level of interest and diverse community groups who were engaged with the approach.

6.7.1 Methodology

To collect data during the implementation on the framework, a qualitative approach was adopted. Fieldnotes were collected by the researcher and one media arts producer through direct observation (40 hours) of the activities and conversations that took place during the workshops and events (Figure 34). The focus was on how well the activities in each phase supported the aims of the project in terms of community engagement and what type of tensions were faced by the media arts producers and the participants.

Additionally, 12 interviews with community coordinators and participants were conducted, and two group debriefing sessions were organised to reflect on the activation programme. The scale and diversity of the activities performed and participants engaged meant that decisions had to sometimes be taken on-the-fly [Crabtree et al., 2013], and we had to be selective during the data collection process. Moreover, data from two reports were collected. The first one was written by KWMC staff for the City Council with the aim to document all the activities organised during the implementation. The second one included data from the participants who had hosted sensors at their houses, and was written by one of the community organisations that participated in the deployment of the sensors (Easton Energy Group). Finally, data from messages posted in Twitter by the community participants was collected.

Data were analysed using inductive thematic analysis [Braun & Clarke, 2006]. However, rather than coding the data to reveal general emergent themes, the approach was to further understand how the specific activities organised within each phase supported - or not the enactment of the framework, and what opportunities and tensions emerged as a result. Following, the findings are presented.

6.7.2 Findings

In this section, examples of the activities that took place during the six phases (along with their duration) that led to the Dampbusters project are presented. In each phase, the key findings are presented according to two themes: community engagement and tensions. For the key phases Framing, Deployment and Outcome, a description of what was effectively contributed to the city commons is offered. Informants are identified by initials and their role in the project.

Figure 34. Participants discussing matters of concern at community workshop.

6.7.3 Phase 1: Identification

Duration: 4 months

Activities

The goal of this phase was to identify local issues that people are concerned about and are prepared to spend time and energy in addressing. Staff at KWMC carried out three key activities for this:

i. A city-wide network analysis involving direct phone calls and visits to neighbourhood partnership meetings and with city stakeholders from charities, community groups and a range of city council departments. This led to the creation of an initial map of existing neighbourhood priorities.

ii. Conversations in hotspots with residents were then conducted by two artists, commissioned by the media centre, to achieve a more nuanced understanding of people's views and experiences around local issues. This entailed engaging in conversation with people in places where they congregate such as at tattoo parlours, bingos, cafes and nail bars. The artists then prepared a report that included their field notes, verbatim from the conversations and hand-made illustrations of the places visited and situations observed. This method provided more detailed insights on the local matters of concern and the every day experiences of people affected by them. It also revealed the general climate in the area, often marked by a feeling of exclusion and disenfranchisement. As described by one of the artists:

> *"There's a geographical divide of course (the river), but a much greater social and cultural one. (...) clients who won't venture into the city centre, even for an appointment, and find all manner of excuses not to engage with other parts of the city" (...) 'People here hear rejection very quickly' - she tells me, 'and are quick to disengage' [PH].*

However, one of the artists also noted that conversations with residents should not began by focusing on problems, or what the community "lacks", but rather by acknowledging the positive existing social capital and resources:

"There's a risk of going in with an idea of a 'lack' within a community and saying we're 'looking for issues'. I visited the salvation army lunch club, and found this tremendous kind of resource and place of generosity and goodwill and social capital - so it's important to be alert and to not just to go in looking for 'issues', which I think can actually be quite a negative view. It's good to also be looking for resources and the different types of capital and data that's going on within a community." – [CP]

iii. Networking event. A networking event was organised by the media centre in partnership with a local HackSpace and the University of Bristol, where people with diverse skills, from technology to community work, were invited to experiment with sensors and learn about the framework and contribute to a commons wall chart that logged things people were willing to share such as skills, technology, data and time. This artefact (Figure 35) was displayed close to the main entrance to the venue and people were invited by facilitators to use post-it notes to write down and stick on the chart what they were willing to contribute.

Figure 35. Commons chart for participants' contributions.

Community engagement: social interactions

Throughout this phase a large amount of social interactions took place: there were meetings with neighbourhood associations and residents, and the media arts producers and the researcher attended a host of Meetup groups, conferences and other events to present the approach and build relationships. Although time-consuming, such face-to-face social interactions helped to raise awareness about the approach and resulted in much engagement:

> *"Face-to-face conversations and direct visits to existing groups meant that we raised a lot of varied interest in the project and for the first workshop had about 60 people attend, and more register their interest " [MK].*

By engaging in face-to-face interactions with different people the media arts producers could talk to people, show them the framework and explain the aims and objectives of the intervention. These allowed them to build relationships and attract others to join in. A broad group of participants were engaged:

- Technology volunteers: including members of Hackspace, university students and researchers, employees of technology companies such as Altitude and Toshiba, Bristol & Bath Things Network Meetup group, comprising experts and hobbyists interested in electronics and robotics;
- Data volunteers: people working at small enterprises and institutes such as Data Unity, South West Data Meetup group, Open Data Institute Bristol, IF Project, Networked Planet, and a data and privacy lawyer;
- University volunteers: researchers in diverse areas, from smart city, geography, politics, living labs, computer science, and engineering;
- Artists: performers, fine artists, makers, pervasive gaming, residents at PM studios Bristol;
- Bristol City Council: Futures team, Environmental health, housing, volunteering, Bristol Is Open, etc;
- Schools: 30 children aged 8 and 9.

Tensions: negotiating matters of concern

The media arts producers acknowledge that the identification phase took longer than expected and that a line had to be drawn for the project to move on. This was done after having identified a number of recurrent issues that were supported by groups of people. As indicated by the director of the media centre:

> *"We knew we had limited time and resources (...) Once a number of issues were identified we 'sense' checked them internally – had they the potential to be sensed?" [CH].*

However, this raised concerns regarding the transparency of the process behind the selection of the issues. What happens to the issues that will not be addressed? Who gets to decide? As explained by one of the community coordinators:

> *"Some issues were so complex that focusing and faming them caused divisions and made progression difficult (...) it is essential to be transparent about the likelihood of issues being taken forwards (...) A clear criterion for assessing, determining and eventually choosing 'sense-able' issues is needed." [MK].*

This phase involved almost four months of engagements characterised by social interactions and conversations with neighbourhood associations and residents.

6.7.4 Phase 2: Framing

Duration: 3 months

Activities

Questioning matters of concern An initial table of issues was made and narrowed down based on the answers to three key questions that were proposed by KWMC in an effort to establish a criteria for the selection of issues:

i. How active is the issue, i.e., is there a large enough group of people interested in this area and would they be able to participate in workshops?

ii. How applicable is the issue to sensor technologies and open data, i.e., could sensor and data help tackle the issue?

iii. Is the issue realistic in scale, i.e., could a prototype tool make a real change by the end of the pilot phase? Is it scalable?

The issues explored were: damp homes, use of high streets, and the correlation between city biodiversity and health.

Contacting and (re)visiting community groups. Once the issues were selected, the media arts producers contacted issue specific groups that they thought would be interested in participating, including those who had been involved in the previous phase. This included:

- Residents: people living in Easton at damp homes and members of campaigning activist group Acorn;
- Subject experts: people working at the Centre for Sustainable Energy, Easton Energy Group, and Bristol Energy Network;
- Community organisations: Talking Money, Shelter, and Up our Street.

A workshop day was organised by the media centre to explore the approach, data, sensing and how to frame the issues. Around 60 people from 13 to 80 years old attended this event. Early on it became apparent that the issue of damp homes had more momentum and interest than the others. Damp homes contribute to a range of health issues and social stigma, and the perpetuation of poor quality housing stock, which is often low in value because the problem is not owned or dealt with. As one of the artists expressed:

> *"In Bristol rents are going up, there are a lot of problem landlords. People in rented properties are already disempowered socially and economically and often find themselves in difficult relationships with landlords where they are unable to make changes to do with damp, drafts or general repairs... It feels like this is a really tangible issue and, as someone who currently rents, I know how difficult it is." [PH]*

Reviewing existing and missing knowledge The media centre contacted experts from the UK's Open Data Institute and energy and retrofitting specialists to collaborate in identifying the tools that could help tackle damp, from sensor technologies to data that was readily available to use or learn from.

Community engagement: purpose

There were many reasons why people felt motivated to address the problem of damp, and this shared purpose supported a strong sense of engagement. While some people were directly affected by the issue, others joined in because they wanted to contribute to finding a solution, even when they did not live in damp homes. As workshop participants explained:

> *"[Due to my work] I spent a lot of time dealing with people living in housing which is not good enough but I never had the money to solve it. I had to say to people 'we can't do anything about it'. This project opens up ways of solving the same old problem but with a new approach. It gives the control back to people" [ST]*

> *"I came here to see how we can create things to help people living in horrible conditions." [MA].*

Moreover, experts engaged because they saw value in collaborating with others to support their causes, and to have access to tech expertise and a community of engaged citizens. Finally, the notion of the city commons was a strong magnet that attracted people and gave them a shared vision to work towards to. As a workshop participant said: "The concept of the commons interests me greatly - that's what brought me here." [II]. A media arts producer explained:

> *"The notion of a 'city commons' brings people together and inspires them to be part of something, to work across disciplines and to work together to make change" [MK]*

One of the artists said:

> *"It's been really inspiring so far, from having started with only a basic understanding of the commons (...) but also learning about different examples of the city commons or the digital commons and how we might contribute to creating them." [PH]*

As a result, a diverse community of stakeholders were galvanised to address the problem of damp houses. They named themselves Dampbusters, giving them a sense of identity and purpose. They all agreed to chart the houses with damp to demonstrate the scale of the problem and to develop sensors that could measure temperature and humidity (these data are crucial to assess if there is condensation resulting from normal household activity or there is a structural damp problem). To cover some of the costs of the intervention the Media Centre allocated funds from a small grant provided by the Council, and it was agreed that the project should complete all the phases in the framework by August 2016 using this funding.

Tensions: matters of concern and common language

While identifying a matter of concern is a powerful way of harnessing the energy of communities, this also means that expectations and urgency to address it are high, which can be hard to manage: "It was difficult to manage workshop participants' expectations. Some seemed to want to go much further with solving the issue in the first workshop." [ME]. Furthermore, early on it became evident that demystifying complex notions such as data and sensors was crucial to create a climate of openness and make participants feel involved. As explained by one of the community coordinators, finding a common language was crucial to foster engagement:

> *"The decision to delay any tech introduction was effective in bringing people together and creating an open inclusive environment (...) Each table was given a 'jargon buzzer', a bell, to be rung when any one started using language that was specific to a particular niche background" [MK].*

Contribution to the city commons

The selection of identified issues and communities of interest were then shared through an online open innovation platform (madeopen.co.uk) where people can further discuss them and possibly work towards tackling them. This was done by posting a description of the activities that had been conducted during the identification phase and the results achieved. They also posted resources and content for people to learn more about the issues, including which organisations where already trying to tackle them and how.

Figure 36. Initial frog-box card board prototype design.

6.7.5 Phase 3: Design

Duration: 4 months

Activities

KWMC organised workshops, group maker sessions and a data hack day. The innovation think tank, the researcher and KWMC organised a workshop (Figure 39) aimed at enabling collaboration between citizens, housing associations, the City Council, data, energy and damp experts and the contributing community to discuss scenarios where new collaborations among them could help to solve the problem. Around 25 participants, including technology and data volunteers, energy and housing experts, citizens affected by damp, artists, makers, researchers, and City Council officials were invited via email. During the workshop participants brainstormed ideas to prototype a commons damp-busting tool:

- map damp homes;
- measure temperature and humidity in homes;
- trigger and enable actions (e.g. self-help, issue a report or recommendations to landlord/tenant, a home visit diagnosis by a community damp know-how team);
- keep the data secure considering privacy implications

Technology co-design Based on the outcomes of the conversations with the damp and technology experts and the people who have damp at home, a prototype sensor was designed and built by a group of technology volunteers, designers and a maker. Various designs were created and critiqued in a co-design workshop. The sessions were facilitated by media arts producers from KWMC.

During the workshop participants agreed that the sensors should be inviting to interact with and suitable for homes with children, adults and pets. Eventually it was agreed to develop one that had much appeal, and looked like a frog – and affectionately became known as the Frogbox (Figure 36, 37, 38). As members in the design team explained:

"There were a lot of ideas for the box, including variants of a dancing sunflower [NL].

"The concept of the frog came to life in the follow up session (...) where the 11 of us there discussed the range of suggested ideas and narrowed it down into one concept [FD].

Five devices were built using Raspberry Pi3 and DHT22 temperature and humidity sensors. Due to time and funding constraints (£106 provided by the community organisation), the group decided to make and test a few sensors before scaling up to larger numbers. One volunteer with software development skills took the lead in coding and making the sensors. His motivation to participate was *"doing good"* and learning new skills, as he had recently purchased a Raspberry Pi to tinker and thought that *"making something useful that will help people" was better than just "playing around" [NL].*

The Frogbox was designed to collect data every five minutes using a Python script; it was saved to a MySQL database inside the box. This sampling was considered sufficient to obtain data about changes in moisture. A simple web site running on Django on each box was developed to provide the users the ability to access the data. It was first decided that the Frogboxes would relay data to a web platform but the community had to scale down their expectation to ensure that it was accessible to all: "... *we could not guarantee that the households we deployed to would have access to the Internet" [NL]*. Additionally, one participant also using open source tools built a prototype for an online damp reporting tool, which was tested and is currently under further development.

Figure 37. The Frogbox temperature and humidity sensor sitting on a cardboard Lilly pad.

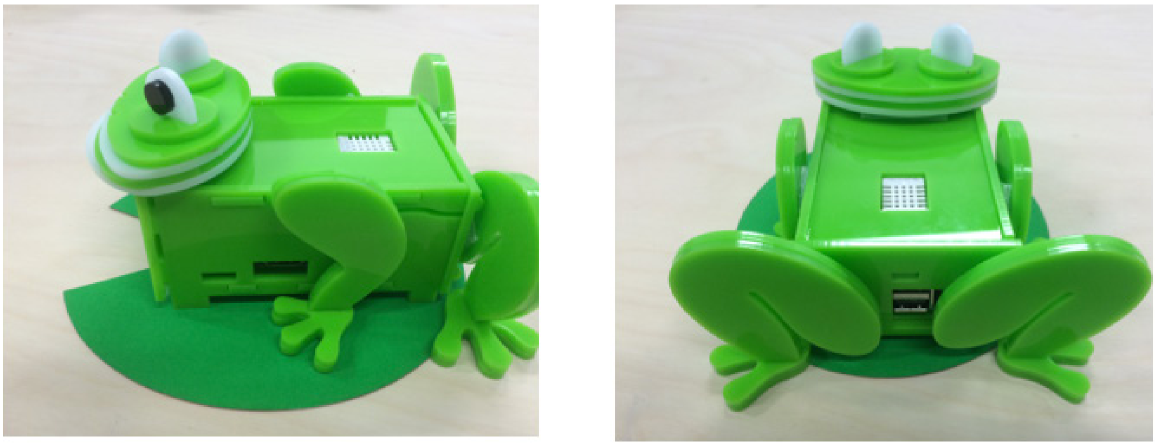


Figure 38. The Frogbox temperature and humidity sensor sitting on a cardboard Lilly pad.

Data annotation

It was suggested that keeping a diary could help people understand what tenants can do to reduce damp at home. For this, the Frogboxes were designed to sit on cardboard lily pads for people to annotate the timestamp of events that might lead to condensation such as taking a shower, cooking, or drying clothes on a radiator.

Community engagement: ownership

From the conversations in the workshops it emerged that people were less concerned about where their data would go than how the issue would be solved (*"If it helps us move towards solutions we would gladly share our data with the community"*, community member at the evaluation dinner).

The community decided that those who participated in the project were contributing to a shared resource and therefore the data had to be open. An exception was considered for more private data (i.e. geo-located reports), which would need to be aggregated and anonymised. While deciding where the data would be hosted, *"[They] seemed more comfortable with the idea of data being held by a community not for profit organisation than by the city council." [MK].* A data agreement was then written and made available to those who were to host frogs at their homes or contribute data to the project.

Regarding the ownership of the technologies, it was agreed that they would use and produce open source tools. Moreover, to cover the cost of the Frogboxes (and later for the deployment), the KWMC allocated a small sum of money (£300) from the grant given by the city council. Participants administered the funds following a participatory budget approach and using the online voting tool stickymoose.com.

Tensions: orchestrating co-design

While co-design sessions were fruitful for brainstorming and creativity, the Media arts producers agreed that it was sometimes tedious to make collaborative decisions on every step of the process, and that it was often only a small group of participants who ended up doing the more sustained making. Moreover, the decision to choose one technology over another caused tensions in the community: a group of Arduino enthusiasts left a workshop after it was decided to use Raspberry Pi. The community later discussed that a way to address these tensions was to encourage parallel lines of development, fostering forking, for people to contribute using the tools that they saw fit and already knew.

The Media arts producers noted that co-design workshops needed to be held in the local area, so that travel would not be a barrier for attendance. They also suggested that a tool to aid co-design should be developed to allow them to share documents and pictures for people to participate in the design process on their own terms. These findings, tensions and how the community addressed them were documented by the media arts producers and the researcher to ensure that leanings could be aggregated, processed and contributed to the city commons in the final phase.

