Understanding the Design and Implementation of Civic Technologies in Resource-Limited Public Organizations

by

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TABLE OF CONTENT

LIST OF FIGURES

FIGURE

LIST OF TABLES

TABLE

LIST OF APPENDICES

APPENDIX

ABSTRACT

With advances in computing and open data, more and more public organizations have collaborated with volunteer technologists – people with information technology (IT) skills who voluntarily help public organizations with their IT needs – to create or adopt civic technologies to solve public issues, and to support civic engagement in local communities. This dissertation aims to inform the design and implementation of future civic technologies in public organizations, by presenting three studies that investigate public organizations' practices when designing and implementing civic technologies. In particular, we focus on the implementation of social media in nonprofit organizations (NPOs), the design process of civic hacking projects, and civic data hack-a-thons in several resource-limited public organizations and communities.

We first investigate how 26 small environmental NPOs leverage social media for various public engagement activities to identify challenges that public organizations encounter when implementing civic technologies. Next, we study two ways that volunteer technologists and public organizations collaboratively create civic technologies. In Study 2, we examine the factors that influence the sustainability of 16 civic hacking projects during which volunteer technologists and public organizations collaborate on designing technologies to solve community issues, both through observations and through 19 interviews. In Study 3, we investigate how to generate actionable data analytics products for NPOs during civic data hackathons, and explore the roles of brokers to support the collaborations between civic technologists and public organizations.

Based on findings from these studies, we argue that evaluating the engagement outcomes through civic technologies, solving the internal organizational challenges that prohibit engagement, and reconciling the needs of various stakeholders, are all crucial for public organizations to better engage with communities through civic technologies. In addition, taking into account various public organizations' constraints and facilitating data literacy is essential for the sustainability of civic technologies in public organizations. Last, building good relationships between various stakeholders and leveraging brokering activities (translation, coordination, alignment, and contact brokering) to bridge different community of practices are all critical for collaborations during the design and implementation of civic technologies. Informed by findings and insights from the studies, we identify design implications and practical guidelines for civic-minded volunteer technologists and public organizations, to foster the design and implementation of civic technologies and the associated collaborative work.

CHAPTER 1. INTRODUCTION

1.1. Problem Statement

Many public organizations (public sector and NPOs) have increasingly adopted "civic technologies"—information technologies that support public services, resolve public issues, and improve the delivery of public goods in the organization (Boehner & Disalvo, 2016; Hou, 2016). Civic technologies support various aspects of civic life, including community organizing, citizen participation, crowdfunding, transportation and social equity (Knight Foundation, 2013, 2015). Unlike e-government systems that make existing public services more accessible, efficient and convenient (Carter & Bélanger, 2005), civic technologies aim to enhance the democratic capacity of governance and public organizations by encouraging more public engagement and citizen participation (Gilman, 2016; Plans & Cities, 2012). Recently, many cities and public organizations have become involved in civic hacking projects by engaging public organizations, volunteer technologists, and the private sector to develop innovative civic technologies and data analytics, as technical solutions to city and community issues (Schrock, 2016). Although civic technologies are considered to increase the efficiency of public services, and to provide innovative solutions to public issues, the adoption rate of civic technologies in public organizations remains low, and the long-term positive impact of civic hacking projects for addressing public issues remains a big challenge for public organizations (McMillan, Engström, Lampinen, & Brown, 2016; Townsend, 2013). The emerging civic hacking activities also bring both the benefit of innovative ideas, and the challenge of interdisciplinary collaborations to the development of civic technologies.

Human-computer interaction (HCI) researchers have investigated how information technologies extend the existing practices of public organizations, such as fundraising and volunteer management (Goecks et al., 2008; Merkel et al., 2007; Voida, Harmon, & Al-ani, 2011). Some HCI research also explores innovative ways of designing technologies that

support community social capital, as well as addressing community issues and civic participation (Korn & Voida, 2015; Le Dantec et al., 2010; Taylor et al., 2012). However, the adoption rate of civic technologies has remained low, the effectiveness of these tools in supporting engagement remains unclear (Lovejoy & Saxton, 2012b), and the long-term impact of civic technology seems limited (Taylor, Cheverst, Wright, & Olivier, 2013).

Existing attempts of HCI research on civic technologies tend to focus mainly on the innovative design and tools required to solve specific public issues, such as transportation, voting, and promoting civic engagement. The complex organizational structure, cultural and political factors that contribute to the successful adoption and use of civic technologies in public organizations are relatively understudied in previous research (Irani, 2015). In this dissertation, we aim to contribute to HCI and computer supported collaborative work (CSCW) research by focusing on characterizing the social and organizational factors in public organizations that influence effective engagement, sustainability, and the collaboration of civic technologies in public organizations. We use a separate case for each design goal: social media use in NPOs, civic hacking projects, and community data hackathons. We investigate the design, collaboration and implementation of civic technologies in public organizations by addressing three facets of civic technologies: *What are the sociotechnical factors facilitating or inhibiting public organizations' effective public engagement through civic technologies? What would enhance the sustainability of civic hacking projects situated in public organizations? What are effective collaborative practices among various stakeholders of civic technologies in public organizations?*

1.2. Public Organization

This section clarifies the characteristics of the public organizations' missions and organizational structures that influence the design and implementations of civic technologies. Public organizations broadly include government organizations and NPOs that care about the public interest, produce public goods and services, and rely on public funding (Bozeman & Bretschneider, 1994; Perry & Rainey, 1988). In this dissertation, we focus on local public organizations in civic and municipal-level entities: nonprofit community groups, non-governmental social service providers, and local governments (villages, towns, townships) (Carroll & Rosson, 2007). Local city governments control the

economy, social freedoms, and political systems of the city, while the community organizations and local NPOs provide social services, and are dedicated to particular social causes and changes.

Public organizations differ from private organizations as they face differing challenges and duties. Local public organizations face challenges of limited finances, time, and human resources in purchasing and managing information technologies. Public organizations, especially governments, must also adhere to complex organizational rules, administrative policies, and bureaucracies for their work practices, that inhibit innovations within the organizations (Light, 1998). Local public organizations, especially community organizations and NPOs, are also lacking in data and information literacy (the ability to manage and use data and technology in their work), as well as expertise (Carroll & Rosson, 2013), and they rely heavily on temporary dynamic workforces such as volunteers for the information technology management (Voida et al., 2011). Local public organizations are dedicated to a progressive process of social change or social values for the local communities rather than seeking financial profits (Moore, 1995), which makes it difficult to assess the social impact of civic technologies. Finally, the work of public organizations involves a diversified group of stakeholders with diverse needs, such as elected officials, government agencies, NPOs, community organizations, volunteers, and citizens (Abzug & Webb, 1999; Freeman, 2010), and the differing values of various stakeholders influence the design and adoption of civic technologies in public organizations (Voida, Dombrowski, Hayes, & Mazmanian, 2014).

These unique characteristics of public organizations render the existing HCI theories based on similar corporate technologies not directly applicable to their civic technologies. For instance, Koch, Füller, and Brunswicker (2011) noted that the crowdsourcing platforms in the public sector were different from corporate crowdsourcing platforms. The unique missions of public sector values and public governance make the crowdsourcing platform in the public sector not only a platform for a "customer voice" of public services, but also a platform for civic education, bidirectional communication and democratization. As a result, there is a great need to investigate the proper technical features, user motivations, communication styles, and organizational practices of civic technologies in public organizations.

1.3. Civic Technologies in Public Organizations

In this section, we summarize various ways that public organizations adopt civic technologies, and the strengths and weakness of these adoption processes, which include vendor civic technologies, research-driven civic technologies, off-the-shelf technologies, and civic hacking projects. These categories are not technical in nature, but pertain to the way they are created and adopted in public organizations. In this dissertation, we focus on the appropriation of off-the-shelf civic technologies and the design and adoption of civic hacking projects, significantly demonstrating the complex sociotechnical challenges in the design and implementation of civic technologies in public organizations:

Vendor civic technologies: Vendor civic technologies refer to the technologies that governments outsource to external vendors through a traditional technology procurement process, when the government needs a service or product. Some vendor civic technologies, such as online voting and license renewals systems, make civic services more convenient (Carter & Bélanger, 2005). Other vendor civic technologies, such as IdeaScale and SeeClickFix, also allow the public to contribute to the development of plans and policies, as well as report city issues. There are many benefits of vendor civic technologies for public organizations: they provide direct solutions to civic problems such as transportation and political process, and vendors can provide long-term support for civic technologies. However, these technologies require dedicated funds and resources for their purchase, development, and training (Voida et al., 2011). For local public organizations that lack technology resources and budgets, vendor civic technologies are not always a feasible option.

Research-driven civic technologies: Many HCI and design researchers have created innovative civic technologies to solve various civic issues and support public organizations' practices through long-term collaboration with local communities and public organizations. Community informatics researchers have worked closely with community partners who have little IT knowledge to build civic technologies that support existing community activities, such as community information-sharing, education, and community heritage (Carroll & Rosson, 2007; Carroll & Rosson, 2013). Recent HCI research has also explored innovative design and technologies that support various civic practices, such as voting,

(Taylor et al., 2012) or building social capital in distressed communities (Dillahunt, 2014a). However, research-driven civic technologies also require research funding to support long-term training, relationship building, and infrastructure development, which is not suitable for all public organizations. These studies also focus on the experimental and innovative ideas, and the long-term impact of each tool is less optimal. The intention for the innovative design and advanced technologies also restricts these civic technologies in their adoption and maintenance by the public organizations (Taylor et al., 2013).

For local, resource-limited public organizations, both vendor and research-driven civic technologies are constrained by the budget and other resource limitations. In this dissertation, we focus on the emerging trend in public organizations to leverage low-cost off-the-shelf technologies (e.g., social media), civic hacking and hackathons to develop new civic technologies.

Off-the-shelf civic technologies: Off-the-shelf civic technologies refer to general information technologies that are appropriated by public organizations to extend existing practices (Voida et al., 2011) or to support civic activities. The flexibility and variety of such information technologies provides a wide range of opportunities for public organizations to use them for civic practices (Dourish, 2003). In this dissertation, we focus on social media and other off-the-shelf civic technologies as examples of exploring the way that public organizations adopt them in support of civic engagement.

Civic hacking and hackathons: Civic hacking is a collaborative technology development process that partners public organizations, civic-minded hackers and coders, and private sectors to create apps and other technical solutions to public issues (Johnson & Robinson, 2014; Schrock, 2016). Civic hackathons refer to one-day or two-day civic hacking events during which public organizations, designers, data analysts, and programmers collaborate in the same space to create civic technologies or to perform data analysis. Recently, more and more cities have become involved in civic hackathon events such as Open Data Day, and National Day of Civic Hacking, developing civic technologies and data analytics to solve public issues (America, 2016). There are also some longer-term civic hacking projects, such as Code for America (CFA), that last from a few months to a year, and during which technology experts work closely with the public organizations to create civic technologies for certain public issues. For public organizations, civic hacking

and hackathons are considered to be effective methods of civic engagement, bringing innovative ideas into organizations, as well as demonstrating the value of transparency, collaboration and participation (Gregg, 2015; Johnson & Robinson, 2014). Despite the enthusiasm for civic hacking, civic hacking apps are also criticized as lacking actual impact on civic issues. Researchers asked how civic hacking could transform from "the tactical level of smart and often playful interventions" to "the strategic level of enduring impact" (Badger, 2013; de Lange, Verhoeff, de Waal, Foth, & Brynskov, 2015)?