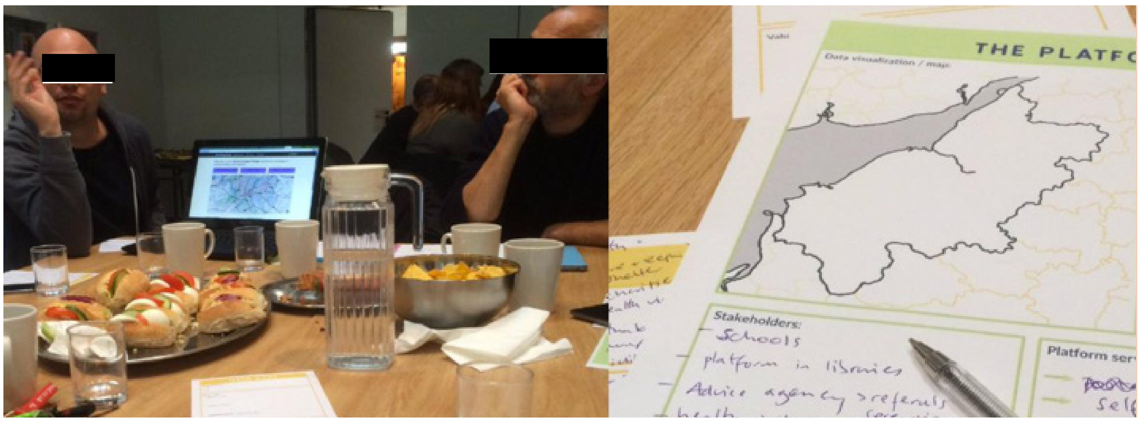


Figure 39. Participants envisioning the design of the Damp-busting platform.

6.7.6 Phase 4: Deployment

Duration: 2 months

Activities

An *'on the ground'* engagement team was created who had existing relationships with neighbourhood residents and were able to recruit people to test the sensors in their home. This was partly achieved because since the beginning of the project the media centre developed good relationships with local organisations such as energy and neighbourhood associations and charities through inviting them to workshops and keeping them updated. The community agreed to use a part of their budget (£300) to pay to Easton Energy Group (EEG), a social enterprise helping local residents to reduce energy poverty, to involve residents that they knew in order to test the Frogboxes. They also announced the deployment in local newsletters and neighbourhood partnership meetings, and sent emails to interested parties.

Testing sensors in the wild

The Frogboxes were deployed for two weeks in five homes in the neighbourhood. These were selected by the community in collaboration with EEG because they were severely affected by damp. The tenants were trained to understand how the technology worked and the data was collected. They signed a data agreement that had been co-created in the design phase.

The media arts producers and the participants involved in the deployment of the sensors recorded feedback provided by users and are currently working on a new version of the Frogbox. For example, they found that while people enjoyed having the sensors at home they wanted to have an easier way of visualising the data and to acknowledge the state of the sensor. The participants are currently working on a new device that relays the data to an online platform and comprises LEDs to indicate if the sensors are on, off, reporting data, etc. The notes taken in the lily pad journals helped people understand how little behaviours can make a big difference to reduce condensation at home. For example, some people didn't like taking a shower with the bathroom window open, but they discovered that opening it up right after the shower has the same effect and its something that they are willing to do.

Community engagement: meaningfulness and skills

The community, in particular those who participated in the design and deployment, felt rewarded due to the positive evaluation of the Frogboxes. As one participant mentioned: *"People were excited to have them [the frogs] in their homes"* [NL] and remained engaged during the deployment: "*We were very lucky we didn't have a single house that changed their mind after we started" [ST]*.

The sensors worked as expected apart from one that stopped reporting data before the end of the testing period. The community suspected that the children at that house put the Frogbox in contact with water: "*The dangers of making a sensor that looks like a frog!"* [NL].

They also felt inspired by some of the stories that emerged.

For example, an unemployed resident who was not able to afford to pay for heating in a house seriously affected by damp hosted a Frogbox and an off-the-shelf electronic electricity meter. After learning how to use both sensors he noticed that his energy bill did not correspond to his real consumption. He used the collected data to confront the energy company and demand a reimbursement, which was granted. This story of empowerment strengthened a sense of community among the participants. As one of them expressed: *"Just for a story like this our efforts made sense"* [ST].

Developing skills

Face-to-face conversations with tenants and training events were organised by the media centre and an extended network of partners to ensure everyone understood what the sensors were and how they worked.

For example, a half-day workshop was run to train 16 local residents to become community damp-busters; people who are knowledgeable about the problem and able to share expertise with other neighbours.

The initiative also inspired other groups to organise activities to help build community know-how about citizen sensing. The local Hackspace ran an open sensor-making workshop and paired 'techy with non-techy people'. A Hackspace in a neighbouring city is now running a series of meet-ups to help people learn sensor and data literacy. Additionally, an evaluation dinner was held for all residents to decide how to improve and move forward. This included sharing of data, data analysis and discussions on how best to make data meaningful.

Business opportunities

A housing association approached the community requesting to buy the Frogboxes. In response, the community member who took the lead in making the sensors decided to develop a business to service the sensors and help tenants tackle damp. While creating sustainable initiatives through fostering local entrepreneurship is a desirable goal of the approach, it was not expected that this would occur at such an early stage of the project.

However, it did create a tension about who owns the prototype:

> *"...we have a real example of a situation where we need to think about ownership and sharing data. Whilst we may not have a ready solution it is very useful to have a tangible case study. [CH].*

The community decided to support the new venture although ensuring that the technologies remain open source and negotiating conditions by which the resulting data can be aggregated in the city commons.

Tensions: need for coordination tools

Although collaborating with local partners that have existing relationships with residents was crucial to the success of the deployment, the media arts producers found that co-ordinating between various partners was complex, requiring a lead project manager or an effective communication tool for a more distributed orchestration.

Contribution to the city commons

The outcome of this phase was a set of open source technologies documented in free repositories (GitHub), open data sets about damp, new relationships and skills.

6.7.7 Phase 5: Orchestration

Duration: 3 months

Activities

A *data hack day* was organised by the media centre, where participants (data enthusiasts, damp experts, researchers, designers and citizens with a wide range of skills) were provided with different datasets, including Frogbox data, self-reported damp homes, City Council health and community data and Land Registry house price information. The goal was for them to discover ways that data can be visualised, layered or mapped to help move towards solutions and galvanise action around the issue. Focal questions were: *where are the damp homes in the city and how bad is the problem? What is the damp in the houses and how is it affecting people? What other factors might play a part in the problem?*

Celebrating achievements

A big event was organised at the Bristol Data Dome, located in the At-Bristol Planetarium. The dome has 98 seats and it is the UK's only stereo 3D hemispherical screen with 4K resolution. The event, which was attended by almost 100 people, celebrated the achievements of the Dampbusters project. It was organised as part of the city's annual biennial and aimed to show how technology and data could be used for the common good through a playful mix of performance and poetry.

Community engagement: meaningfulness and networks

The participants were highly motivated by exploring the data during the hack day and expressed their enthusiasm in Twitter: *"Great hack day @knowlewestmedia today for #bristolapproach. Smashed this together to show damp home factors #Dataviz"* [DB] (Figure 40) and *"an interesting day exploring damp homes data at @knowlewestmedia #bristolapproach..."* [MB]. They found correlations between data on the topography of the neighbourhood and damp reports, as well as correlations between damp and the number of inhabitants in a property.

The participants also discovered that although residents of damp houses tend to be stigmatised, damp housing doesn't necessarily correlate to income. In addition, new forms of cooperation among engaged stakeholders emerged. People contributed photos to the city commons of damp in their and others' homes, and worked with experts to identify the type of damp. Other community workers stepped in to provide advice to the participants on how to take action to prevent damp. This entailed, for example, opening the bathroom window after having had a shower, ventilating the kitchen while boiling or cooking food, and not drying clothes on the heater.

The Media Centre then provided the Council officers with the collected evidence of damp along with proposed new measures on how to improve the situation (i.e. considering change to the licensing of private landlords). Furthermore, landlords and tenants were encouraged to work together to solve problems for mutual benefit.

Figure 40. A tweet from a participant who attended the data hack day.

Tensions: Developing skills

It became apparent that meaningful participation is directly associated with having the skills to contribute. Although much work has been done to support the development of technology skills and data literacy among participants, the media arts producers acknowledge that more needs to be done. As the director of the organisation stated: "... *We are about to launch a tech and cnc/laser cutting skills programme for 120 community members (...) We see a need to run tech skills programmes alongside of the project"* [CH].

A schools programme was rolled out during Autumn 2016, to teach students how to make Frogboxes, how to read and visualise data, and what data privacy means. This included around 30 children aged 8 and 9 years old (Figure 41).

Figure 41. School children making Frog-boxes.

6.7.8 Phase 6: Outcome

Duration: 1 month

Activities

The project was perceived to have delivered a successful outcome, by the councillors, local residents and community groups. New partnerships were developed between renters, council workers and damp experts who are collectively tackling the issue of damp homes. As two participants explained:

> *"The Bristol Approach is interesting because it is not just a matter of getting the technology right - it's taking a much more holistic approach to gathering data and using it." [NL]*

> *"It's a big step to make local people feel like they've got the power, explaining data, taking the fear out of that space, and then getting them in an empowered space where they can actually be involved." [AG]*

Tensions: funding and political context

During the development of the Dampbusters intervention there were changes in the city's political landscape. The City Council had supported the development and implementation of the framework both by providing a small grant to KWMC and by contributing expertise, opening up data that was requested by the community, engaging in discussions around how to use data platforms, and even mediating between residents affected by damp and landlords. As the director of KWMC expressed:

> *"More importantly is the support for citizen engagement and a willingness to engage with a commons approach and role of citizen in co-design of the smart city. Whilst Bristol has always supported citizen engagement in the smart city it has also taken a more conventional smart city route of building the tech first and then do the community engagement (...) So there is a tension between what the city (and business) does and what the approach advocates." [CH]*

However, during the deployment of the project there was a change of administration and a new Mayor took office. Moreover, the director of Bristol Futures also left office. This created a sense of uncertainty regarding the sustainability of the project and whether the community would still be supported by the City Council:

> *"We now have a new mayor Marvin Rees (Labour) leading an agenda of great inclusion, opportunity and support to disadvantaged communities. So I'm envisaging that [the City Commons approach] will chime with this administration and be supportive of the community engagement issue based approach [...] This has yet to be played out in practice." [CH]*

Contribution to the city commons

The Dampbusters project was able to contribute to the city commons in the following ways:

- New tools (the Frogboxes and online mapping tool) were co-designed using open source technologies and shared via accessible repositories.
- Open data was gathered to help visualise the prevalence of damp in people's homes and its correlation with other important factors (health, house prices, and people's habits at home). The community is currently negotiating the integration of these data in the city's data platform.
- New networks were created to extend the reach of the project and support inclusive participation.
- Participants developed new tech and data literacy skills
- Business opportunities emerged
- Learning how to apply the framework to tackle matters of concern was acquired and shared through a users' guide that is publicly available online.
- Other communities are now looking at using the framework, which has also received wide media coverage from the BBC, Wired Magazine, Dutch National TV, and more. The approach and framework were presented at the House of Lords as an example of good practice of citizen engagement in the UK.

During the debriefing sessions and interviews the contributing participants and the media arts producers often reflected on "the approach" or "the framework". They agreed that the framework had helped them guide and orchestrate collaboration while keeping everybody updated, engaged and on board. As this participant suggested:

> *"Through this approach, people can really start to feel that their voice is being heard and that something is actually being done about it. I feel the framework works well, and is a necessary guide to prevent the project going off course and help guide the activity [FD]".*

Moreover, the framework provided a narrative that attracted and galvanised people under a shared vision:

> *"The framework (...) has given us a way of explaining how we collectively build commons thinking, and put forward a more collaborative city that defines a role for the citizen. We are building a different narrative to challenge the smart city tech-down thinking." [CH].*

6.8 Discussion

This chapter presented the application of a novel framework aimed to scaffold and orchestrate the co-design of innovative socio-technical systems to tackle real community needs at the grassroots level.

The model addresses a gap in the literature as more HCI and PD researchers doing civically engaged projects advocate for a rhetoric of engagement [Rogers & Marsden, 2013] or a turn to openness [Martilla & Botero, 2013] where the knowledge and know-how of experts is shared and handed over in a way that empowers people to make, fix, fork and sustain their own tools [Rogers & Marsden, 2013; Teli et al., 2015; Taylor et al., 2013]. Such aspirations require that groups of people outside academia are able to come together, contribute time, efforts and resources, and learn new technical skills in a coordinated manner to produce and enact new socio-technical interventions. However, the examples of frameworks that support and guide these processes so that people can drive them without management or control by researchers are still piecemeal.

As described in this chapter the framework was successful in galvanising different members of a community to address the problem of dampness affecting several households. It enabled collaboration among diverse stakeholders (from residents living with damp to Council officers, tech and data enthusiasts, experts and community workers), and the co-design of bottom-up sensing and mapping technologies that played a key role in enabling people to record, visualise and analyse the scale of the problem.

Furthermore, the findings suggest that the framework was more than just a guide to orchestrate participation. It also became a narrative tool that allowed KWMC to gain support for its work on citizen engagement (in practice often overshadowed by technology), and galvanised people to work towards a shared vision, where the commons acted as a magnet for engagement. The participants felt represented and empowered, and experienced joy in contributing time, resources and efforts to address common issues (cf. [Ruddick, 2010]). In this sense, the framework became a boundary object [Star & Griesemer, 1989], a lingua franca that scaffolded the complex collaborations on the ground, allowing the Media Centre to drive a process that entailed intricate social, political and technological dynamics.

Having six clear stages helped the community to reflect on the work that was being made, to celebrate achievements and to learn about the processes that were enacted [Hayes, 2011]. For example, when someone was talking about planning activities at the design or the orchestration phase it was understood how they followed or preceded other planned ones. However, it also became apparent that the framework was not enough by itself, as other tools for the coordination of participatory processes were necessary to keep people updated and engaged in between events.

Moreover, due to its strong focus on the commons, as an alternative way of creating and/or managing resources that can contribute to the common good, the framework became a vehicle to discuss tensions that are important when using sensing technologies. For example, the issue of who owns the technology and the data was raised during the design of the technologies and when someone saw an opportunity to develop the frog prototype into a commercial product. Tensions emerged when deciding which issues should be addressed and what technologies should be used. The community followed an open and participatory approach to resolving such conflicts while shedding light on the need to further develop tools and methodologies to support their orchestration work. The framework works well as an orienting and coordinating device. However, it requires also taking the following considerations on board:

6.8.1 Meaningful engagement

6.8.1.1 Matters of concern

Starting with matters of concern is crucial for gathering engagement and momentum among a loosely connected group of people [Le Dantec & DiSalvo, 2013]. The case study reported in this chapter showed how damp homes were particularly pertinent to those living in rented accommodation, where collecting evidence of its prevalence through new sensing technology was a powerful vehicle to move the Council into action. Moreover, other people who were not directly affected by the issue at stake felt compelled to participate because they wanted to contribute to a social good.

However, matters of concern imply urgency and are often contested. For example, there were tensions when the project instigators had to decide what issue to tackle, which led to other two issues not being addressed. Moreover, people being affected by damp wanted to find a solution as soon as possible, without taking the time to evaluate different alternatives. The case study highlighted the need to manage expectations [Adams et al., 2013] and enable transparency from the beginning, making sure people accept the timing and limitations of the intervention and explore all possible ways of tackling the issue before embarking in a solution.

6.8.1.2 Narrative

The vision of the commons was a magnet that attracted participants and contributors. Moreover, it provided a narrative that created opportunities for bootstrapping existing skills and resources, making people feel useful together and in control of the data and the technologies [Teli et al., 2015]. Furthermore, by creating a pool of accessible resources (from data to technologies), people, networks and skills can be galvanised at addressing real situated needs.

However, the data collected and the tools developed need to be managed (cf. [Ostrom]). This became evident when the community discussed who would own the resulting data, and weather it should be open or not, which led to the writing of a data ownership agreement. Other discussions emerged when a member of the community found the opportunity to start an enterprise to commercialise the frog sensors, which had been co-created as an open source technology and a commons. One way to address ownership challenges is to develop protocols from the very beginning of a project, including an action plan to support the emergence of entrepreneurial and commercial activity in a way that is fair and agreed by the community. Documenting and sharing best practices can alleviate tensions in subsequent collaborations.

6.8.2 Participatory orchestration

As discovered in the Dampbusters project, following distinct phases that have a beginning and an end helped the stakeholders plan, orchestrate and communicate actions. Although phases can overlap and it can be useful to move back and forwards sometimes to revisit actions the framework provides the backbone against which to do this while keeping the process in track. Phases also create opportunities for reflection and celebration of achievement, while they facilitate the process of sharing learning [Hayes, 2011].

Furthermore, the work of community coordinators can be supported by the use of digital tools that enable commons action groups to form, organise, and make decisions together, as well as map, visualise and make sense of data. Supporting the orchestration of such a complex project in the wild necessitates making decisions with partial (or no) knowledge on tight timescales. There is a balance between structure and having to make decisions on the fly. The level of specificity of the framework, which allows for community coordinators to decide what type of activity should be conducted and for how long in each phase is appropriate for this kind of process [Star & Griesemer, 1989].

6.8.3 Skills and networks

Building relationships between existing local communities is an obvious way of scaling up engagement. However, it is easier said than done. Key is to provide an openness to the project, that enables 'on boarding' of people, communities and groups at various stages, who have an investment in the issue at stake or have something to contribute to the intervention. Likewise, it is important to work out how best to leverage existing networks, know-how and resources [Crabtree & Chamberlain, 2013].

Face to face encounters seem critical [Steels & Tisselli, 2008] as found in the Dampbusters project. However, to sustain engagement is it also crucial that people are supported in developing technical skills and data literacy in a way that is accessible and enjoyable, throughout the intervention. Sharing a common language by de-mystifying concepts, and organising events for people to learn skills can increase confidence and ability to create change by themselves.

6.9 Conclusions

This chapter presented the application of the City Commons framework, which outlines how communities can design and use sensing technologies themselves to respond to their concerns and aspirations.

The starting point is to address matters of concern, foster citizen contributions while nurturing a city commons. The framework is intended to be handed over to community groups, organisations and stakeholders in governments to guide and scaffold participatory processes. The role of the researcher is to galvanise, assist and offer external help at pressure points. They can provide the bridge between those who lack of technical and data literacy skills that deters inclusive participation in this programmes, with those who have such skills and want to contribute their expertise.

In terms of answering research question four (How can the notions of meaningful engagement, sustainability, and impact inform strategies to achieve successful community-led, civic tech interventions?) the Dampbusters study demonstrates the effectiveness of having a framework that aids the process of participatory orchestration. In this regard, the model acts as an orienting and communication device, providing a common language for engaging citizens to participate in technology innovation for the common good. It also highlights the value of galvanising communities around a shared vision that fosters joy and empowerment [Ruddick, 2010]. Furthermore, by fostering collaborative practices, the city commons approach can promote new forms of social innovation and community cohesion, and produce accessible capital to infrastructure civic action [Le Dantec & DiSalvo, 2013].

However, the framework should not be seen as a blueprint or panacea for community engagement when addressing local or global concerns, such as recycling, air quality, litter, etc. As the case study has shown, what it can do is provide a way of coordinating and managing a multi-faceted process with different expectations, skills, and where challenges and tensions arise along the way. Often community projects fail because such problems arise and are not resolved effectively or where funding becomes the main concern. Adopting an open, prosocial approach where it is clear what the common goal is and how each can contribute at which phase is key. The framework provides a tool to scaffold, structure and orient people under a vision that makes collaboration possible and rewarding. In this way, the researcher can remain as a facilitator and observer of the process, intervening when asked by the community rather than managing processes and following a research agenda.

6.10 Summary

In this chapter the implementation of a new framework has been presented. It outlines how communities can design and use sensing technologies themselves to respond to their concerns and aspirations.

The starting point is to address matters of concern, foster citizen contributions while nurturing a city *commons*. The framework is intended to be handed over to community groups, organisations and stakeholders in governments to guide and scaffold participatory processes. The role of the researcher is to galvanise, assist and offer external help at pressure points. They can provide the bridge between those who lack of technical and data literacy skills that deters inclusive participation in this programmes, with those who have such skills and want to contribute their expertise. By fostering collaborative practices, the city commons framework can promote new forms of social innovation and community cohesion, and produce accessible capital to infrastructure civic action [Le Dantec & DiSalvo, 2013].

7 Discussion

The previous chapters have described three case studies investigating engagement with off-the-shelf and novel civic technology interventions in different community arrangements.

The first case study, CrowdMemo, focused on how a group of school children, teachers, older people and members of a photography collective used assemblages of of-the-shelf technologies to address heritage preservation in a rural town in Argentina. The second case study focused on how individuals and publics used Smart Citizen, a crowdfunded novel sensing prototype platform to monitor the environment. The third case study, Dampbusters, focused on how publics in Bristol, aged 13 to 80, used the City Commons framework derived from the findings of the first two studies to co-design novel sensor technologies to address a problem of damp in houses.

These investigations have provided considerable understanding regarding how groups of people come together and galvanise around technology to address issues of concern. In some cases these socio-technical interventions have sustained over prolonged periods of time and have been appropriated by external stakeholders who were not initially involved with them. In this regard, the case studies have shed light on the factors that contributed to sustaining the engagements. Finally, an assessment of the impacts achieved by the interventions reported in the case studies highlights the ways in which community-led civic technologies can contribute change to society. This chapter discusses these experiences and findings, in relation to the research questions stated in the introduction. It also discusses methodological and operational insights gained as a result of this investigation.

7.1 Community engagement

A key aim of this thesis was to explore the **factors underlying meaningful community engagement with civic technologies.**

While individual engagement with technology has been broadly studied in HCI [Maslach et al, 2001; O'Brien & Toms, E. G., 2008; Peters et al., 2009; Attfield et al., 2011; Kim & Kim, 2013], little is known about what are the contributing factors leading to community engagement with technology. This means, understanding why groups of people who share common interests and attributes [Brown & Schaff, 2011] would galvanise around certain technologies and appropriate them to act at the civic level.

In the literature, community engagement has been described as a process by which identified groups of people, who may be connected geographically, by interests or affiliations, work together with the purpose to address issues that affect their wellbeing [CDC, 1997; Hlalele & Tsotetsi, 2015; McCloskey et al., 2013]. However, there is a lack of research addressing how such common issues are articulated and what is the role played by technology in facilitating meaningful engagements around them. This section discusses three key and interdependent factors that have been found to contribute to facilitating community engagement with civic technologies: publics and matters of concern, novelty, and narratives.

7.1.1 Publics and matters of concern

The traditional smart city approach to deploying civic technologies has often been criticised for being top-down and a technology-push [Greenfield, 2013; Teli et al., 2015]. The starting point of the intervention typically is the technology itself, and community engagement comes after as a resource to enact action and produce content with the tools. A similar approach characterises many HCI research projects, in particular those following a technology probe strategy where researchers design novel technologies and deploy them in real world settings to observe how they are used over a period of time, and then reflect on this use to gather information about the users and inspire ideas for new artefacts [Hutchinson, 2003]. While this approach can provide valuable insights on how people use or do not use a certain technology and can help designers to make better and more usable systems, it might not be sufficient to support the design of systems that can be useful or meaningful for communities who face situated needs. The question of community engagement with technology remains unresolved: what makes people come together to meaningfully use and appropriate technologies?

The case studies undertaken in this thesis have shown that people who share a need or a concern are more likely to galvanise, and that a matter of concern [Latour, 2004] is a driving force for engagement. Technology seems to come after, when there is an articulated matter of concern, an issue at stake. For example, CrowdMemo emerged as a response to community concerns around heritage preservation. People in Arequito were preoccupied because of how rapidly the landscape of the village had changed, leading to the deterioration of places deemed meaningful and hence their shared history. More importantly, they had an idea about how they could collectively tackle the issue at stake: producing storytelling about the community memories. This shared sense of purpose coupled with a hunch on how to effectively tackle a matter of concern fostered engagement and action.

The investigation on Smart Citizen further validates this observation. The studies analysing the early cohort in Barcelona highlighted that having crowdfunded the same project and being geographically bounded was not enough to create a sense of purpose and foster civic action. While it is true that there were other factors that hindered engagement with the technology, such as lack of technical skills and issues with the robustness and the reliability of the technology, these challenges were overcome in the Amsterdam community. The experience in Amsterdam showed that recruiting participants who were concerned about a common issue and ready to act upon it, in this case measuring air quality, attracted people who shared a purpose, which fuelled their interest in the intervention and laid the ground for the configuration of a public [Le Dantec, & DiSalvo, 2013]. While the Barcelona participants had crowdfunded the same technology project, the community in Amsterdam felt compelled to collect data to inform a debate on and take action against air pollution.

This supports that starting with an issue that attracts people is a successful way to galvanise a community which is willing to cooperate towards achieving a shared goal.

In fact, a matter of concern motivated one of the most successful projects in citizen sensing. It is the case of SafeCast, the crowfunded intervention, which emerged as a response to the nuclear disaster at the Daiichi power plants in Fukushima [Kera et al., 2013]. As Latour points out, participatory processes should be issue-oriented if they aim to trigger engagement because the public is above all interested in a particular issue rather than in the participatory process itself [2007]. It is important to note that here, the concept of community is replaced by that of a publics, a notion that addresses the ways in which participants venture to enact desired futures and instigate change [Björgvinsson et al., 2010; Le Dantec & DiSalvo, 2013]. Dewey [1954] defines a public as a dynamic configuration of individuals, influenced by a specific set of conditions, and bound by common cause to confront a shared issue, rather than a pre-existing generic group of people. In this regard, the notion of the public seems appropriate to the context of civic technologies in that publics are not stable social groups that necessarily share an identity that enables a sense of membership or attachment [Hummon 1992; Brown & Schaff, 2011] but rather emergent social arrangements that form when issues require their involvement [Marres, 2007]. Here, the attachment stems for sharing a situated issue rather than from a well established identity. The notion of publics can therefore explain how heterogeneous groups of people galvanise to act upon an issue in the context on a specific set of conditions. These people might not share other bonds and even might be at odd with each other in a different context or with regards to other issues [Le Dantec & DiSalvo, 2013]. This thesis demonstrates that both, communities and publics galvanise around matters of concern. While in Arequito, CrowdMemo was instigated by a geographically bounded and well-established community; in Smart Citizen and Dampbusters individuals interested in tackling environmental issues formed publics.

Within HCI, researchers working with communities following participatory processes increasingly recognise the value of identifying matters of concern as a driver for meaningful engagement [Le Dantec & DiSalvo, 2013; DiSalvo et al., 2014; Teli et al., 2015]. While CrowdMemo and Smart Citizen support this argument, little is known about how to identify and articulate matters of concern. Following the City Commons approach, which starts with the identification of matters of concern, the Dampbusters draw much engagement from a public that galvanised around the issue of damp houses. Moreover, it indicated ways in which community issues can be detected, mapped and discussed. An approach is to follow a network strategy to map out communities, organisations, businesses and other bodies that either have well established issues or that are affected by similar matters of concern [Le Dantec & DiSalvo, 2013]. While this method can contribute a general map of issues, a more on-the-ground approach may be needed to further understand how the issues actually affect people. Conducting conversations in hotspots with residents, which entail talking to people in every day places where they congregate, provided a more nuanced understanding on the local context where matters of concern emerge and the every day experiences of people affected by them.

However, matters of concern are often contested. In fact, Le Dantec & DiSalvo recognise that contention is a crucial part of a public, which they describe as "a plurality of voices, opinions, and positions" [2013: 243]. In Bristol choosing to address one matter of concern over others meant that people whose issue was not addressed felt left behind. In CrowdMemo, tensions arose when the community had to choose which places should be preserved and which shouldn't. Even harder was to select and prioritise whose memories were worth being recorded and sharing, therefore choosing how the story of the town should be interpreted and communicated.

The research presented here demonstrates that it is important to manage expectations [Hayes, 2011] and enable transparency from the beginning, making sure people accept the limitations of an intervention and explore all possible ways of tackling the issue before embarking in a solution. Furthermore, matters of concern imply urgency and engaged communities expect that their collective efforts will lead to a successful resolution as soon as possible. However, experimental technologies such as Smart Citizen are not necessarily robust and reliable. For example, the community in Amsterdam felt disappointed when they found the data that had been collected didn't have the necessary quality to become evidence demonstrating how polluted the air in their neighbourhoods was. In this context, it is fundamental that expectations are managed and communities accept the limitations of the technology.

Finally, the articulation of matters of concern allows both for people to identify and engage in civic issues, as well as for the emergence of new relationships between individuals and resources: these relationships have been defined as attachments [Marres, 2007; Le Dantec & DiSalvo, 2013; Teli et al., 2014]. Le Dantec & DiSalvo argue that the participation itself is insufficient to account for the formation of publics and that constituting or infrastructuring a public involves creating the means to discover and express the dynamic and changing attachments of a particular group [2013]. They find that such process of creating attachments is opposed to framing issues, in that the latter are characterized as stable entities that are used to set limits to unstable things [Marres, 2007]. In consequence, framing issues entails a form of normalisation over the dynamic contentions that inhabit a public, therefore reducing issues to a set view or frame.

On the contrary, the research presented here showed that framing an issue doesn't necessarily imply a normalisation of the issue at stake, opposite to the creation of attachments but rather a pragmatic approach to foster action. In fact, in CrowdMemo and Dampbusters there were processes of participatory framing where participants negotiated the aims and terms of the interventions. While this entailed compromises, they didn't hide or disregard dissent and contentions but rather encouraged debate and fostered practical agreements that made action possible. It is argued here that framings, if done following a participatory and transparent approach can actually help to strategize solutions and assemble a path to action. This is important because too often civic projects fail because contentions cannot be effectively dealt with and collective action is in consequence hindered.

7.1.2 Novelty

Novelty also appeared to be a contributing factor to community engagement with civic technology. In all three case studies, novelty raised interest in the interventions, both at an internal level (e.g. in Smart Citizen, interest in the novelty of the technology was one of the primary reasons why people crowdfunded the project), and at an external level by fostering media coverage that in turn strengthened internal engagement. A similar correlation was found in early civic technologies, such as the Community Memory project. In 1975 it was reported that many people who interacted with CM had never used a computer before. The novelty of the system had a positive impact on creating engagement, with people sometimes creating a honey-pot effect [Brignull & Rogers, 2003] around the terminal while waiting to use it [Colstad & Lipkin, 1975].

However, it is important to consider that novel technologies are typically largely unfamiliar to most people [DiSalvo et al., 2009]. This means that while novelty can trigger engagement by inspiring curiosity and enchantment [McCarthy et al., 2006] they may be harder to use and appropriate by those who lack technical literacy. What CrowdMemo demonstrated is that off-the-shelf ICT, which people know how to use and even own, can be used in novel ways, also triggering curiosity and engagement while supporting uptake. The combination of mobile phones, digital storytelling and QR codes represented a novel assemblage of technologies, which was rarely used in Argentinian schools at the time of the deployment of CrowdMemo. During the intervention, participants often referred to the novelty of the technological approach, which generated a positive attitude to the project. The Smart Citizen case studies highlighted that, in fact, people where unfamiliar with the technology but still felt attracted to fund and use them. The investigations demonstrated that people in Amsterdam, who were interested in addressing a matter of concern (and supported by community champions to learn how to use them) overcame technical challenges and successfully appropriated the tools. In Bristol, the novelty of the frog-shaped sensors was also an element of engagement, attracting adults and children to become part of the Dampbusters' efforts to tackle damp homes.

These findings suggest that technological novelty can be a lever for engagement, evoking curiosity and possibly attracting people to become interested in and join civic interventions. However, some considerations need to be taken into account. First, in a low technology literacy setting it is possible to trigger curiosity and interest by using novel assemblages of off-the-shelf technologies. Familiarity with the tools can ease the process of uptake and appropriation. Second, novel technology tools such as sensors and IoT devices may attract people, although they might need time and support to learn how to use them. In this case, if there is a matter of concern that needs to be addressed, publics are more likely to go through the challenge of learning how to effectively use the technologies to achieve their goals.

As we will see in the following sections, social interactions and community champions play a key role in facilitating this process.

7.1.3 Narratives

A common factor emerging in all three case studies has been the positive contribution of narratives in supporting community engagement with civic technology interventions. In CrowdMemo, like in many other community memory projects [Bidwell et al., 2010; Lambert, 2013; Tisselli & Seels, 2008] storytelling was instrumental in creating a narrative that galvanised the community and created a sense of belonging. In fact, storytelling is central to how communities preserve their heritage, and technologies – from the press to mobile devices – have enabled different ways for storytelling to be created, stored and shared. For a geographically bounded community, who shared a past, situated memories and places, storytelling can reinvigorate the sense of belonging, therefore strengthening attachment and engagement. However, can this occur among publics who emerge around matters of concern, without necessarily sharing an identity?

The investigations on Smart Citizen demonstrated that, again, narratives played an important role in fostering engagement. Many of the groups that pursued sensing interventions, including the research and innovation projects that used and appropriated the technology shared the vision that bottom-up participation in smart cities should be promoted. Smart Citizen was even conceptualised by one of the instigators of a citizen sensing effort as a "critical artefact", a product of critical design that was instrumental to the enactment of that vision. Smart Citizen was associated to values such as openness, bottom-up and empowerment. It emerged at a time when publics at the grassroots level were galvanising to contest the dominant top-down and corporation driven narrative of the smart city. In rigour, critical artefacts, although seemingly finished products, are not explicitly intended as consumer products or as practical solutions to obvious user needs.

Unlike cultural probes [Gaver, 1999], Bowen's [2008] critical artefacts aim to provoke critical reflection on the assumptions underlying the conceptualisation of their contexts and the social scenarios suggested by their use. Narratives are a significant component of critical artefacts, both because the objects need to be explained to users through storytelling and because these users will produce them as an outcome of a critical reflection process. The conceptualisation of Smart Citizen as a critical artefact, seems appropriate to explicate how it was viewed by those who engaged with it and why it was therefore appropriated. The low-cost and open source Smart Citizen Kits were seen as a contestation of the discourse of the big technology companies, and capable of empowering citizens to take a leading role in the smart city, independently collecting and sharing data to act on their environments and transform their cities.