1.4. Studies Motivations

To understand the sociotechnical factors that influence the design and adoption of civic technologies in public organizations, we took a practice lens of HCI research in this dissertation. The practice lenses of HCI research are interested in the context of interaction, the appropriation of technologies, the push towards research "in the wild", and they aim to solve complex real-world problems (Kuutti & Bannon, 2014). Unlike traditional HCI research that focuses on controlled, short-term, and lab-oriented studies, the practice paradigm focuses on long-term actions situated in certain time, space, material and cultural contexts. Thus the practice lens is more suited to civic technologies, which are situated in a complex social context—public organizations. Although existing HCI already engages with the various design practices that support civic practices, an in-depth analysis of the design and adoption of civic technologies in practice within public organizations, can enhance the impact of civic technologies for public organizations practices and civic engagement.

Using the practice lens, we examine three challenges of the use and adoption of civic technologies in public organizations in practice. First, although many public organizations appropriate social media to promote civic engagement, and also involve the public in the decision-making process, the effectiveness of engagement was low (Lovejoy & Saxton, 2012b).

Second, the existing civic hacking projects lack plans for sustainability, i.e., how public organizations could maintain the civic technologies in the long run and how civic technologies could have endurable impact on community. The term "sustainability" indicates both adoptability (the ability for community partners to adopt the technology) and

endurable impact (long term impact of technology) of civic technologies. As a result, we consider sustainability as an important outcome of civic technologies in this dissertation. Although existing civic hacking projects have contributed to problem deliberation and creative idea generation (Lodato & DiSalvo, 2016), their sustainability ensures a more direct impact on public organizations' day-to-day work, civic engagement, and citizen participation, especially when they have the internal technical expertise and resources to develop and manage civic technologies. Sustainable civic hacking projects also avoid a waste of time and resources of public organizations and applications if they successfully solve public issues (Townsend, 2013).

Last, there is a lack of shared practices and common ground (Convertino et al., 2008)—shared knowledge and beliefs—among the stakeholders of civic hacking, which may lead to failed collaboration and civic hacking projects. As a result, it is critical to study ways of laying common ground across the organizational boundaries during civic hacking.

The exploration of the three cases of the dissertations attempts to clarify three key points in the research endeavor of civic technologies in public organizations. First, understanding the complex sociotechnical factors of the appropriation of social media could facilitate more meaningful engagement through civic technologies. Second, studying the design and implementation of a civic hacking project that focuses on sustainability—the feasibility of public organizations to adopt, maintain, update, and develop civic technologies—could reveal underlying sociotechnical characteristics that lead to civic technologies that have more endurable impact on communities. We will specifically focus on factors in the iterative design process that could enhance the potential sustainability of civic technologies in communities. Third, studying a data hackathon event and the roles of brokers, would provide insights into understanding how to foster common ground during the collaboration between various stakeholders in creating civic technologies.

In this dissertation, we also focus on various outcomes of civic technologies in public organizations. From the civic engagement perspective, we are interested in the effect of civic technologies in helping public organizations to engage community members in their missions. From the technology adoption perspective, we are interested in whether the civic technologies are successfully adopted by the public organizations, and sustainably

used. From the collaborative perspective, we focus on the extent that various stakeholders, especially volunteer technologists and public organizations, successfully collaborate in addressing public issues, by leveraging civic technologies.

1.5. Research Questions

In particular, this dissertation addresses three research questions (RQs) related to the sociotechnical factors of the design and adoption of civic technologies in public organizations.

RQ1: How do public organizations (e.g., small NPOs) use social media for public engagement?

RQ2: What strategies do participants in civic hacking projects use to improve the sustainability of civic technologies for local public organizations?

RQ3: What are the roles of brokers in successful collaborations between public organizations and volunteer technologists?

1.6. Related Theories

In this dissertation, we study the design and implementation of civic technologies in public organizations, drawing on several HCI and CSCW theories on organization information adoption and collaborations. First, we leveraged previous research on various levels of civic engagement (Arnstein, 1969; Lovejoy & Saxton, 2012b) to analyze public organizations' social media practices. Second, we leveraged practice-based research such as the adaptive structuration theory (Desanctis & Poole Scott, 1994) to analyze the relationship between organizational factors, and nonprofit public engagement practices on social media. Lastly, we also leveraged CSCW theories like brokers (Pawlowski, Robey, & Robey, 2004) to understand how to support the dynamic, temporary collaborations between diverse stakeholders (Lee, 2007; Lee & Paine, 2015) during the design and use of civic technologies in public organizations.

1.7. Thesis and Contribution Statement

In this dissertation, we extend existing HCI and CSCW literature on civic technologies by characterizing various sociotechnical factors that affect the design and

adoption of civic technologies in public organizations. The main thesis statement and contributions are:

RQ1: How do public organizations (e.g., small NPOs) use social media for public engagement?

We argue that public organizations should leverage various social media features and pay attention to organizational factors (low digital literacy, limited resources, organizational politics) to achieve various levels of public engagement goals. We also argue that the design of social media tools should take into considerations of public organizations work practices, especially link NPOs existing database with social media analytics tools.

RQ2: What strategies do participants in civic hacking projects use to improve the sustainability of civic technologies for local public organizations?

We note several important factors that should be considered during the design process of civic hacking projects to improve the potential sustainability of civic hacking projects. We argue that sustainable civic hacking projects should leverage off-the-shelf technologies, low-tech tools, and existing infrastructure to ease the adoption barriers. We also highlight the importance of facilitating the partnership between various stakeholders, understanding of community practices, and data literacy to support the long-term maintenance and impact of civic technologies in public organizations and communities.

RQ3: What are the roles of brokers in successful collaborations between public organizations and volunteer technologists?

We identify the important roles of brokering activities (e.g., translation, cooperation, alignment, and contact brokering) in facilitating the complex collaborations by bridging the common ground between volunteer technologists and public organizations.

Overall, the dissertation also contributes design implications and practical guidelines for volunteer technologists and public organizations to create effective civic technologies and to organize effective civic technology design programs such as civic hacking programs and hackathons.

1.8. Dissertation Outline

The rest of the dissertation is structured as follows: In Chapter 2, we begin by presenting a literature review of previous HCI and CSCW research on the design and implementation of civic technologies in public organizations. This literature review highlights salient research regarding public organizations' challenges in the adoption and implementation of information technologies, and the ways in which civic technologies and civic hacking provide alternative ways for diverse stakeholders to collaborate, in enabling civic engagement and addressing public issues.

In Chapter 3, we examine the strengths and limitations of various social media platforms for NPOs to achieve their public engagement goals. Examining how NPOs leverage multiple social media platforms, we note that the design of social media platforms should take into account multiple organizational issues and collaborative practices that influence effective, interactive engagement with the public (Hou & Lampe, 2015).

In Chapter 4, we investigate a civic hacking project that partners volunteer technologists and public organizations to create 16 sustainable civic technologies which address various public issues in a small city. Based on this analysis, our work shows that the technical features, community characteristics, and organizational factors must be taken into account when designing sustainable civic technologies that are easily adopted and maintained by resource-limited public organizations (Hou & Lampe, 2017).

In Chapter 5, we study NPOs' engagement through short-term collaboration with data experts in a civic data hackathon. Through an analysis of the data hackathon processes and outcomes, we identify the key roles of brokers in bridging the knowledge and literacy gaps between volunteer technologists and public organizations during their collaborations, and discuss the implications for civic data hackathons (Hou & Wang, 2018).

In Chapter 6, we summarize the results and examine the fostering of civic engagement through civic technologies for public organizations, and the sociotechnical factors that influence the design and adoption of civic technologies in public organizations. We further discuss the differences between the design and implementation of civic technologies in NPOs and public sectors. This chapter concludes with broad implications for understanding the relationship between public organizations and civic technologies.

CHAPTER 2. BACKGROUND AND LITERATURE REVIEW

Successful civic technology requires the tools to support the civic engagement goals of public organizations. It requires the organization and community to provide proper support for the deployment of tools, and the diverse stakeholders to deploy smooth collaborations. Research of civic technologies spans across the following disciplines: HCI, social science theories, business and organization theory, urban planning. However, I scoped my review to social science theories, HCI, and CSCW literature about civic engagement and civic technologies, because this dissertation aims to contribute to the design of civic technologies and the collaborative practices of stakeholders.

In this section, we will first review the definition of civic technologies in various disciplines, and their general research agendas. Then we will review three lines of research that support successful design and implementation of civic technologies in public organizations. First, we will review the civic engagement theories and the way that civic technologies (especially social media) support civic engagement. Second, from the organization perspective, we will review the practice-based research on organizational factors of civic technologies' adoption and usage. Lastly, from the collaboration perspective, we will review CSCW theories about dynamic collaborations, and collaborations of civic technologies in public organizations.

2.1. Overview of Civic Technologies Research

In general, civic technologies refer to the information technologies that support various aspects of civic life and public services, especially the civic engagement and citizen participation in public governance and problem solving. Civic technologies are not restricted to the digital format of governance practices and public services (e.g., digital governance or e-government), but focus more on technologies that support civic engagement and citizen participation (Gilman, 2016). Other civic technologies also

frequently leverage open data from government and public organizations to create data analytics, visualization and information tools which make public information transparent and solve community issues (Janssen, Charalabidis, & Zuiderwijk, 2012; Schrock, 2016). Many disciplines (e.g., public administration, public relation, communication, HCI, CSCW and design research) have studied civic technologies from multiple perspectives. They have discussed various civic technologies ranging from public organization-driven to citizen-driven process. Recently, emerging research has investigated how the design process of civic technologies could facilitate civic engagement.

Civic technologies as business: In the business field, the definition of civic technologies comprises the civic practices of public organizations, citizens, and private sectors. Microsoft's vice president stated, "civic tech ranges from engagement between the city government and its population on social platforms, all the way to enterprise solutions that offer deep government IT problem-solving" (Microsoft, 2014). Living cities (Plans & Cities, 2012) defined civic technologies as "the use of digital technologies and social media for service provision, civic engagement and data analysis", and categorized civic technologies into three fields: improving the quality and accountability of public service, facilitating resident-driven improvements to neighborhoods, and deepening participation in public decision-making. The Knight Foundation (Foundation, 2013) analyzed the business potential of civic technologies and concluded that it has been growing quickly, and with investment of over $431 million in 2013. They also categorized civic technologies into five categories, based on separate civic outcomes: community organizing, social network, crowdfunding, collaborative consumption, and government data.

Civic technologies and governance: E-government and public administrative researchers have also investigated civic technologies, specifically how they could support governance and citizen participation. Linders (2012) also proposed a typology of civic technologies based on the possibility of citizens coproducing digital government systems with governments. He grouped civic technologies into three categories that support the design, execution and monitoring of governance and public services: Citizen sourcing (C2G or citizens providing input to government), government as platform (G2C or government providing information and guidance to citizens), and do-it-yourself government (C2C or citizens self-organizing without government involvement).