In the Dampbusters intervention, again, narratives fostered engagement. In this case, the vision of the commons proved to be a magnet that attracted people who felt represented by notions of common good and citizen empowerment. It led to discussions on the ownership and governance of the smart city, the technologies and the data. It also facilitated the emergence of *commoning* dynamics; a contributive context where people felt motivated to dedicate time an effort to address the problem of damp, even if they were not directly affected by it. In fact, narratives, visions and imaginaries have long been recognised as powerful drivers for engagement, galvanising people around a shared vision that evokes joy and empowerment [Ruddick, 2010]. Narratives have been used as a means to encourage individuals to think and behave in ways that will contribute to the collective good and to motivate individuals in challenging situations (i.e. [Redman, 2005]). Narratives seem to play an important role in galvanising publics, even when its members don't share an identity or history.

The contribution of narratives to elicit community engagement with technology has been largely overlooked in research in computer science. The studies presented in this thesis suggest that publics and communities assemble and share narratives that both explicate their engagements with technology and can potentially attract others. Narratives may be a way to also frame matters of concern and nurture collective action by providing answers to why we do something in a certain way. As demonstrated by the Dampbusters case study, narratives can be embedded in a framework helping to articulate publics and foster collective action.

7.1.4 Summary

This section has discussed three factors that emerged during the case studies as being positively associated with community engagement and the formation of publics around civic technologies. First, it explained how communities and publics emerge around specific issues that are articulated as matters of concern. The primary aim of the engagement is to address the issues and enact change. Secondly, it explicated how novelty can trigger engagement with technology, by eliciting curiosity and attracting people to join in civic interventions. This not only happens with novel artefacts but also with novel assemblages of off-the-shelf tools. Thirdly, it discussed how narratives and storytelling play a key role in galvanising people to use technologies that they view support their visions. While these factors can be explained in isolation they blend in practice, as both matters of concern and technologies encompass understandings of a given context that are often shared among communities in the form of narratives.

7.2 Sustainability

The second research question set out at the beginning of this thesis was, what are the factors that contribute to the sustainability of a community, its practices and the resulting technologies?

The previous section discussed three factors that were found to foster community engagement with civic technologies. However, how can these engagements and the outputs of the interventions sustain over time? Civic technologies are often presented in terms of their functionality and potential, both in the literature and in the media. What is often missing is an account of how they have been used over time and whether they have become useful tools for communities to act on the civic domain. The sustainability of community technologies is often discussed in relationship to the duration and extent of participation and with regards to the durability and appropriation of the material artefacts. For example, drawing on their experience of over two decades of engagement with the Blacksburg Electronic Village, Carroll and Rosson [2013] found that extending existing practice, using open access tools, and promoting long-term participation and recognising the existing overlapping networks were positively associated to sustained community engagement. Merkel et al. [2004] delved into the importance of supporting the development of technical literacy in community technology projects to increase appropriation and use over time. Taylor et al. [2013] found that planning for handovers, evaluating success and keeping on-going relationships were critical to encourage the sustainability of technologies and their associated community practices.

The case studies presented in this thesis suggest that sustaining community engagement is a process of *infrastructuring*, in the sense of putting in place and articulating the socio-technical mechanisms for enabling and supporting publics over time [Björgvinsson et al., 2010; Ehn, 2008; Le Dantec, 2012; Le Dantec et al., 2011; Star and Bowker, 2002]. These socio-technical mechanisms entail assemblages of material artefacts (i.e. the technology), skills and capacity, social interactions and networks. Moreover, while bottom-up socio-technical interventions are typically referred to as self-organising, the research presented here demonstrated that a level of human orchestration is required to sustain participation.

The notion of infrastructuring stems from a new trend in participatory design that advocates for a move from an understanding of design concerned mainly with design-for-use and focus on design-for-future-use, conceived to create a conducive environment to sustain a community of participants. In this sense, designed systems are not seen as fixed products but rather as on-going infrastructure, and socio-technical processes that relate different contexts [Star & Ruhleder, 1996; Le Dantec & DiSalvo, 2013]. Infrastructuring, then, is the work of creating socio-technical resources that intentionally enable adoption and appropriation beyond the initial scope of the design [Björgvinsson et al., 2010]. To constitute a public requires engaging in infrastructuring because it is through this process that resources are developed, allowing communities to act in response to issues. This section explores the main factors that have been found to contribute to processes of infrastructuring that led to sustaining community engagement with civic technologies: valued ownership, skills, and social interactions.

7.2.1 Valued ownership

An important factor for creating sustainable participation and outputs in civic technology interventions is ownership. The term ownership is typically used in the fields of law and psychology. In the former, it refers to the right of possessing something and being able to exercise a form of control over said property. In turn, psychological ownership is a cognitive-affective state that reflects an individual's awareness, thoughts, and beliefs that the target of ownership or a piece of that target (e.g. an organisation) is theirs [Pierce et al., 2001]. Ownership is innately linked to engagement as research has demonstrated that feeling that one owns something can have strong motivational properties. For example, people care for and nurture their possessions [Avey et al., 2009]. The case studies presented in this thesis revealed three interdependent factors that contributed to fostering people's sense of ownership over civic technology interventions: material ownership, participatory approaches, and value.

7.2.1.1 Material ownership

In community-focused efforts ownership over the technology itself has been found to be critical for the sustainability of an intervention [Carroll & Rosson, 2007; Merkel et al., 2004]. This was found to be a significant factor in the success of CrowdMemo, where participants owned the technology that was used in the project and were trained in the skills necessary to use it in novel ways, for example, making digital stories with mobile phones. As discussed by Taylor et al. [Taylor et al., 2013], using off-the-shelf technologies can increase the sustainability of an intervention because it bypasses many of the challenges associated with handovers of experimental technology prototypes. Specifically, off-the-shelf technologies, such as mobile phones, and established infrastructures, such as 3G networks, are far more robust than research prototypes, generally require less maintenance, and if they fail can easily be fixed or replaced. Material ownership means that people are in possession of and in control of the artefacts that make an intervention technically viable. Owning the technology, as seen in CrowdMemo, also means that people possibly have the skills required to operate it and appropriate it in the long term.

However, although necessary, material ownership is not sufficient for sustained engagement. Insights from the Smart Citizen case study in Barcelona revealed that funding and owning the technology does not necessarily translate into active participation, a fundamental issue that has been largely overlooked in previous reports that equate the success of a crowdfunding campaign with the active use of the civic technologies [Kera et al., 2013; Abe, 2014]. Those in the Amsterdam community were lent devices in exchange for participation and proved to be more engaged than those in Barcelona. They felt responsible for the data they produced and collaborated to envision meaningful ways to act on their environments; for example, by mapping noise levels in an area to revise legislation for bars and cafes. It could be argued that the participants felt ownership over the intervention itself through their practical and emotional involvement [White, 1959], for which the sensor technologies were a necessary means. This suggests that a sense of **meaningful participation** can nurture a feeling of ownership, and that people may feel like they control and have a right over an intervention when their participation is required for its social enactment and future achievement. Along similar lines, Le Dantec and DiSalvo [2013] argued that the ownership was not only about the ownership of the material product itself, but also about the ownership of future attachments and social relationships around the civic technologies. They observed the role of ownership in the work of infrastruturing as it oriented the participants towards appropriating the technology to articulate shared concerns and engage in design for future use.

As seen in chapter 6, the City Commons approach puts ownership at the centre of the participatory process. It builds on the notion of the commons to establish, from the beginning of the intervention, a space for collaboration that is based on individuals' contributions to achieve a collective good that is managed and governed by the community [Ostrom, 2015]. As seen in the Dampbusters intervention, the vision of the commons successfully galvanised people, fostering conversation on timely topics such as who owns the data and the technologies? Who can use them and how? It also embedded a strong sense of attachment to the intervention. The commons approach seems to enact both, legal ownership in terms of property rights and psychological ownership in terms of feeling of control and attachment. The Dampbusters case study demonstrates that following a commons approach can both foster community engagement and ownership.

7.2.1.2 Participatory approaches

Following participatory approaches, such as Action Research, can enable a sense of meaningfulness by ensuring that the intervention delivers value to the stakeholders involved [Crabtree et al., 2013; Taylor et al., 2013]. People in Arequito who took part in CrowdMemo had a strong sense of ownership, which was a consequence of several factors. They instigated the project by contacting the researcher with a request to collaborate. They also raised all of the funds to support it. The stakeholders were involved from the outset in the organisation and logistics of the project. This included setting the goals of the intervention in collaboration with the researcher, organising interviews between children and old people, and public social gatherings like the premiere. In Bristol, like in CrowdMemo, both KWMC and the City Council instigated the collaboration with the researcher and participated in the development of the framework, which they then applied in a number of local projects on their own terms, one of them leading to the Dampbusters intervention. In the Smart Citizen pilot in Amsterdam, the participants where involved in setting up some of the goals of the project and making important decisions such as what to do with and how to use the collected data; which fostered their sense of ownership.

Moreover, all three interventions, CrowdMemo, Smart Citizen in Amsterdam and the development of the framework in Bristol provided **value** for all of the stakeholder groups that were involved. For example, in the first case, children were excited about using the technologies and curious about the stories they were told by the old people they interviewed. Elderly participants felt valued and useful and enjoyed sharing their memories with the children and having them preserved as digital stories. Members of the photography collective valued CrowdMemo because it encouraged the community to reflect about the architectural heritage of Arequito. Teachers valued learning new technology skills that enhanced their classroom practice. The school management found value in being able to play a significant role at the heart of the community. In Bristol, the Dampbusters participatory intervention delivered value to the City Council and KWMC, who deepened their efforts towards citizen engagement and digital inclusion, to the varied stakeholders interested in addressing the issue of damp housing (from residents to landlords and neighbourhood associations), and to the many community members who wanted to contribute their time and skills to effect positive change. These case studied suggests that following Action Research principles can facilitate a sense of valued ownership: involving community stakeholders in the conception and running of the intervention and ensuring that the project provides value for each stakeholder. The importance of these factors for sustained engagement has been recognised in the Action Research literature:

> *"As stakeholders devise a course of action that 'makes sense' to them and engage in activities that they see as purposeful and productive, they are likely to invest considerable time and energy in research activities, developing a sense of ownership that maximises the likelihood of success. [Stringer, 2004: 168]".*

To this end, the City Commons approach builds on these principles and fosters the development of a sense of ownership by instantiating an Action Research process. From the first phase, identification, participants decide what the focus of the intervention will be. In the second stage, framing, they agree on how to tackle it, what needs to be achieved, who the stakeholders are and how long the intervention should last for. The sense of ownership continues to be developed through the design, deployment and orchestration phases, as participants learn how to make their own technological artefacts (leading to a form of material ownership) and implement them while negotiating a governance protocol, both for the tools created and the data collected. During the sixth phase, output, the participants document and discuss their achievement, they reflect over the intervention and their participation to possibly embark in a new action cycle. As demonstrated in the Dampbusters case study, following such a participatory approach fostered community efficacy and affectance (the power to influence one's environment), both attributes of psychological ownership [White, 1959].

Finally, the CrowdMemo and Dampbusters case studies demonstrated that an important aspect in the development of a sense of belonging and ownership is to share a **common language.** In CrowdMemo the participants who continued the intervention renamed the project to make it sound more local and facilitate sensemaking. They replaced CrowdMemo for 'Natives and immigrants at the 202 of Arequito' to refer to the relationship between the children (digital natives) and the older people (digital immigrants). Coincidentally, KWMC and Bristol City Council renamed the city commons approach as The Bristol Approach. In the Dampbusters intervention a 'jargon buzzer' was used during workshops to prevent people from using niche terminology. The importance of language has been stressed in the Action Research literature, in particular to suggest that interventions should be documented following the “verbatim principle”, which emphasises the use of terms and concepts drawn from the words of the participants in an effort to minimise the propensity to conceptualize events through the researcher’s interpretive lenses [Stringer 2013]. The case studies in this thesis suggest that the use of non-technical language in every phase of the intervention (not just in the documentation) can foster inclusiveness and ownership, as well as recognise forms of appropriation (i.e. changing the name of the intervention).

7.2.2 Skills and capacity

Engaging in a technology intervention typically requires that community members have technical skills that allow them to make sense of and proficiently appropriate technological tools. In projects like CrowdMemo, where broadly available ICT such as mobile phones, online platforms like YouTube and digital cameras are employed the intervention is likely to profit from participants’ existing skills, reducing the learning curve. Building on these skills, it is easier to support the development of more advanced techniques such as the making of digital storytelling and using QR code readers. Merkel et al. have also identified the importance of developing participatory processes that take advantage of a community’s skills in order to develop and sustain an intervention [2004]. In CrowdMemo, this was done by using the participants’ technology and embedding workshops and sessions of training in the school curriculum.

However, as pointed out by [DiSalvo et al., 2009], while personal computers and mobile phones are pervasive in everyday life, sensing technologies are still novel and largely unfamiliar to most people. It is necessary for people to become accustomed to and learn how to use these tools before they can meaningfully engage with them. Along these lines, the studies on Smart Citizen demonstrated that having an active participation in an intervention that uses novel IoT sensing devices requires that users have technical skills and data literacy. For example, it was found that users struggled to set-up their sensor kits, which hindered their engagement with the intervention. Additionally, once users managed to connect the sensors and start gathering data many of them, especially those in Barcelona, disengaged if they couldn’t make sense of or use the resulting data. In the Dampbusters project, following the City Commons approach several workshops and meetups were organised to support the community to develop the technical skills that were necessary to co-design and make the sensors, as well as to make sense of the collected data. As learnt from all three case studies, community coordinators and champions can support the development of skills in the community by:

- **Providing troubleshooting advice and documentation:** this should be accessible for non-experts. This means, translated to the local language and free of technical jargon and complex terminology. Step-by-step guides are useful in that they can demonstrate how to do something, e.g. setting up a sensor or producing a piece of digital storytelling.
- **Fostering internal learning by organising group meetups, lectures and workshops** where people feel comfortable asking questions, sharing and mongling was crucial to support the CrowdMemo, Smart Citizen and Dampbusters communities to develop technical and data literacy skills, as well as to build capacity. Workshops in particular are the backbone of collaboration as they offer opportunities for people to interact, contribute their own skills and knowledge and develop new concepts, ideas and solutions while taking into consideration different needs and perspectives. As asserted by Muller *"Workshops are (...) a kind of hybrid or third space, in which diverse parties communicate in a mutuality of unfamiliarity, and must create shared knowledges and even the procedures for developing those shared knowledges"* [2003:20]. The place where workshops are held has a strong impact on attendance and inclusiveness. While Muller suggests that they should be held at the workplace [2003], the Dampbusters intervention showed that to achieve inclusive participation the workshops needed to be held in the area where the beneficiary community resides or where transportation is not a barrier.
- **Enabling peer-to-peer assistance:** the findings from both studies on Smart Citizen showed that processes of learning can take place within the community, when members with more technical skills help others to overcome issues. Merkel et al. [2004] also discussed how engaging volunteers with technical skills was crucial to the sustainability of community ICT interventions. This process can strengthen social interactions among participants and the overall sense of community. Volunteers with technical skills can also lead the development of technical infrastructures,

as shown in the Dampbusters study, where one volunteer took the lead on the hardware and software development of the Frogboxes, while another one led the design and making of the frog-shaped enclosures. However, technical volunteers may have preferences over technology, which can create tensions within the community. For instance, in Bristol, the choice of Raspberry Pi over Arduino meant that a group of prospective contributors who were Arduino enthusiasts abandoned the intervention. It is important that community champions and orchestrators help overcome these tensions by creating opportunities for people with different skills and preferences to contribute (e.g. by fostering parallel lines of development).

The case studies in this thesis demonstrate that embedding skills and supporting capacity development is crucial to the process of insfratructuring publics. Skills are necessary to use, design, create and meaningfully appropriate technologies. While interventions that use broadly available ICT that people already know how to use might need to dedicate less efforts to training sessions, those that utilise more novel devices such as IoT and sensors should create opportunities for people to learn how to interact with them and even make and assemble them. Furthermore, as we will see in the next sections, workshops and sessions where people meet to learn provided the added value of fostering social interactions.

7.2.3 Social interactions

Social interactions are known to be an important enabler of community building [Carroll & Rosson, 2013; Hayes, 2011] and necessary for the development of social cohesion peer pressure and social norms [Consolvo et al., 2009; Schultz et al., 2007]. It is through social interactions that we form ties with others and build social capital [Putnam, 2002]. Social interactions emerged as an important factor supporting the sustainability of both the CrowdMemo and Smart Citizen interventions. In the former, the face-to-face encounters between older people and children had a positive impact on engagement and the QR codes on facades became talking points that contributed to sustaining community engagement by providing opportunities for people to meet and talk. At the public celebrations, such as the premiere, people again had the opportunity to meet, which contributed to strengthening the community bonds. In contrast, the study focusing on the Smart Citizen community in Barcelona highlighted that the users felt that poor community building actions by the Smart Citizen team had hindered engagement (c.f. [Nov el al., 2010]); the lack of social interactions among users (both online and offline) prevented them from helping each other with technical difficulties, discussing and making sense of the data, and even planning joint activities to further develop the project. They expected the Smart Citizen team to organise events to foster community connectedness. As a result, the City Commons approach places special focus in creating opportunities for social interactions, which again had positive results in the Dampbusters project.

These cases studies however demonstrate that there are different ways in which civic technology interventions can foster distinct types of social interactions, and that civic technology interventions can articulate them according to their needs and possibilities:

- **Face-to-face conversations:** between different community members and as a result increase their engagement with project. In CrowdMemo, the encounter between children and the elderly members of the community was identified by interviewees as one of the most important aspects of the project. In Smart Citizen, the lack of social interactions among participants in the Barcelona community had a detrimental effect on the sustainability of the intervention. Steels & Tisselli [2008] argue that face-to-face meetings between community members are essential to the success of an intervention because they create the necessary trust and engagement for collective action. Face-to-face interventions can be fostered by organising events and by creating opportunities for people to meet, mingle and talk.
- **Public events and celebrations:** organising events around themes pertaining to the intervention can create opportunities for participants and outsiders to meet and interact, resulting in an expansion of the community and the impact of the intervention. Such events are known to foster community connectedness and social capital [Hayes, 2011; Caroll & Rosson, 2013]. In particular, previous studies have highlighted the importance of organising events to celebrate milestones, which can increase the community's sense of efficacy and pride [Hayes, 2011]. For example, during a three-month long intervention using Smart Citizen Kits in

Amsterdam, The Waag Society organised three face-to-face events. Participants reported that these actions had been a key driver supporting their engagement with the project. In CrowdMemo, the organisation of three key events facilitated social interactions: the premiere; 'Cafe Literario'; and the 'Encuentro en la Llanura'. At these gatherings community members and townspeople who were not initially involved with the project could share experiences and discuss the digital stories, and more generally the heritage of the town, in a group context. Following people who attended the event visited the school in subsequent days to request information on the project, express their interest and even share more anecdotes about the places represented in the microdocumentaries. In the Dampbusters, the initial networking event led to the formation of a diverse community of contributors by inviting people from different backgrounds and skillsets. This shows that public events play an important role both in supporting the emergence of publics and communities as well as sustaining them. Nevertheless, organising events that are inviting and inclusive can be challenging. People who work full time may not be able to attend unless the events are organised in the evening and there is evidence that certain places can deter participation from particular groups (e.g. people who have not had the opportunity to go to school often avoid going to meetings that are held on educational institutions, as reported by Cornwall [2008].

- **Distal interactions:** blogs, websites, emails and coordination platforms such as Trello or Slack can also facilitate social interactions among community members. These forms of distal interactions where deemed important by community coordinators in all three interventions reported in this thesis. In the Dampbusters project, for example, the community coordinators found that distal interactions where useful to keep people on board and taking part in participatory process between face-to-face events such as workshops. They used emails to hold discussions and platforms such as stickymoose.com to support complex interactions such as decision making, voting and budgeting. In the Smart Citizen, the communities in Barcelona and Amsterdam meet during an online session held via Google Hangout, an opportunity to interact that was highly valued by all the participants. In CrowdMemo, the project's blog and the YouTube channel allows participants and outsiders to share views and anecdotes both about the collected memories and the intervention itself. While off-the-shelf platforms were considered useful by

> the communities in all three interventions, in Bristol the coordinators found that it was often hard to choose a platform or channel that everybody was comfortable using. While some preferred email others preferred to use social media or even mobile phone messaging systems. It was also felt like an integrating platform would be desirable, allowing people to coordinate activities, discuss, vote and engage in participatory budgeting from an integrated platform.

CrowdMemo, Smart Citizen and Dampbusters demonstrated that increased community identity and civic action can come about by facilitating social interactions. Moreover, there are different opportunities to support social interactions, both face-to-face and distal.

7.2.4 Summary

The process of infrastructuring enables members of a community to identify and address issues in an on-going manner, creating a socio-technical interventions that enables the trajectory between a current situation and a future one [Le Dantec & DiSalvo, 2013]. In this sense, infrastructuring becomes a crucial component to foster the sustainability of a community over time. CrowdMemo, Smart Citizen and Dampbusters revealed some of the factors that play a key role in the process of infrastructuring community engagement. These are valued ownership, which entails notions of material ownership and meaningful participation, and participatory approaches; skills, and social interactions. These factors play a crucial role in the configuration of a conductive space where meaningful collaboration towards a shared goal can take place. They demonstrate that the technology, although necessary, is only one aspect in the process of building and sustaining groups that aim to achieve positive social change.

7.3 Impact

The third question asked at the beginning of this work was, what kind of societal impacts can bottom-up civic technology interventions have and how should they be assessed?

In the last decade we have seen a raise in HCI projects that seek to address social challenges and achieve positive change. Borhner & DiSalvo [2016] have referred to this as the turn to the civic, while Hayes noted that a comparison between the proceedings of the 1990, 2000, and 2010 CHI showed a substantial increase in the publication of civically engaged research [2011]. In fact, in 2005 the CHI conference established the Social Impact Award to recognise individuals who promote the application of HCI research to pressing social needs. Examples of criteria for selection include facilitating use of technology by diverse populations, increasing access to technology in low literacy context, reducing economic barriers for access to technologies or supporting technologies for international development and conflict resolution, among others.

The case studies presented here shed light on some impacts that research and bottom-up civic technology interventions can achieve. An obvious starting point is to assess whether an intervention has achieved the goals that it was set up to achieve or not. However, there are other positive impacts that emerge as part of the process of infrastructuring, namely the development of community bonds, capacity and skills; or the establishment of new social collaborations that can catalyse change. Moreover, external impacts such as those reported in the CrowdMemo and Smart Citizen studies can be counted as impacts due to their capacity to empower other publics and communities. Five key notions related to the potential impact of civic technology interventions emerged across the work reported in this thesis. Some are directly linked to the intervention, such as effectiveness, social collaboration innovation, and community capital; while other two are indirect: communications outreach and appropriation.

7.3.1 Effectiveness

The effectiveness of a civic technology intervention relates to the goals that were set up from the outset by the stakeholders groups. Naturally, they relate to the matter of concern that instigated the formation of the publics in the first place, but as the case studies have demonstrated the stakeholders usually have different motivations to become involved. For example, CrowdMemo emerged around a concrete matter of concern [Latour, 2004], namely heritage preservation. A preoccupation for the increasing degradation of the places that were fundamental to the collective history of the community galvanised people in Arequito to take action. However, the school staff wanted to find a way to integrate new technologies in the classroom, which meant that both teachers and students acquired new technical and digital literacy skills. The photography collective wanted to raise awareness about heritage preservation and engage local people in the process of documenting the state of the town. The researcher wanted to investigate the factors enabling the sustainability of civic technology interventions.

The impact indicators collected during and after the project demonstrate that these goals were partially achieved. In fact, the tangible heritage of the town was preserved as several places deemed important for the community here refurbished and the intangible heritage, namely the memories of the townspeople were recorded and shared. The teachers and students learnt new digital skills and integrated technologies in their educational practice. The researcher was able to study the intervention and articulate factors that had contributed to the sustainability of the intervention, which lasted for over two years and beyond.

The case studies reporting on how communities used Smart Citizen show a different picture. While the community in Amsterdam galvanised with the ambition to measure air quality they found that the sensors did not provide the data that was needed to make sense of the problem and foster remedial actions to improve air quality. The Waag Society and Amsterdam Smart City, in their role of project instigators were more interested in exploring how novel bottom-up technologies could help citizens to become more active in the civic domain. While the latter was partially achieved, in the sense that the stakeholders did effectively organise the intervention and learnt about the challenges and opportunities associated to the enactment of civic engagement through technology, it is unclear if these goals where shared and valued by the participating citizens. Ultimately, they all agreed that the project had led to some learning about how to articulate this kind of engagements and how to use sensor technologies and make sense of data. While some participants disengaged because the goal of tackling air pollution was not met, others remained engaged because they understood that the intervention was a first step in the right direction. What this experience showed is that for an intervention to be effective there needs to be clarity regarding what the goals are, where the stakeholders need to be transparent about their ambitions and the community has to negotiate the boundaries and aims on their collective effort. Moreover, there needs to be a joint plan set up from the beginning that states what these goals are and how they will be achieved and measured.

The City Commons approach attempts to facilitate this process during the Framing phase. The idea is that before moving into designing plans and tools the community knows what the aim is and all the stakeholders find value in contributing to an outcome. The Dampbusters case study shows how the instigators identified the problem of damp and stakeholders who were interested in addressing it. Together they agreed that the aims of the intervention were to chart the houses with damp to demonstrate the scale of the problem and to develop sensors that could measure temperature and humidity. For KWMC and the City Council, the goal was to test the framework and learn more about how to run large-scale civic engagement processes to address real urban challenges. Taking into account resource and time constraints, the stakeholders decided to first pilot their tools at a small scale and complete a first framework cycle. As a result, they developed a prototype mapping tool to collect and geolocate damp reports and also designed and made the Frogboxes. While the ambition of the participants was to remedy the problem of damp houses, the goals that they had agreed on were those mentioned above. During the Outcomes phase they assessed their results and considered that had been effective in terms of achieving their goals. They are now moving on to scale up the intervention, which entails improving the sensors and the reporting tool. On their side, KWMC and the City Council considered that they had achieved their goal to test the framework and motivated the development of new forms of civic participation to tackle a local problem.

What the case studies show is that measuring the effectiveness of civic technology interventions is a complex process, which requires that a number of tasks and processes be put into place. These are:

- The stakeholders transparently communicate their goals from the outset, even if they are meta-goals, just as testing a framework or the enactment of certain participatory processes. While goals may change over time, it is important for the stakeholders to articulate what is expected from the intervention and how the latter can deliver value to all.

- The stakeholders agree on these goals and on the indicators that will be utilised to assess their progress towards them. To ensure that both the goals and the indicators are meaningful to the community, methods such as "community level indicators" proposed by Woods et al. [2016] can be implemented.

- The goals are realistic in scope, time and scale. For example, some participants in the Amsterdam community disengaged because they thought that they were going to be able to measure and mitigate air pollution. However, the intervention did not achieve this goal mainly because the sensors were not robust enough to accurately measure air quality. Nevertheless, the instigators agreed that the intervention had been effective because they did learn about how to run participatory civic projects. This mismatch between stakeholders goals can be problematic, leading to the community participants to feel like they have been used to achieve goals that they were unaware of; a challenge that has been highlighted by Arnstein [1969].

- The goals are long and short term. It is clear that certain ambitions such as mitigating air pollution or mapping all the houses with damp in a city can be hard to achieve. However, as shown in the Dampbuster study the stakeholders can agree on smaller goals that help them move towards the larger one. This can lead to quick wins that foster engagement and a sense of effectiveness [Kotter, 1995].

- The process of impact assessment is done collaboratively and the stakeholders discuss what has been achieved and what was failed. This can lead to a better understanding of what happened and possibly a new agreement on goals and indicators.

While agreeing on goals seems to be crucial to the effectiveness of a participatory intervention, it is likely that goals might change during the course of a project. In particular, this can happen if the community is tackling a problem that is complex and has unknown ramifications. For example, in Amsterdam the community learnt that measuring air quality is significantly harder that what they had expected, and that the collected data needed to be processed for them to be able to make sense of it. In CrowdMemo, the participants found that not everybody agreed on the stories told about the places that had been selected, and that memories were sometimes contested. A way around these unexpected discoveries is to ensure that the stakeholders revisit their goals during the intervention to ensure that what they aim to achieve can actually be achieved, or even have the opportunity to agree on new goals and indicators. Involving domain experts, as done in Bristol and Amsterdam, and help to ensure that the aims of the intervention are sensible.

7.3.2 Social collaboration innovation

The case studies have demonstrated that although technology is important to address matters of concern, sometimes, to be resolved, the articulation of new collaborations between different groups and individuals is required [Steels & Tisselli, 2008; Chamberlain et al., 2012]. For example, a group of citizens may discover that air pollution in a specific neighbourhood is beyond healthy levels. They may also identify that the main cause for pollution is the amount of vehicles using a main road. While knowing this is important, the solution may be in hands of the City Council, that should find a way to limit the traffic in the area.

This was evident in CrowdMemo, when the children established a connection with the elderly to be able to access and document the memory of the community. Moreover, after the community mobilised to protect certain places in Arequito the Town Hall assigned resources to refurbish the places. Without the intervention of the Town Hall, which was not initially involved in the project, this outcome would have not been possible. In Bristol, the community identified that rented houses in an underprivileged neighbourhood were severely affected by damp. They established a partnership with the Easton Energy group who knew the area and the local residents to be able to deploy sensors in those houses. Moreover, they managed to initiate conversations with landlords to collaborate towards a solution. In Amsterdam, establishing collaborations with the air quality experts meant that participants learnt about the challenges of measuring air quality and received support to improve their practices.

In all three case studies the establishment of new social collaborations has been instrumental to the enactment and, in some cases, effectiveness of the interventions. Moreover, it seems like solutions often emerge from these articulations, where different skills and capacities are combined. This is particularly important when dealing with complex matters such as urban challenges, which entail social, political and economic constraints. An impact of civic technology interventions can be their ability to foster innovative social collaborations, which can be transformative for society. However, as learnt from the case studies, this can be challenging in particular if the different groups don't share goals in common or are in conflict. As argued by Arnstein, in the end "citizen participation is a categorical term for citizen power" [1969:216] and, naturally, powerholders might not always want to share or give away their power. An approach to this is, as learnt in the Dampbusters study, to negotiate how a collaboration may be enabled for mutual benefit. For example, when some landlords realised that open data about damp could be aggregated with land property data revealing that they were renting houses that were in poor conditions. This meant that collaborating with the intervention could help tenants while not damaging their reputation. Clearly, the sustainability of these new social collaborations can help achieve grander goals in the long term.

To foster the emergence of social collaboration innovation, civic technology interventions can:

- Identify key power holders that are instrumental to the solution of the issue at stake. In CrowdMemo, for example, allowing the experts from the Ministry of Education to document the intervention meant that digital storytelling was later on taught to thousands of teachers in the state of Santa Fe, and that the Chamber of Deputies awarded the intervention. These actions raised the profile of CrowdMemo and fostered community pride.

- Establish relationships on equal footing, negotiating how the intervention can be mutually beneficial. In the Dampbusters intervention this was crucial to engage landlords and the City Council.

- Negotiate power dynamics by discussing how a collaborative effort is required or may lead to better outcomes. In Amsterdam, for example, air quality experts saw the potential of collaborating with citizens who were interested in collecting and sharing data, which would increase the granularity of the official sensing network and lead to larger datasets.

- Demonstrate the value of the intervention by mobilising people and engaging diverse stakeholders. Like in CrowdMemo, when the Town Hall became aware that over 600 people had attended the public premiere they decided to support the intervention.

7.3.3 Community capital

It has been shown throughout the case studies how, as a result of processes of infrastructuring, communities developed various forms of capital. This entailed social capital, in the form of new bonds and ties among participants and with external stakeholders [Narayan-Parker, 1999]; new skills, from technical to data literacy [DiSalvo et al., 2009]; and capacities such as collaboration, decision making, planning and execution [Merkel et al., 2007]. Community capital is the result of a sum of different types of capital, including environmental, human, social and cultural capital and is crucial to the sustainability and resilience of communities. It has been largely studied in the field of development [Callaghan & Colton, 2008] but remains under explored in HCI.

In the process of producing community capital, the commons and commoning [Bollier, 2007] can provide a framing to make sense of and enact open, collaborative and contribution-based practices, opening up questions related to ownership, responsibility and control over how technologies and solutions to common challenges are designed, delivered and made accessible to others. In this sense, the commons become an organisational arrangement that enables communities to address issues on their own terms and for the common good.

Assessing if and how civic technologies foster the development of community capital can help plan and deploy more impactful and beneficial interventions. CrowMemo, Smart Citizen and Dampbusters have all in different measures, contributed to the development of community capital. For example:

- Cultural capital entails the man-made tangible and intangible things that underpin community life, including the heritage, language, ethnicity, sense of aesthetics, stories, traditions, values, etc. [Throsby 1999]. Culture is structural to identity and to the enactment of social capital. By preserving the heritage of Arequito, CrowdMemo supported the development of cultural capital, which is directly linked to the sustainability of a community.

- Human capital refers to the collective skills, knowledge, or other intangible assets of individuals that can be used to create value for them and their community [Becker, 2009]. By fostering the development of hard and soft skills, from sensor literacy to capacity and collaboration, CrowdMemo, the Smart Citizen intervention in Amsterdam and Dampusters increased the human capital of the communities involved. There is evidence that human capital is transferable, and that individuals apply their skills and capacities in different contexts.

- Environmental capital refers to the natural resources that sustain the life of a community, from air to water and land [Costanza & Daly, 1992]. These commons are crucial to the survival of individuals and communities. Like the Smart Citizen intervention in Amsterdam, a large number of civic technologies aim to address environmental challenges. If effective, these kinds of interventions can help communities to monitor and protect their natural commons, and increase awareness about their state.

- Social capital, as described before, refers to the set of relationships that have developed around shared values, norms and trust [Coleman, 1988]. The interventions studied here enabled social interactions, fostering the development and strengthening of ties and bonds.

In the best cases, the community capital fostered by civic technology interventions will last and develop even further, allowing publics and communities to improve their environments and situations. What is important to note is the profound impact that socio-technical ventures can have if they are planned and orchestrated to support the development of community capital.

7.3.4 Appropriation

A final type of impact that was revealed in the case studies is external appropriation. Appropriation can have different meanings, but a common denominator across them is the notion that individuals are active actors who play a role in the adaptation of technologies to serve their own purposes [Dix, 2007]; and that people integrate technology into existing practices or create new uses that differ from common use patterns. Here the term 'external appropriation' is used to indicate how individuals and groups who were not initially involved with an intervention have adapted it to meet their own goals.