Community informatics: Much of the community informatics research has been investigating how information technologies could better serve community engagement and community practices. These studies usually take action research, or participatory design approaches, to design and implement innovative tools "in the wild" for neighborhoods and communities (Crabtree et al., 2013). Early community informatics research built digital infrastructures like community networks to support community computing capabilities, community involvement, and social capital (Kavanaugh & Patterson, 2001). Recently, community informatics researchers also created civic technologies to support various community practices such as crime prevention (Erete, 2015; Lewis & Lewis, 2012), community heritage (Balestrini, Bird, Marshall, Zaro, & Rogers, 2014; Fox & Dantec, 2014; Han, Shih, Rosson, & Carroll, 2014) and social interactions (Taylor, Lindley, Regan, & Sweeney, 2015).

HCI and civic engagement: Multiple groups of HCI researchers have investigated various ways that information technologies support civic life, and they categorize civic technologies into two types: information technologies that support the top-down engagement from authorities to citizens, and the bottom-up, grassroots civic engagement activities. This line of HCI research focuses on the critical role of designers to support the later bottom-up and grassroots civic practices. These studies draw on Lefebvre's (2002) distinction between the 'privileged moments' and 'product-residue' in everyday life. Privileged moments are civic engagement experiences associated with invitations from institutions of power, where the authorities extend the privilege of participating to citizens only when needed, through a structure of power designed by experts, which is merely refined with input and feedback provided by users. Product residue, on the other hand, refers to political life in everyday life and the strategies that the public uses to confront an issue. Drawing on Lefebvre's theory, Hirsch (2008) noted two contrasting paradigms of political participation: consensual and contestational views. The consensus and convenience paradigm focuses on rationality and consensus as the basis for democratic decision-making and action. The typical goal of e-democracy initiatives is to improve the mechanism of governance by increasing the participation of citizenry through convenience and accessibility, and to translate traditional democratic activities into online tools for

participation. On the other hand, he argued the importance of more bottom-up civic participation as contestation design: the multiplicity of voices inherent in social relations.

The design of this category, as a result, focuses on contestation and an adversarial design for activist technology. For instance, using the audio sensors connected to mobile phones (encased in coconuts), he installed a sensing network in the neighborhood surrounding the San Jose airport to monitor audio pollution produced by planes flying overhead. When the sensors detected sound above a given threshold, they would automatically call the City of San Jose noise complaint line, registering an (often humorous) complaint. Voida, Yao, and Korn (2015) extend Hirsch's work by grouping civic technologies into four categories: deliberation, situation participation, disruption, and friction. Deliberation refers to civic technologies that move offline services online (e.g., e-government and e-democracy), and it is public organizations that primarily moderate and administer these civic technologies. Situated participation technologies leverage ubiquitous computing to engage citizens in civic interactions. This includes temporal embedding, social embedding (e.g., social media), and spatial embedding (location-based technologies). Disruption civic technologies refer to those technologies that aim to reveal, address, reflect on, and support privileged moments like civic disobedience. Finally, friction civic technologies are based on the idea of product residue in everyday and contestational politics, and aim to provoke citizens into reflecting on the conditions of civic life.

Design as civic engagement: Another line of HCI research on civic technologies focuses on how the innovative design process itself, such as participatory design, workshop, and civic hacking, could facilitate civic engagement and problem solving. This line of research is inspired by Dewey (1927) public theory, which defined public as the social group emerged in response to a common public issue. According to Dewey, there is no massive crowd or singular all-inclusive public, but rather a multiplicity of publics. In addition, the multiple publics merge into stakeholders in response to particular shared social conditions. Drawing on Dewey's public theory, Le Dantec and DiSalvo (2013) argued that the design of civic technologies should not only provide a solution to a public problem, but should also facilitate the construction of multiple publics around the issue. To illustrate this argument, they conducted a series of participatory design research projects that involved multiple stakeholders in the design and problem articulation process, and

expressed matters of concern by creating civic technologies for certain public issues (Disalvo, Lukens, Lodato, Jenkins, & Kim, 2014).

Recent research also investigates how the design and data analysis process of civic hacking could facilitate citizen participation. Schrock (2016) described various ways that civic hacking could contribute to activism and advocacy, such as requesting, digesting, contributing, modeling and contesting data. Requesting refers to civic hackers' work to request open data from government to make more open data available. Digesting refers to civic hackers interpreting and making sense of the open data by applying information knowledge. Contributing refers to contributing data sources related to civic issues. Modeling refers to using the code and open data to create partly working prototypes for local issues. Other work describes how civic hackathons enable citizen participation. Irani (2015) conducted an ethnography research on a hackathon in India and noted that it represented an entrepreneurial citizenship that celebrates Silicon Valley values of social change through a lean and agile process (i.e., finding a solution through quick iterations across collaborative teams). However, she also noted that the hackathon generated prototypes, but had little impact on real problems, and the prototypes were rarely implemented in public organizations. In addition, the hackathon participants had no time for "real footwork" that built coalition and trust with community partners and citizens. Lodato and DiSalvo (2016) described civic hackathons as "issue-oriented hackathons.", and they argued that civic hackathons construct "proto-publics" that are partially engaged in the problem solutions through the temporary collaborations between stakeholders. Nevertheless, they also demonstrated that the civic hackathon teams treated the dynamic real-world issues as static technical problems and worked iteratively around them based on the available technical capabilities and systems.

In this dissertation, instead of creating new civic technologies that facilitate bottom-up civic practices, we focus more on how the public organizations could better engage with the public through civic technologies, and provide more convenient services. In addition, we are interested in investigating how various stakeholders collaborate and sustain civic technologies through civic hacking and data hackathons.