In CrowdMemo, for example, neighbouring communities took up the format of the intervention and developed their own projects in Pujato and San Jose de la Esquina. The Ministry of Education in Santa Fe adapted the underlying principles of digital storytelling and created a training programme for school teachers. We have also seen how the Smart Citizen interventions in Barcelona and Amsterdam were replicated in other cities, where instigators contacted both the Waag Society and Fan Lab Barcelona to learn more about how to set up their own pilots. A number of groups in different cities inside and outside the UK have been in touch to appropriate the City Commons approach to enable new civic engagement interventions. It is clear that external appropriations can potentially scale up the impact of civic technologies. Two main factors contributed to fostering the external appropriation of the projects: communications outreach and openness.

- Communications outreach: All three interventions were presented in the media, which contributed to fostering other outcomes. For example, in CrowdMemo, media coverage meant that external stakeholders became aware of the project while internal stakeholders developed a sense of pride. Like in the case of Smart Citizen, it was the perceived novelty of the approach in the former, and the technology in the latter than attracted journalists to write stories about them. The City Commons approach also received media coverage, appearing in the National Dutch TV and Wired as an enabled of bottom-up citizen engagement opportunities. While journalists rarely described the challenges associated with these interventions but rather focused on the promising aspects, their stories helped to raise the profile of the interventions. This often created opportunities to establish partnerships and get funding, such as in the case of Smart Citizen.

i. Openness: a common denominator across all three case studies was their openness, which facilitated their appropriation and adaptation by external stakeholders. Openness here is used to define an attribute that goes beyond the notion of open source technology. For example, CrowdMemo was designed to be open in the sense that it used widely available and low cost off-the-shelf technologies, provided clear step-by-step instructions on the project website, and explicitly encouraged appropriation. In consequence, the project provided an attractive opportunity for other schools striving for ICT training and learning activities using readily available technologies. In Smart Citizen, indeed the fact that the technology is open source fostered its appropriation by academic, practitioners and organisations running research initiatives. The project has also been able to attract large amounts of funding, in particular from the European Union, that promote the use and appropriation of open source and affordable technologies to increase bottom-up participation in cities. This approach to advancing civic tech through the use of open source technologies has been investigated by Teli et al. [2015] who found that it increased sustained participation and innovation in the co-creation of solutions to urban challenges. Moreover, researchers working on civically-engaged projects [DiSalvo et al., 2009, Vlachokyriakos et al., 2014] and advocating for a turn to openness in participatory design [Marttila & Botero, 2013, Teli et al., 2015] increasingly aim to promote empowerment through technology by demonstrating, and handing over to people open toolkits, technologies and know-how for them to use and appropriate for their own situated purposes [Rogers & Marsden, 2013].

The experiences in the case studies shed light to a number of factors that seem to contribute to the external appropriation of civic technology interventions. These are:

- Using off-the-shelf broadly available and/or open source technologies
- Providing step-by-step guides on how to design and deploy the interventions
- Documenting and sharing the processes, facilitating knowledge of how and why things worked out or didn't
- Aiming for wide media coverage
- Establishing networks with other groups who are facing similar concerns or interested in similar topics.

7.3.5 Summary

This section has discussed some of the impacts that were achieved by the three case studies presented in this thesis. They have been categorised in terms of direct impact, which includes effectiveness, social collaboration innovation, and community capital; and indirect impacts, including communications outreach and appropriation. As argued by Heyer & Brereton, methods for impact assessment need to be better integrated within HCI if the field aims to achieve and demonstrate positive social impact [2010]. Identifying and assessing impact is important to promote accountability, track progress and make sense of the effectiveness of a project, which in turn helps to inform decisions to improve it, and to increase motivation [Gray-Felder & Deane, 1999]. The impacts discussed in this section do not aim to provide an exhaustive method of assessment but can be useful to illuminate the potential ramifications of civic interventions and the responsibilities that researchers and practitioners face when collaborating with publics in real world settings.

7.4 Supporting participatory orchestration

The fourth question asked in this thesis was, how can the notions of meaningful engagement, sustainability, and impact inform strategies to achieve successful community-led, civic tech interventions?

In this thesis I have conveyed the notion of participatory orchestration to refer to the non-hierarchical process of infrastructuring, which is enacted by community champions or facilitators and entails following participatory approaches, supporting the development of valued ownership, skills and social interactions (chapter 4 and 5). In chapter 6 a strategic framework that builds on the notions of meaningful engagement, sustainability, and impact was co-created with partners as a boundary object [Star, 1989] that aids the process of participatory orchestration by scaffolding it according to six key phases: identification, framing, design, deployment, orchestration, outcomes. The effectiveness of these strategies was demonstrated in Chapter 6.

Recent grassroots civic movements that use technology, such as the Arab Spring and the Occupy Movement have been characterised as self-organising and emergent [Van Stekelenburg, 2012]. While they do in fact challenge traditional discourse on how social action requires identifiable and hierarchically positioned leaders, these movements build around forms of non-hierarchical leadership that are relational and socially constructed [Wood, 2005]. Sutherland et al., found that democracy and participation are the key principles underpinning these organisations, where forms of direct democracy are privileged over representative democracy. By documenting five instantiations of grassroots social movements they also found that to facilitate decision-making face-to-face meetings were held, where members debated activities and facilitators oversaw the processes. Moreover, acting as coordinators, participants planned and organised events to sustain the movements and achieve their goals [Sutherland et al., 2016]. What these examples demonstrate is that grassroots does not equate to lack of leadership and organisation. In contrast, bottom-up civic action requires that new forms of distributed leadership are socially constructed and that people employ methods to organise and orchestrate participation in a horizontal and transparent way.

The three case studies presented in this thesis exemplified forms of championing and orchestration. In CrowdMemo, a member of the photography collective acted as a champion and contacted the stakeholders, organised the first meetings and motivated others to support the initiative. However, he was not recognised as a leader, as all the participants had equal weight in making decisions over the intervention. In fact, the members of the photography collective, the school staff and the researcher collaboratively organised and deployed CrowdMemo in a rather horizontal fashion. In the Smart Citizen study, compared to the one in Barcelona, the intervention in Amsterdam demonstrated that a more orchestrated deployment led by local champions significantly fostered community participation. The Waag Society and a group of experts and volunteers orchestrated the Smart Citizen pilot by engaging a group of users with diverse interests and skillsets, adapting the technology and providing skills, and facilitating social interactions and peer to peer assistance, that in turn fostered community engagement throughout the intervention. This type of orchestration resembles that proposed by Crabtree et al. [2004], where the community creates a conducive environment for cooperation among members, augmenting the shared resources of the community to collectively tackle difficulties.

The role of facilitators, orchestrators or champions becomes crucial, and projects that evolve around concrete orchestration provided may have higher chances of achieving sustained participation and possibly effectiveness, where a key part of this involves establishing the goals of the project and the participation means. Maruyama et al. [2013] asserted that technical volunteers working in open data projects for social change needed more than hard skills such as programming or design expertise. To become "change agents" they also require soft skills like communication, negotiation, persuasion and change management. Additionally, to infrastructure successful movements they need to publicise success, maintain momentum, and rally supporters. Project orchestrators can partner up with organisations that have in depth knowledge of the particularities of different communities to better assess how to enable inclusive participation. The case studies on CrowdMemo, Smart

Citizen and Dampbusters revealed key strategies for participatory orchestration to support the sustainability of civic technology interventions:

- Mobilising people around matters of concern, connecting networks and establishing partnerships across different interested parties [Crabtree & Chamberlain, 2013]
- Organising initial stakeholders meetings and facilitating discussions about goals, milestones and methodologies
- Recruiting, inviting and drawing people to participate
- Identifying different interests and abilities among participants and enabling processes where each can perform roles that contribute to the community
- Supporting the development of skills, identifying gaps and bringing along experts and champions who are knowledgeable about issues and can help frame and focus community efforts [Corburn, 2005]
- Fostering social interactions through the organisation of meetups, events and workshops that can keep participants engaged [Steels & Tisselli, 2008]
- Mediating in situations of crisis, contacting experts, helping to channel discussions and facilitating consensus and compromise
- Findings a common language that supports collaboration among participants with different skills and backgrounds
- Fostering a space of collaboration and inclusiveness mitigating gender and cultural biases

7.4.1 City Commons framework

The City Commons approach (chapter 6) assembles notions of meaningful engagement, sustainability, and impact into a cohesive strategic framework that supports participatory orchestration. Meaningful engagement is achieved by drawing engagement from matters of concern and their associated publics or communities; by following a participatory commons-based approach to technology design, that enables community ownership and builds a shared narrative. Sustainability is achieved by *infrastructuring*, which includes nurturing community capital, supporting the development of skills and capacity, social bonds and new collaborations so that communities can effectively tackle the issues at stake. Impact is achieved directly through the effectiveness of the intervention, and indirectly by producing open commons: novel open source solutions to local challenges, which can be appropriated by external stakeholders.

Applied in the Dampbusters intervention, the City Commons approach demonstrates how it can aid the process of participatory orchestration of bottom-up civic interventions. This is done by scaffolding the complex process of issue-solving and technology co-design into an easy-to-follow sequence of six phases: identification, framing, design, implementation, orchestration, and outcomes. The framework should not be seen as a solution to the problem of sustained community engagement per se, but rather as a management tool that allows communities to self-organise to act in the civic real in pursue of social change.

As revealed in the Dampbusters project, the City Commons framework can aid the process of orchestration by providing phases for champions to plan, enact and communicate crucial actions in a sequential structure. Although phases can overlap or develop in parallel the model provides the backbone against which to do this while keeping the process in track. Phases also create opportunities for reflection and celebration of achievement, and facilitate the process of sharing learning [Hayes, 2011]. Nevertheless, the case study also showed that the framework alone is not enough as participatory orchestration requires the use of tools and platforms that enable commons action groups to form, organise, and make decisions together. Moreover, it was found that due to the complexity of the collaborations involved in a civic technology intervention, decisions need to sometimes be taken on the fly. This entails revisiting past phases, organising unexpected workshops and events or sorting out tensions. To this end, the level of specificity of the framework, which allows for community coordinators to decide what type of activity should be conducted and for how long in each phase is appropriate for this kind of process [Star & Griesemer, 1989].

7.5 Methodological insights

The approach adopted in this thesis in order to investigate sustained community engagement with civic technology interventions was to investigate existing interventions and to design, deploy and evaluate novel ones.

To do this a general case study and qualitative in the wild approach was adopted, which included the use of action research and ethnographic methods [Coghlan & Brannick, 2009; Hayes, 2011; Hearn & Foth, 2005]. Within this approach, a number of individual techniques have been applied to engage with pre-existing communities, collaborate in the set up and evaluation of interventions, observe behaviours and assess impacts. This section discusses the challenges faced in working with communities in the wild pursuing social change, and explores the strengths and weaknesses of various methods used in the different contexts.

7.5.1 Evaluation of the approach

The approach adopted has been successful in terms of providing an assemblage of methods that were suitable to the study of natural occurring phenomena in real world settings with pre-existing communities. The ethnographic component allowed me to become embedded in different communities and achieve a deeper understanding of their contexts and practices, as well as facilitating the collection of data over prolonged periods of time. The Action Research component allowed me to engage with stakeholders to collaborate on equal footing, planning, deploying and evaluating interventions. However, these experiences have also revealed a number of challenges that must be considered when working and engaging with communities in this way. This section discusses reflections on the approach adopted and advice to others who may use a similar methodology.

7.5.2 Key strengths and opportunities

The primary strength of using the methods adopted in this thesis is that they allow for the study of engagement with civic causes and technologies by a variety of communities in different contexts and in the long term. Long-term studies are rather rare in HCI and certainly challenging to conduct (e.g. [Brynjarsdottir et al., 2012]). However, there are numerous academic and societal benefits of producing this kind of research. Below, I describe three key strengths and opportunities of the method adopted: familiarity with the context; extended data collection; and horizontality, collaboration and scale.

7.5.2.1 Familiarity with the context

Firstly, a key strength of using ethnography is the ability to study emergent behaviour that is deeply embedded in a complex socio-political and economic context. Civic technology interventions cannot be studied detached from the conditions that motivate their emergence. Citizens galvanise around matters of concern and seek ways to use technology to address their needs, to effect change in a direction that they trust is better or fairer. These lead to behaviours and outcomes that have to be studied in situ, because they are both catalysed and constraint by a specific context. The researcher needs to be embedded to make sense of that context and how it affects the observed phenomena.

In Bristol, for example, changes in the political landscape had an impact on the development of the City Commons approach and the general mood of the partners, KWMC and Bristol City Council. First, the change of Mayor to a different political party (Labour) meant that we lost the support of the Council, which had been involved with the development of the City Commons approach. Then, the Brexit vote followed, creating even more uncertainty among the stakeholders and the community participants. It would be naïve to think that these factors did not have an effect on the ways in which people engaged with the projects that were being researched. For example, the general mood changed, there was uncertainty and KWMC had to focus on fundraising to ensure the sustainability of their team and the interventions.

7.5.2.2 Extended data collection

Secondly, ethnography allows for the collection of data over long periods of time. This is fundamental in a study that seeks to understand sustained community engagement. Applying ethnography meant that I could collect data over time, observing how visions, behaviours and relationships changed. Long-term engagement made it possible to map out a panorama of the players that have influence over the intervention and to identify how the personal aspects of individuals have an impact on the course of action.

For example, while investigating Smart Citizen in Barcelona I became closer to the project instigators and witnessed how their vision of what society should be set the course for the design of the technology from a focus on IoT individual sensors to a focus on community interventions. This shift meant designing more features to support communities, which are being implemented in the present. Ethnography afforded the fascinating opportunity to become embedded in a context and see how it and the agents involved evolved throughout time. However, it is of course hard to know to what extent my own presence and research had an impact on this outcome. Doing ethnography means that the researcher shares time and space and builds relationships with those being studied. This of course demands that line is drawn to protect people’s privacy.

7.5.2.3 Horizontality, collaboration and scale

Thirdly, Action Research allows for the researcher to establish partnerships to conduct action and research simultaneously, with the goal to improve an aspect of reality [Hayes, 2011], empower the subjects of enquiry and foster social change [Kelly, 2005]. Following this approach, CrowdMemo and the City Commons framework (and its implementation in the Dampbusters project) became unique opportunities to enact and evaluate the factors that contribute to sustained community engagement with civic tech, while addressing problems in heritage preservation, damp housing and civic engagement.

The method provides powerful mechanisms to collaborate with others to plan, act by applying technology to address real issues on reality, observe and reflect. In this regard, the resulting technology intervention is developed according to the culture and needs of the beneficiary communities, who will have equal ownership throughout the process and over the outcomes. This of course necessarily entails a deep understanding of the community and the context and the issue at stake, for which adding an ethnographic component is useful. It also requires the negotiation of goals, ambitions and roles, which is complex because partners typically have their own agendas and there has to be compromise.

Lastly, a key strength of using Action Research is that the researcher is not alone and the projects undertaken can build on a multiplicity of skills, networks and resources, possibly leading to increased scale and impact. For example, a project of the magnitude of CrowdMemo, which involved training 260 children and 22 teachers, coordinating all the stages of production of nine micro-documentaries, including the organisation of interviews with older people, the collection of historical content like pictures and footage, and the organisation of public events would have been hard to achieve by a researcher alone. Similarly, the first cycle of the Dampbusters intervention lasted 16 months, comprised 45 events and workshops, and engaged 717 participants aged 13 to 80. This kind of project is rare in HCI where the length of the studies, including those conducted in the wild, usually run from 2 weeks to a few months [Carroll & Rosson, 2013].

7.5.3 Key challenges and limitations

There are of course numerous limitations of following the approach that was adopted in this thesis. Both ethnography and action research are incredibly time demanding, which can be problematic for PhD students who have limited time and funding to develop their research. This thesis includes three long-term projects taking place in different countries (Argentina, Netherlands, Spain, and the UK), which means that they overlapped at times and required considerable traveling. Moreover, it is very easy to get caught into the operational and political demands that characterise any multi-stakeholder collaboration in an emergent setting [Adams et al., 2013]. This leads to situations where the lines separating project management from research are blurred, and the researcher can struggle to gain perspective and differentiate the anecdotal from the rigorous. Below, I present the key challenges that emerged during the application of the methodological approach: finding and engaging with communities; collecting data over time; role of the researcher; and tensions and pains.

7.5.3.1 Finding and engaging with communities

Studying sustained community engagement with civic technology interventions entails that the researcher needs to (i) find existing interventions where instigators and participating communities are willing to collaborate with an external researcher, and (ii) finding and engaging with stakeholders who are willing to become collaborators in the design, deployment, and evaluation of civic tech interventions.

With regards to (i) there are many challenges. On the one hand, it is hard to find existing interventions where the members are happy to take a researcher on board, share information and be open and honest. There were two occasions where I approached interesting civic projects but was unable to reach to an agreement over the terms of the collaboration. Many community technology projects require external funding to sustain. This means that the project instigators need to share a successful story about the impact and reach of their efforts. If this story is not representative of the facts, then of course the researcher will find it hard to conduct the investigation. The instigators are likely to monitor the work of the researcher to verify if her findings are in disagreement with their story. Of course a researcher wouldn't want to prevent the community from accessing funding but at the same time she has to work with independence and rigour. When these tensions cannot be dealt with from the beginning, then it might be better to take separate ways.

On the other hand, bottom-up efforts can struggle to sustain, which makes them prone to failure or stalling. In many cases they run out of funding, loose traction or suffer from irreconcilable differences among participants. While a lot can be learnt from a project failure, the researcher can be left out of crucial discussions. The researcher can find herself with very little capacity to collect any data on what happened, which may lead to an unfinished study. While this is very hard to prevent or solve, it is fundamental that the researcher builds trust with the collaborators and remains in frequent contact and aware of existing tensions. Additionally, it might be useful to plan milestones that can be achieved during the length of the project to prevent a situation where the researcher is left out with an unfinished study and useless data.

7.5.3.2 Collecting data over time

As described above, a positive aspect of using ethnography is the capacity to collect data over extended periods of time. This often takes the form of field notes, pictures and even footage. While this is positive in terms of being able to observe changes in behaviour and the evolution of interventions throughout time, the researcher can struggle to assess how much data is enough, and how long should data be collected for. Additionally, a pressing issue for researchers applying action research is the need to collect data on the impacts of an intervention. Impact and fact-checking are important parts in the Action Research cycle. This can of course require that the researcher continue to collect data over time as meaningful impacts begin to emerge. Has there been appropriation and adaptation of the technology? Has community capital been developed? How are participants applying the skills that they developed? Assessing these kinds of impacts requires for the researcher to remain engaged with the community for years.

An approach is to build a relationship of trust with an informant and to arrange frequent calls or emails. In CrowdMemo, for example, I remained in touch with a member of the photography collective who kept me updated on how the intervention evolved during a period of almost three years. This was useful in terms of being aware of how the project evolved and changed while I was already working on the Smart Citizen studies. Clearly, establishing a relationship with an informant can be helpful as long as the limitations of having a single source of information are taken into consideration.

A different approach was followed in the Smart Citizen study, where data were collected for two more years after the end of the initial study, while the collaboration with KWMC in Bristol was well under way. During these two years many things happened, which were relevant to the research but would have required considerable amount of time to analyse using thematic analysis. Where to focus? A decision had to be made to focus on impact indicators, annotating data that could shed light on what happened with the project throughout time, and whether the experiences of the pilot interventions in Amsterdam and Barcelona had any impact on the Smart Citizen technology. To facilitate the process of data collection a lightweight method was developed. It consisted of creating a template with the key impacts that had been observed to far, such as: academic research using Smart Citizen, external appropriations, citizen sensing pilots, research and innovation projects, media coverage, etc. (including a blank space for other emergent themes). Having a template in a Google Drive file meant that I could track the progress of the project in an organised manner that incorporated a level of analysis. Data was introduced in monthly basis and then processes and incorporated to the study in the general section on Smart Citizen.

7.5.3.3 Role of the researcher

Above all, the biggest challenge when conducting research with communities in the wild following a participatory approach is the articulation of ones role as a the researcher. On the one hard, there's the need to become a "trusted intermediate" [Crabtree et al., 2013], as being embedded in the community provides opportunities to discover the intricate dynamics of community engagement, how bottom-up civic tech endeavours operate from the inside, and to establish connections that open new doors to research opportunities. However, it often means that the researcher becomes the *glue* between the community and the project instigators. This was the case during the Smart Citizen pilots, where community participants who were unhappy with the lack of robustness of the technology often approached me to complain in ways that they wouldn't in front of the project instigators or community orchestrators. On their side, the latter justified their faults with me and enquired about the participants' views and comments. Being the glue that connects the stakeholders can be problematic because one's interpretations over specific comments may bias the communication. I found that a good approach was to participate in the conversation by openly sharing and discussing the findings of the research with them. This meant that I could discuss themes rather than commentary, contributing to the community in the role of a researcher in situ.

Nevertheless, there is a gap between research and practice, and ensuring that research based on action in the real world meets the academic criteria of rigour and validity is often a challenge. Doing participatory research in the wild means that many factors cannot be controlled for and that decisions have to sometimes be made on-the-fly [Rogers, 2011]. This makes the process of operationalization very complex and the researcher can find herself struggling to make reality fit in the corset of methodology, divided between project management and research, often negotiating mismatching expectations between stakeholders. Adams et al. have referred to some of these tensions using the term "boundary creature" [2013], and have advocated for acceptance of this hybrid status. In their view, as a "boundary creature" we can facilitate the move from innovation to scalable and sustainable technology solutions.

7.5.4 Summary

This section has presented a discussion of the methodological approach adopted in the thesis. In sum, ethnography and action research have been successful methods to investigate three case studies where different communities engaged in civic technology interventions. The key strengths of the method have been discussed in terms of having provided opportunities to achieve familiarity with the context, perform data collection over extended periods of time, and enabled horizontality, collaboration and scale. However, there have also been challenges and limitations: finding and engaging diverse communities and stakeholders, collecting data over time, and constantly redefining the role of the researcher.

The section also discusses how these challenges were overcome. The following section will summarise these findings and draw conclusions and themes for future research.

7.6 Future work

The findings in this thesis suggest a number of potential future research directions: expanding the City Commons framework, impact assessment models, common platforms, and tools for orchestration, evidence sharing and documentation.

7.6.1 Expanding the City Commons framework

This thesis has contributed a methodological and strategic framework for the participatory orchestration of civic technology interventions. The framework has been successfully applied in Bristol. However, there is an opportunity to further validate the framework by testing it in the context of different community arrangements and social contexts. Would the model be useful to interventions taking place in rural settings? What is the optimal number of participants that could be involved in each phase and what skills should they have? How can groups using the framework share learning and evidence?

KWMC in Bristol will continue to apply the framework and other groups in cities have contacted them to also apply it. This creates an opportunity to investigate how other communities galvanise around matters of concern and follow the phases in the framework to effectively tackle them. Researching on these new instantiations of the City Commons approach could help to answer some of the questions that I have raised above.

7.6.2 Impact assessment models

Long-term studies are rare in HCI. Researchers tend to focus on short-term exploratory design and studies of use, which limits the possibilities of investigating how people come to adapt and appropriate technologies over time. Heyer & Brereton have recognised the need to embrace "*an approach to designing social technologies that can both support and evaluate emergent use over time*" [10: 283]. This thesis has embraced the challenge of conducting long-term studies, both to assess sustainability and the kinds of societal impacts that civic technologies can have. To do this required the need to assemble bespoke methods, which built on ethnography but required a lighter weight approach that supported data collection by one individual over periods of one to three years. While this first attempt is valuable, I appreciate that more work needs to be done.

There is a pressing need to assemble more structured methods that researchers can quickly adopt to monitor impact at the short, medium, and longer term, and to assess to what extent their interventions have met the goals that they were set out to achieve or led to unexpected ramifications. Having an assessment tool would also indicate where to look for impact indicators, and how to approach the problem. One possibly is that methods will come from fields like sociology, economics, and development studies that are not core to current HCI research practice. However, these methods need to be adapted to the needs and foci of the HCI researcher.

7.6.3 Participatory common infrastructures

This research has evidenced the need for technical infrastructures that aid participatory orchestration and commoning. The City Commons framework is a useful methodology that helps facilitators in the planning, deployment, and assessment stages (chapter 6). However, as found in the Dampbusters study (chapter 6), facilitators found that they needed tools to coordinate actions, enable transparency, communication, voting and debating among the contributing community. Moreover, they highlighted the need for commons platforms; meaning infrastructures that allow people to access, contribute, use, and appropriate common resources. While it has been argued here that the commons is not merely a set of resources but rather a form of social organisation that prioritises democratic contribution, horizontality, transparency and community governance, there is an opportunity to investigate how the capital resulting from commoning can be captured and made accessible to others. For example, as a platform Wikipedia allows people to contribute, share and act on knowledge. How could this be done to crystallise, nurture and grow a city commons? There is a need to make the city commons actionable, abundant and accessible.

Commons systems comprise two elements: the content and the infrastructure [Benkler & Nissenbaum, 2006]. The content itself is the concrete outcome that emerges from a contribution, for example, a data set. The infrastructure includes all underlying technologies that enable the production of such outcome, following from the previous example, this would be the sensor and the platform that hosts and visualises the data set. Moreover, a set of support services (funding, documentation/education, governance protocols, contribution orchestration, etc.) are required for the commons to be functional and to thrive with the support of an engaged community. Additionally, to make a set of common or shared resources accessible and actionable to contributors and users, some features and support services are required. Agents will need tools and skills to interact with the commons and use them in ways that can produce value. For instance, it is not enough with publishing open data for communities to derive value from them. Such data sets should be downloadable in a format that allows interoperability and readability. The research presented here suggests some attributes that can inspire the design of city commons platforms. These are:

- **Abundance**: commons should generate an extended city offering that increases opportunities by providing access to universal and actionable capital for contributors, for other citizens, local enterprises and/or for the city council.

- **Accessibility**: be designed to be accessible, appropriated and reused under the most permissionless possible approach.

- **Actionability**: Be associated to infrastructures and support services that embed skills in the community and foster use and contribution.

- **Governance/management:** be designed to be managed transparently, jointly and directly. Include a clear protocol for use and contribution, supervision mechanisms and actions to penalise abusive behaviour. Enable awareness regarding community members, contributions and resource use.

- **Rewards**: be associated to incentives and rewards that match citizens' motivations to contribute.

There are ample opportunities for technology designers to explore these themes further and support the complex task of participatory orchestration. In doing so, they could potentially foster empowerment at the grassroots level.

7.6.4 The right to contribute

There is also a need to investigate how policy, at least at the city level, can provide a regulatory framework that establishes and fosters the right of the citizen to contribute to the co-design of both the city's physical and digital realm, and to be protected and not exploited by others for profit or for purposes other than intended. There is a need to organise better regulatory framings that:

- Support citizens to contribute data, and to participate in problem solving activity – to develop systems of fair rewards incentives related to city improvements.

- Establish principles, a code of ethics, and 'rules' of engagement with open data and tech that become the backbone of the city commons.

- Enact transparent governance agreements that prioritise both citizens' privacy and the common good.

- Ensure open data is accessible and useable as well as available. Whilst it might not be a requirement for the local authority to 'own' and manage the platform, the responsibility for ensuring that it is accessible, and open to all citizens and used for the common good should be retained by the local authority and supported by citizens.

7.6.5 Business models for community civic tech

Last, funding is a crucial factor associated to the sustainability of civic technology interventions, this includes not only the money that is necessary to pay for and repair the technology itself but also the funds to compensate those who dedicate time and efforts to maintain and fix it. On the one hand, research-led projects are usually tied to research funds, which has raised concerns about how to sustain the technologies after the researcher has left the field and the funding is over [Taylor et al., 2013]. On the other hand, crowdfunding can be a successful way to kick start a technology intervention, an approach that is increasingly adopted by entrepreneurs developing civic tech [e.g. Air Quality Egg, Safecast]. However, this thesis has shown how a successful crowdfunding campaign will not necessary lead to an active community of users. In fact, it seems like crowdfunding is one form of citizen contribution. In the case of Smart Citizen, it was seen how other sources of funding were needed to continue to evolve the project, this included mainly European research funds. In this regard, Teli has argued how specific funding strands from the H2020 programme, CAPS in particular (Collective Awareness Platforms for Sustainability and Social Innovation) have made it possible for participatory community-led interventions to be developed [2015].

Still, both crowdfunding and European Research projects are not sustainable means of funding. Interventions may fail to continue after the funds are exhausted. How can a community-led intervention be self-sustaining? There is a need to investigate what type of business models may help bottom-up civic technologies to capture a portion of the value that they generate to subsist and develop. For example, Wikipedia relies on a donation model to cover its costs, which in the financial term 2015-2016 raised to 66 million US Dollars, including salaries, Internet hosting, professional service expenses, and special events, among others [Wikipedia, 2016]. However, a donation model may not be suitable to smaller scale interventions. Arduino, for example, follows a different approach, where the key product is an open source board that uses a Creative Commons license (Attribution-Share Alike). This means that anyone can make copies of the board, redesign it, and even sell boards that copy the original design. However, if they republish the reference design, Arduino must be credited. And if the board is changed, the new design must be registered under the same Creative Commons license to ensure that new versions of the board will be equally free and open. The only thing that is trademarked is the name Arduino itself, which means that if anyone wants to sell boards using that name, they have to pay a small fee to Arduino. Through this model the enterprise ensures that the project will remain open and that the efforts of volunteer contributors will remain a commons rather than a proprietary asset [Thompson, 2011]. The model seems to be successful for hardware products, but would be harder to apply to intangible outputs.

Patel et al. have showed how many civic technologies have received funding from grants and venture capitals but need to develop business models to evolve [2013]. In the burgeoning ecosystem of civic technologies and the raise of community –led efforts researchers should not underestimate the need to investigate how such enterprises are funded and what business models are more likely to foster contributive interventions that recognise the efforts of volunteers, and ultimately contribute more value to society that the value that they need to capture to be sustainable. Such strategies and business models could nurture the development of more commons-based projects.

7.6.6 Summary

This section has presented a discussion of the methodological approach adopted in the thesis. In sum, ethnography and action research have been successful methods to investigate three case studies where different communities engaged in civic technology interventions. The key strengths of the method have been discussed in terms of having provided opportunities to achieve familiarity with the context, perform data collection over extended periods of time, and enabled horizontality, collaboration and scale. However, there have also been challenges and limitations: finding and engaging diverse communities and stakeholders, collecting data over time, and constantly redefining the role of the researcher. The section also discusses how these challenges were overcome. The following section will summarise these findings and draw conclusions.

8 Conclusions

In the last decade, new approaches to improving cities – by making them more sustainable, resilient and efficient have emerged: from the top-down technology-centred vision of the smart city [Hall, 2000] to more citizen-centric attempts such as the Co-city, Sharing city and Fab City.

The latter share in common a focus on the contributive power of people, who can use technology to collaborate to nurture urban commons [Iaione, 2016], support environmental sustainability and efficiency by sharing assets and services [CCKorea & Bo-ra Jung, 2016] or seek self-sufficiency by engaging in hyper-local production and circular economies [Diez Ladera, 2016].

Researchers in human-computer interaction have long advocated for technology to support and foster civic participation and to help to reconfigure the running of government and the production of public services [Vlachokyriakos et al., 2016]. The last decade has seen the raise of civic tech or digital civics, which Borhner & DiSalvo have described as a “logical step” in HCI’s articulated turns – from the cognitive, to the social, to the cultural, and now to the civic [2016: 2970]. Researchers are increasingly collaborating with communities to design and deploy new technology infrastructures with the goal to effect positive social change: from new voting systems empowering activists [Vlachokyriakos et al., 2014] to citizen sensing interventions for environmental monitoring [Kera et al., 2014] or community-led mobility services [Teli et al., 2015].

Central to the design of civic tech is the notion that researchers should design with citizens rather than for consumers [Olivier & Wright, 2015], and that community-led technologies have the potential to reconfigure power relations between citizens, communities and the state [Borhner & DiSalvo, 2016; Vlachokyriakos et al., 2016]. These new configurations of government and citizens should be relational rather than transactional, "in which political thinking and action can be co-produced and co-owned through dialogue across differences in experience, values, and knowledge" [Olivier & Wright, 2015:62]. However, a key challenge in the design of technology to support community structures is how to ensure the sustainability of the resulting tools and practices [Taylor et al., 2014] in order to truly achieve the positive social impact that is aimed [Hayes, 2011].

This thesis has explored the complex context of civic technology. The aim was to better understand the factors that support community engagement with these socio-technical interventions, as well as the factors that can facilitate the sustainability of those engagements. It also aimed to identify what kind of societal impacts civic technology can achieve, and to draw strategies for communities to self-organise interventions to achieve their own situated purposes. To do this, three interventions were studied and one framework was developed.

First, I followed an Action Research approach to design and deploy CrowdMemo (Chapter 4), a long-term intervention where a community used novel assemblages of off-the-shelf technologies to support heritage preservation in an Argentine town. The intervention lasted for over three years and achieved broad impact inside and outside the community. How was such sustainability achieved? What contributed to the success of CrowdMemo? This study highlighted the importance of using off-the-shelf technologies to increase adoption from the bottom-up, providing training and facilitating social interactions. It also demonstrated the benefits of following a participatory approach to foster community valued ownership and an openness approach to boost the external appropriation and impact of the intervention.

In Chapter 5 the crowdfunded sensing platform Smart Citizen was investigated. The focus was on how communities in Barcelona and Amsterdam used the Smart Citizen sensor prototypes to monitor the environment, and the larger impacts achieved by the project. The community interventions took place between 2013 and 2014, and the evaluation continued until 2016. Unlike CrowdMemo, here the case studies investigated the engagement of different urban communities with novel technology prototypes (sensors and a data platform) in interventions planned and organised with no participation of the researcher. I followed an ethnographic approach that allowed me to become embedded in the communities, making sense of how people came to engage with the interventions but also how certain actions enacted by community champions and facilitators (specially in Amsterdam) promoted and helped to sustain engagement. The studies reported in chapter 5 show how participatory orchestration is crucial to the uptake and sustainability of civic technology, as it can infrastructure communities to develop a sense of ownership, skills and social bonds that in turn foster adoption, appropriation and impact. Moreover, it was found how Smart Citizen was associated to a narrative of bottom-up empowerment, which had a positive impact in attracting people to engage with the project and, in some cases, to appropriate it.