2.2. Challenges of Engagement Through Civic Technologies in Public Organizations

The primary goal of civic technologies is to support civic engagement and public participation (Gilman, 2016). From the tools perspective, it is critical to understand how to design civic technologies that support the civic engagement goals of public organizations. However, recent research suggests that public organizations have not effectively used civic technologies for civic engagement goals. In this section, we will review social science theories related to various levels of civic engagement and citizen participation. Then we will review research on how civic technologies such as social media could support various levels of engagement goals and the challenges of these endeavors.

2.2.1. Levels of Citizen Engagement with Public Organizations

Civic engagement is defined as the individual or collective actions that aim to identify and address issues of public concern and improve the community's future (Adler & Goggin, 2005). Many urban planning and public administrative theories discuss various levels of civic participation from the public sector perspective. The most recognized model of civic engagement from the public organization perspective is Aronstein's Ladder model (Arnstein, 1969), which proposed a hierarchy of civic engagement which citizens could utilize to participate in a public organization's decision making and planning process. The bottom of the ladder is non-participatory, which includes manipulation and therapy. Levels three to five are informing, consultation, and placation, in which citizens' opinions could be heard (tokenism). Higher levels include partnership, delegated power, and citizen control, in which citizens gain power and decision-making clout. Arnstein's work has greatly influenced later thinking on urban planning and many other fields of citizen participation, and scholars have created an extended version of Arnstein's ladder for various contexts. For instance, Kingston (2002) proposed a model with a ladder of e-participation for urban planning, which categorized civic technologies into various levels, ranging from basic information delivery using a website, through increased participation using online discussion forums, to a higher-level participation using online decision making systems (Figure 1).
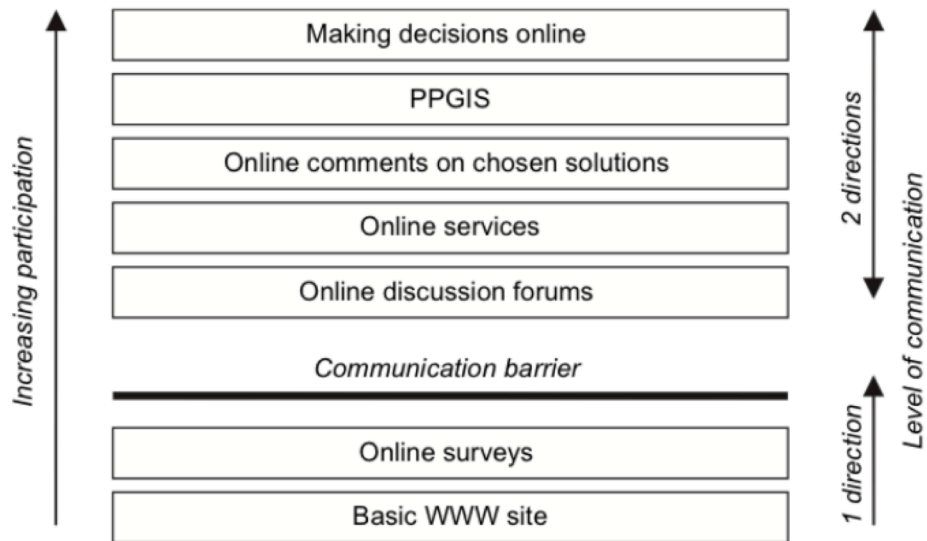
Figure 1. A Ladder of E-participation (Kingston, 2002)

2.2.2. Social Media and Citizen Participation

Among all the civic technologies that support civic engagement, social media are considered as communication tools that are low-cost, as well as having rapid information disseminations, and rich interactive features that afford various civic engagement activities such as civic discourse and citizen complaints (Linders, 2012; Obar, Zube, & Lampe, 2012). Social media interactions also increase the transparency of public organizations, and improve access to engagement data such as community demographics (Mergel, 2013a). Based on the content analysis of public organization social media sites, researchers found that public organizations have increasingly adopted social media to support various levels of civic engagement practices in a way that is similar to Arnstein's Ladder model, from one-way informing, to dialogic conversations and direct participation. For instance, research on NPO social media use revealed three main public engagement functions: information, community, and action (Guo & Saxton, 2014; Lovejoy & Saxton, 2012b).

The information messages mainly aim to increase awareness of the organizations' causes among both current and potential supporters. Community messages aim to maintain a sense of community through interactive conversations. Finally, action messages attempt to convert social media interactions into advocacy actions, such as fund-raising, or attending a face-to-face meeting. Mergel (2013a) found that government agencies also use

three strategies on social media, including push, pull and networking. The push strategy is to use social media sites as an additional communication channel to get a message out, which is a one-way strategy with the goal of providing transparency and enabling more accountability and trust. Pull is a two-way strategy with the goal of engaging the public by soliciting information or requesting certain actions that are related to consultation, deliberation, and satisfaction. Networking is a strategy with the goal of cross-boundary, two-way communication leading to collaboration between government agencies and the public; it is related to community building and the creation of issue networks.

2.2.3. Lack of Interaction on Civic Technologies

Although public organizations try to achieve multiple levels of civic engagement goals through social media and other civic technologies, existing research reveals that public organizations mostly use social media as a one-way information dissemination tool and fail to leverage the interactive features of social media and civic technologies for two-way interactive engagement (Lovejoy, Waters, & Saxton, 2012; Sommerfeldt, Kent, & Taylor, 2012; Uzunoğlu & Misci Kip, 2013). Research on public sector social media use also revealed that local governments stick to "push strategies" to provide one-way information (Mergel, 2013b).