Drawing from the findings of the studies reported in chapters 4 and 5, chapter 6 describes the process by which these themes were organised in an actionable framework for community-led civic technology interventions that was designed in collaboration with stakeholders for them to be able to plan and deploy their own interventions. Rather than having to plan for a hand-over (cf. [Taylor et al., 2014]) the partners naturally took on the framework because they had contributed to its development in the first place. Like in CrowdMemo, this was possible by following an Action Research approach, where the collaboration was democratic and horizontal, and we ensured that value was delivered for all the stakeholders. The resulting framework is both a communication and planning tool. It attempts to ensure that interventions prioritise community ownership, that people are supported to develop technical skills and capacity, that social interactions are fostered and new social collaborations are developed. It seeks to maximise impact and community capital by contributing to the development of a city commons, understood not online as resources (open technology and data, training, etc.) but mainly as a mechanism to organise and enact sharing and contribution for a common benefit [Bollier, 2007].

The framework was used in Bristol and led to the Dampbusters project where residents in two neighbourhoods co-designed and deployed novel sensor technologies to tackle a problem of their own concern: damp housing. This case study (in chapter 6) demonstrated the usefulness of the City Commons framework, which allowed an organisation that had never organised a citizen sensing intervention, to plan and deliver a successful one. Using six sequential phases, from identification of matters of concern through to assessment of outcomes, the framework scaffolds the complex social and technological dynamics that infrastructure sustained community engagement with civic technology. It supports orchestrators and participants, from residents facing concerns to tech volunteers, experts and researchers, in planning, communicating and performing key actions. It was also found that the focus on the commons served as a narrative that, like in Smart Citizen, galvanised people, provided a shared sense of purpose and strengthened engagement.

In sum, this thesis contributes to the understanding of community-led civic technology interventions, and sheds light to factors that are crucial to foster engagement, sustainability, and impact. These findings aim to inform the design and deployment of more democratic, non-hierarchical and participatory socio-technical processes, to address common challenges based on the citizens' contributive capacity. In the current times of socio-political turmoil and austerity plans there is a need to design and test new approaches to civic participation, production, and management that can strengthen democracy, deliver value, and consider the aspirations, emotional intelligence and agency of individuals and communities. There is a need to ensure that all citizens, and in particular those from disadvantaged communities are empowered to contribute and participate in the design of the city for all of us.

8.1 Major contributions

The main contribution of this thesis is **twofold**.

- **On the one hand,** it defines and unpacks a set of sensitising themes that identify and conceptualise:
    i. the drivers that foster meaningful community engagement with bottom-up civic technology interventions: this includes the articulation of **matters of concern, novelty,** and **narratives.**
    ii. the factors that enable their sustainability: it has been shown how sustaining community engagement with civic technology is a process of infrastructuring that requires of on-going **participatory orchestration**. This comprises the articulation of factors such as **valued ownership**, which includes material

ownership and the adoption of **participatory approaches**; and **community capital**, which includes **skills, capacity,** and social **interactions**.

iii. the impact of these interventions in terms of their direct and indirect consequences. Firstly, the **direct impacts** are internal to the intervention, and include: **effectiveness**, its capacity to achieve the goals that it was set up to achieve, its capacity to foster the emergence of **social collaboration innovation;** and its capacity to nurture **community capital.** However, it has been demonstrated that they can have **indirect impacts,** which mainly come in the form of external appropriation. These appropriations are likely to occur when the project achieves of **communication outreach** and follows an **open approach**. The former refers to media coverage and external appropriations of the intervention of the resulting technologies. The second dimension, **openness**, relates to the consequences of using open source technologies and processes in terms of engagement

- **On the other hand**, this thesis contributes a City Commons framework for the design and orchestration of bottom-up civic technology interventions. The model assembles notions of meaningful engagement, sustainability, and impact into a cohesive strategic model that supports participatory orchestration. Furthermore, this thesis also contributes recommendations and guidance stemming from the implementation of the framework. The framework and the guidance can be appropriated by community groups, organisations and stakeholders in governments to guide and scaffold participatory processes. The iterative application of framework can lead to the growth of the city commons, which also includes the know-how regarding the processes that are necessary to enable civic engagement.

8.2 Minor contributions

This thesis also contributes an exploration of the role of the researcher in the context of supporting the development of community-owned and managed civic technologies.

Although not central to this PhD, I consider this contribution to be relevant and timely as HCI researchers move towards designing technology with citizens, and attempt to contribute their know-how to empower people rather than to promote a rhetoric of compassion [Rogers & Marsden, 2013]. The studies reported here show how researchers can follow participatory methods to engage with stakeholders, without having to manage or control the intervention but rather contributing expertise, helping and fire fighting when necessary. This type of approach can support the sustainability of the intervention and contribute societal and academic impacts.

The Smart Citizen study in Barcelona has demonstrated that crowdfunding does not necessarily lead to active participation. This means that, the fact that people have funded a technology does not mean that they intend or will use it. This extends previous findings that do not differentiate the success of a technology to the success of the crowdfunding campaign that made it financially possible. While funding can be considered a form of participation, it is not directly associated to active usage.

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Annex 1

An open-ended questionnaire was sent to people who had been involved with CrowdMemo one year after the launch of the project. It was sent via email and contained two sections. The first one was aimed at collecting demographic data. The second one focused on how people recalled the project and what other activities had taken place after I left the field. A sample of the questions have been translated from Spanish to English and are presented below:

i. In your opinion, what were the most interesting aspects of the Crowdmemo project?

ii. How would you define the reactions of the wider community towards Crowdmemo?

iii. Do you think CrowdMemo was useful for different members of the community to talk about the history of the people? How?

iv. How can projects like CrowdMemo trigger citizen participation in issues such as the protection of community assets?

v. Are there any anecdotes that you remember – or any particular opinions regarding the impact of CrowdMemo on the community?

vi. What happened during the 12 months after the project?

vii. What have been Crowdmemo's weaknesses and how could we improve it?

viii. What sorts of activities have made you reflect on the history of your community and its heritage? How?

Annex 2

Following three screenshots from the survey that was sent to Smart Citizen users is presented. The aim of this survey was to collect data, which was presented in chapter 5, from people who had backed the Smart Citizen campaign via the crowdfunding platform Goteo. The survey comprised 5 sections focusing on: (i) demographics; (ii) level of technology expertise, and motivations to support the project (including affiliation with the project instigators); (iii) usage of Smart Citizen kit and platform; (iv) user participation in the Smart Citizen community; and (v) evaluation of the project and wish list.

Smart Citizen Community Survey

This survey is part of a research project within the ICRI-Cities institute (www.cities.io). The results will be used to evaluate the level of engagement of users with the Smart Citizen kit and platform, and will serve as a basis to develop the platform further to improve the user experience with it.

I am a:

- Male
- Female
- Prefer not to say

I am based in:*

City, Country

My age group is:*

- 10-18
- 19-25
- 26-31
- 32-38
- 39-45
- 46-51
- 52-58
- 59-65
- 66-71
- more than 72

I consider myself a:*

Tell us about your interest in the usage of new technologies

- Technology savvy (passionate about technologies in a practical way: I can program and hack electronics)
- Technology newbie (I just started to program and play with different tools)
- Curious about technology (I want to start to use more technologies)
- No interested in technology (I am ok of being a consumer of things done by others)

Do you personally know other people who own a Smart Citizen Kit or are related to the project?*

- Yes. I knew them before joining the Smart Citizen project
- Yes. I met them through the Smart Citizen project
- Yes. I know people from Fab Lab Barcelona
- No. I don't know anybody who owns a Smart Citizen kit

If you answered yes to the previous question. How many other Smart Citizen users do you know personally?*

- 1
- 2 to 5
- 5 to 10
- More than 10

How frequently do you interact with other members of the Smart Citizen Community through the project's website?*

- At least once a week
- Every two weeks
- Once a month
- Hardly ever
- Never

Why did you decide to participate in the Smart Citizen project?*

- I want to show a environmental problem in my community
- I want to experiment with new tools
- I have a professional practice related with the issues tackled by the project
- I am a researcher and want to use in my field
- I want to be part of a data gathering community
- Other:

If it is ok for you please paste the URL of your Smart Citizen Kit
go to http://www.smartcitizen.me and paste your smart citizen kit url here

I am familiar with the following tools and platforms:*
Please specify in which level of expertise

	Never	At least once (hello world level)	Basic user (familiar with it)	Advanced user (developed at least one project with it)	Expert (I do it in a professional basis)
Arduino					
Java programming					
API's					
Web development					
Hacking electronics and software					

I am interested in:*
Please tell us which subjects attract your attention

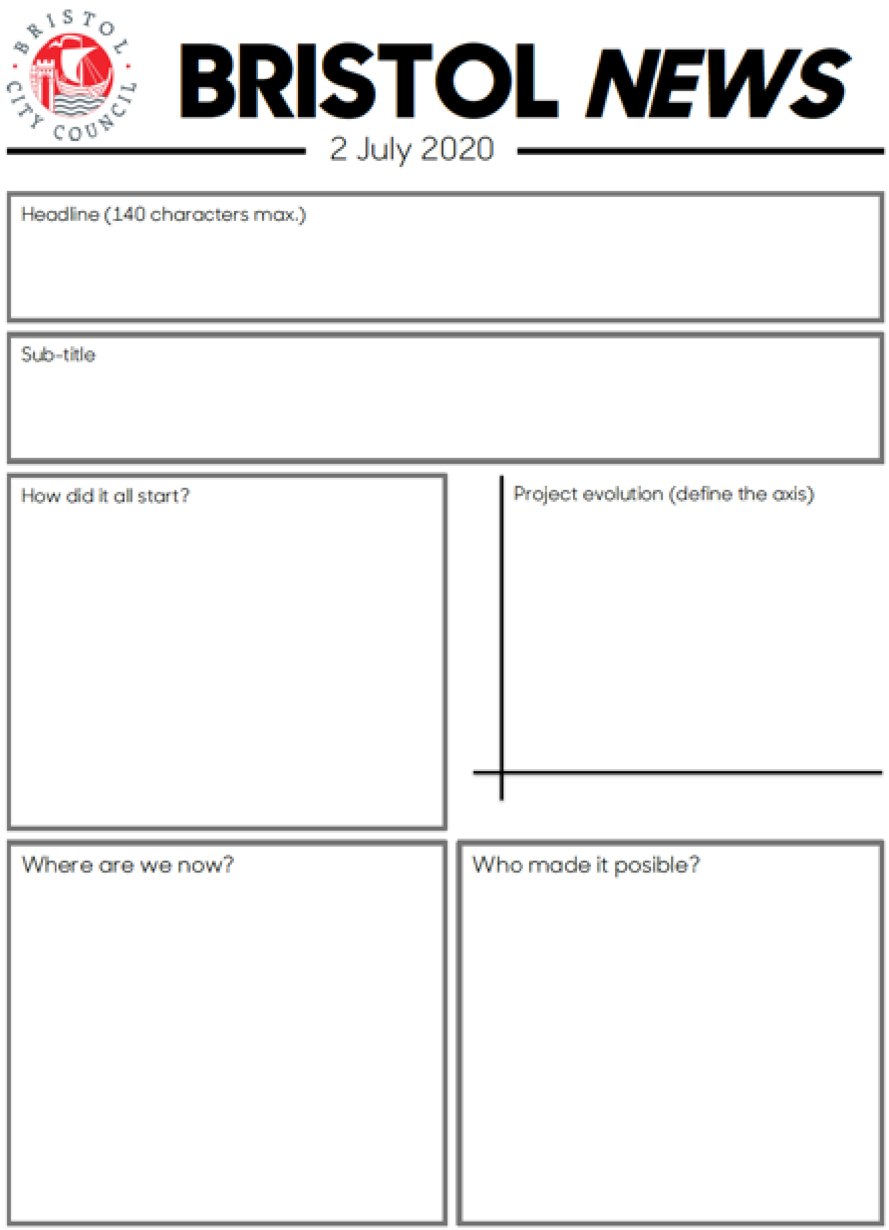
- Open Data
- Tools for Developers
- Open Hardware
- Smart Cities
- Internet of Things
- Citizen Science
- Environmentalism
- Other:

How did you find out about the Smart Citizen project?*

- Fab Lab Barcelona
- Other Fab Labs
- People I know
- Online search
- News in media
- Goteo.org
- Other:

Annex 3

A template of the future newspaper employed during the first co-creation workshop held in Bristol is presented (chapter 6). The template was designed by the researcher in collaboration with the thin ktank Ideas for Change. The aim was to create a tool that could foster collaboration in the design of solutions to social challenges, envisioning the ecosystem of agents that would be required and what strategy should be followed to produce a successful solution.


BRISTOL CITY COUNCIL

BRISTOL NEWS

2 July 2020

Headline (140 characters max.)

Sub-title

How did it all start?

Project evolution (define the axis)

Where are we now?

Who made it posible?

Annex 4

Jokebox: Coordinating Shared Encounters in Public Spaces

Figure 42. The Jokebox deployed at a bust stop in Ensenada, Mexico.

CrowdMemo revealed that novel technology encounters, social interaction and conversation can facilitate engagement and foster its sustainability. Moreover, it supported previous findings suggesting that involving the community from the outset in the goals and setup of the intervention, as well as using off the shelf technologies and providing skills [Chamberlain et al., 2013; Hayes, 2011; Hearn & Foth, 2005; and Merkel et al., 2004] contributed to creating a sense of ownership among participants that fuelled sustained community engagement. However, as described in the literature review of this thesis, much HCI research on civic and urban technologies is based on novel prototypes designed by researchers at the lab and with no direct participation from the community prior to the evaluation phase [Koeman et al., 2014; and Rogers et al., 2010].

To better understand the relationship between civic and urban technologies, novelty, social interactions, conversation, and engagement I proposed the JokeBox study. This case study aimed at exploring how a novel public display could be designed in order to support social interactions and conversation in the public place, and whether this could act as a driver to sustain engagement (in this case, minimally defined as users returning to the place to interact again with the device). What type of engagement can novel public displays that have not been co-designed with a specific community enable? Urban public displays have been associated to social connectedness because they may enable conversation among users (e.g. [Bird & Rogers, 2010] and [Koeman et al., 2014]). Can a device whose main purpose is to enable novel technology encounters and social interaction overcome the novelty effect and achieve sustained engagement?

The Jokebox study contributed to the understanding of how public displays can be designed to foster eye contact, and how eye contact can trigger shared encounters among people in public settings. Although related, it has not been included in the main corpus of studies presented this thesis because the Jokebox cannot directly be characterised as civic technology and because, unlike CrowdMemo, Smart Citizen, and Dampbusters, this was not a long term study on sustained community engagement.

Summary

Face-to-face social interaction is associated with the cohesion of communities and the development of social capital [Putnam, 1993]. At an individual level, interacting with others increases happiness and wellbeing [Kim, 2012]. Encounters that include humour and conversation can support psychological and physiological health [Ruch, 1998; Epley &Schroeder, 2014; Kim, 2012]. This suggests that such social interactions should be encouraged.

However, facilitating social interaction in public spaces is hard to achieve [Goffman, 1972; Paulos & Goodman, 2004; Muller et al., 2009; Fischer & Hornecker, 2012; Kim, 2012; Willis et al., 2010; Simmel, 1903]. This is in part due to the fact that city dwellers often adopt a "blasé attitude" [Simmel, 1903] or civil inattention [Goffman, 1972] to separate themselves from the plethora of stimuli available in cities [Milgram, 1992]. Strangers typically glance at each other and then look away demonstrating that they are aware of each others' presence, but do not wish to interact. These rules of non-interaction seem to be accentuated when we share constrained spaces [Kim, 2012; Goffman, 1972] or a routine with a stranger. Milgram et al. [1992] coined the term "familiar stranger", which had previously been discussed by Jacobs [Jacobs, 1961] to refer to those people who we frequently encounter (e.g. at the bus stop every morning) but never interact with. He also noted that there are exceptions to these rules of non-interaction: if we come across familiar strangers outside the everyday routine (e.g. while away on holiday) or in the presence of a highly unexpected event that serves as an "ice breaker".

Sharing a social encounter can often lead to a positive experience [Epley & Schroeder, 2014; Kim, 2012], especially if it is brought about by an unexpected [Milgram et al., 1992] or wondrous [Paulos et al., 2008] event. However, given the sophisticated strategies that people use to not interact with others, it is important that interaction with any intervention is discretional [Paulos & Goodman, 2004]. How can urban interfaces enable eye contact and lead to shared encounters, while at the same time protecting people's personal space and therefore easing social apprehension? To address this question I proposed the Jokebox, a novel lightweight technology that can attract two passers-by to look at each other and coordinate a sequence of actions in order to hear a joke.

This study followed a qualitative approach to evaluate the Jokebox in an in-the-wild-study [Rogers, 2011] at three different locations in Mexico: a bus stop, a park, and a shopping centre. The results demonstrate that designing the Jokebox to encourage micro-level coordination facilitated a wide range of shared encounters that were quite consistent in their structure. By encouraging people to make eye contact and by using audio rather than having the content appear on a screen the system engaged them in a process of face-to-face interaction that often led to further conversation and laughter. It was also found how opportunities for macro-level coordination were crucial to the success of the installation, but varied widely. Firstly, the context in which the Jokebox was situated significantly influenced how well this kind of sequencing worked; and secondly we observed how strangers championed interactions by guiding and encouraging others to engage with the Jokebox, and how returning users and local characters appropriated it for their own purposes.

The contributions on this study inform the design and deployment of novel interfaces that aim to support shared encounters in public places.