However, there is a lack of studies which reveal successful strategies for public engagement through civic technologies, and this is relevant to dissertation RQ1. *How to evaluate the effectiveness of civic technologies, especially social media, in achieving public organizations' public engagement goals? What are the factors that influence public organizations' use of social media in a more interactive way*?

2.3. Public Organizational Challenges Influencing the Adoption and Sustainability of Civic Technologies

The challenges of low interaction on social media and other civic technologies lead us to pay attention to the organizational contextual factors of civic technologies, and to ask if there are organizational constraints that prevent public organizations from utilizing civic technologies for civic engagement. In addition, previous research reveals the overall challenge that adoption and sustainability of civic technologies in public organizations and

communities presents. Successful adoption and sustainability ensures a more direct impact on the day-to-day work, civic engagement, and citizen participation of public organizations. Stable and easy-to-maintain projects are especially critical for public organizations which lack internal technical expertise and resources to develop and manage civic technologies. In this section, we will review the existing literature on the organizational and social structure governing the adoption and sustainability of civic technologies in public organizations.

2.3.1. The Practice-Based Research of Civic Technologies

One way to understand organizational factors of the design and implementation of civic technologies in public organizations is practice-based research (Kuutti & Bannon, 2014). The practice-oriented research on information technologies originates from (Giddens, 1984)'s the theory of structuration, which explains how social structures—such as rules and transformational relations—interplay with human actions in organizations. These studies revealed that, high-quality interfaces and content, as well as the practice of using information technology, are both critical for the adoption of information technology (Bullen & Bennett, 1991; Grudin, 1988; Kling, 1991). For instance, Grudin (1988) argues that failures in organizations' technology adoption were due to imbalances between those who received benefit and those who used technology, ignorance of the extra work required maintaining application, and potential disruptions to the existing work. Drawing on Gidden's structuration theory, Desanctis and Poole Scott (1994) proposed adaptive structuration theory that elaborated on the complex interplay between IT, social structures, and social practice in the adoption of groupware technologies. They focused on (a) structures that were embedded in technologies and (b) structures that emerge as human actors interacted with technologies. Orlikowski (2000) further proposed *practice lens* and *technology-in-practice*, which refers to the structure of technology use enacted by social actors while they interact recurrently with a particular technology artifact. The individual expectation and confidence in technology, reward structure, as well as organizational norms and culture, all decide the organizational technology adoption. Using practice-based theories like structuration theory, previous literature analyzed various civic technology adoptions and use in public organizations, such as crowdsourcing (Kim, Mankoff, &

Paulos, 2015), social media (Lampe & Roth, 2012), and government IT systems (Puron-Cid, 2013).

2.3.2. Challenges in the Adoption of Civic Technologies in Public Organizations

Using practice-based research, previous research revealed several challenges in the adoption and implementation of civic technologies in public organizations. Previous research revealed several factors that influence the adoption and usage of information technologies, as well as: (1) organizational resources and skills (2) administrative factors (3) dynamics of workforces such as staff and volunteers and (4) organizational culture. These results inspired us to further explore the organizational factors that influence the effective engagement with citizens through civic technologies.

Several studies have found that organizational resources and administrations influence the adoption of information technologies in public organizations. For instance, Ebrahim and Irani (2005) noted that IT infrastructure, security and privacy, IT skills, and organizational and operational costs all influence e-government adoption in public sectors. Ganapati and Reddick (2012) found that the primary barriers to state governments adopting open e-government included state legislation, federal guidelines, and the willingness of state chief information officers (CIOs).

Studies on public organizations, especially NPOs found that the dynamic workforces in these organizations pose great challenges to the adoption and use of civic technoloigies. Carroll and Rosson (2007) noted that stress suffered by staff and other volunteers, lack of budget flexibility for IT, a lack of volunteers who can help with IT, and reluctance to use volunteers for IT all influence the adoption of community informatics tools. Voida et al. (2011) noted that the reconfiguration of homebrew information systems in NPOs interplayed with time, funding, and expert limitation, as well as with the diversity and fluidity of information needs, stakeholders, and work context. Kim et al. (2015) found that the barriers to NPOs adopting volunteer data collection mobile technologies included resource constraints, the cognitive factors, the depth of volunteer engagement, and stakeholders' perspective of civic technology.

Recent research on open data and civic technologies also identified several organizational challenges when developing civic technologies using open data at the city

level. For instance, Boehner and Disalvo (2016) interviewed city staff, connectors, and civic hacking volunteers about their views on data, city, and civics. Their results noted challenges such as difficulty in accessing data, fragmentation of public organizations, problems in business innovation as a metaphor for civic technologies, and a general lack of literacy in data, design, and civics in public sectors. McMillan and Chavis (1986) also investigated the challenges of open data and smart city in four European cities. They found that there was a power issue of data, and that someone damage to city practices could be caused by one individual, manipulating access to the data. For instance, a contractor charged the city extra money for repetitive reported repairs from a civic technology platform. Public organizations also worried that the openness of data would harm the reputation of the city and government. In addition, government bureaucracy constrained the effectiveness of civic hacking apps. For instance, all civic technologies had to be publically procured with a well-defined and fixed specification, which constrained future changes and updates.

Recently, some research has investigated how public organizational structure directly influences public organizations' civic practices. Harding, Knowles, Davies, and Rouncefield (2015) studied a civic crowdsourcing tool and noted that bidirectional conversation between citizens and civic authorities was important in establishing trust. However, political and organizational factors—such as personnel changes, operational challenges, and the lack of appreciation between civic stakeholders—negatively influenced the trust between the civic authorities and the citizens and how active they used the tool to provide feedback on citizen's reports. This leads us to explore several questions related to dissertation RQ1: *How are the civic technologies like social media used in practice by public organizations to support civic engagement? What are the organizational factors underlying public organizations' failure to achieve the civic engagement goals, especially the interactive conversational engagement goals?*

2.3.3. Support for the Adoption of Civic Technologies in Public Organizations

Another contribution of the practice-based research is to understand how to support the adoption of the newly designed civic technologies in public organizations. Through long-term research collaborations with community organizations, previous "in the wild"

studies provide deep insights into balancing technology innovations with sustainable changes in the target environment (Hayes, 2011; Merkel et al., 2004). These studies revealed factors that are critical for the successful adoption, sustainability, and engagement of civic technologies in public organizations, such as infrastructure, visibility, ownership, and building skillsets.

Research on community informatics emphasizes the importance of both technical and social infrastructure in support of the sustainability of the civic technologies in the community. Infrastructure is composed of the installations, facilities, resources, services, and social practices that enable information system activities (Star & Ruhleder, 1995). Researchers argued that civic technologies should not only be built on the technology infrastructure that supports community innovations, but they should also consider the new social-cultural practices that support the maintenance of technologies in communities. For instance, Carroll and Rosson (2013) noted several important work practices for successful, sustainable community informatics projects, and emphasized the importance of infrastructure in designing and maintaining civic technologies in communities, including extending existing practice, using open access tools, activating new informal learning, and building new cost-benefit models.

Prior work also indicated the potential of off-the-shelf technologies to reduce the costs and learning curve of innovative technologies. For instance, on reflection of the handover of an innovative digital noticeboard and bespoke systems to the communities, Taylor et al. (2013) discussed replacing the innovative components with mainstream, off-the-shelf technologies to enhance the sustainability of the technologies in the community. Balestrini et al. (2014) also suggested that leveraging off-the-shelf tech (mobile phones) and infrastructure (3G) could support sustained community engagement with a community heritage preservation system.

Many studies also emphasized the importance of building partners' ownership of technology (Carroll & Rosson, 2007; Carroll & Rosson, 2013). Le Dantec and DiSalvo (2013) also noted the role of ownership in the work of infrastructuring, as it oriented participants towards engaging in design for future use. They argued that the work of ownership is not the ownership of the material product itself, but more importantly, the ownership of future attachments and social relationships around the civic technologies.

The existing literature also emphasizes the importance of building the technical skills of community partners to maintain civic technologies (Merkel et al., 2004; Taylor et al., 2013). Recent ICTD research also discussed building researchers' skills to work with communities. For instance, Winschiers-Theophilus, Zaman, and Yeo (2015) organized a workshop to educate novice and guest researchers in building and maintaining relationships with rural communities.

However, prior work is primarily based on long-term research projects, and the question remains whether these strategies are applicable in short-term collaboration between the civic-minded volunteer technologists and the public organizations during the civic hacking process. These studies also tend to emphasize the roles of designers and researchers, and the characteristics of the public organizations and various stakeholders are not studied sufficiently. There are still remaining questions related to dissertation RQ2: *How could public organizations overcome the organizational constraints to better design and implement civic technologies? What are the best practices of civic hacking that can transform innovative ideas to create a sustainable impact on public organizations and communities?*

2.4. Challenges of Dynamic Collaboration in Creating Civic Technologies in Public Organizations

To support successful civic technology design in local public organizations, it is important not only to understand the features and the organizational context of civic technologies but also to understand the collaborative work among various stakeholders during the design and implementation of civic technologies. Previous research on civic technologies in public organizations has demonstrated the importance of involving stakeholders to incorporate various ideas and perspectives of the public issue. The complex collaborative work among stakeholder groups, however, poses challenges of building common ground, discrepancies in knowledge and work practices, and temporary collaborations. CSCW theories about common ground, cross-organizational, and temporary collaborations are thus useful in analyzing the collaborative work of various stakeholders during the design and analysis process of civic technologies and civic hacking.

2.4.1. Characteristics of Civic Technologies Collaborations

Previous research revealed that the design and implementation of civic technologies in public organizations involved diverse stakeholders and complex collaborative work. Individual stakeholders hold individual values and interpretations about civic technologies. Voida et al. (2014) found that even though several stakeholders may share the same values on the e-government system, such as efficiency, access, and education, they interpreted the values in differing ways. For instance, access means lowering the barriers to the system by the system designer, yet it also means getting people both in the door and navigating the whole process for the system workers. Aoki et al. (2009) also found that there are remarkably differing views among stakeholders of a crowdsourcing environmental mobile sensing platform, such as government, advocacy NGOs, emitters, and citizens. For instance, their views differ on how the organization should run the project, the goal of the data collection, how the data will be used, the value of the data, and the credibility of the citizens in the crowdsourcing task. As a result, they suggested that the design of the tools must meet the needs of coalitions of groups, such as using social networking tools to connect groups, as well as supporting long-lived campaigns to maintain the efforts.

The emerging civic hacking projects also pose great challenges to collaborations between civic-minded technologists and public organizations. Civic hacking projects usually involve short-term commitment from civic-minded technologists without the responsibility to maintain or deploy it after the temporary collaborations. While civic technologists understand the technical details, they lack the comprehensive understanding of the complex operational and political factors that govern the public organization actions. The short-term civic hackathon and data dive event also creates new challenges for collaboration. For instance, working on projects that are outside of one's normal workflow may provide challenges for continuity of this activity after the brief cooperative stint is over. The short-term collaborative events also provide pressures on team dynamics, such as the need to go through team formation and development stages relatively quickly to be productive, as well as keeping the dynamics and enthusiasm for completing projects at the conclusion of the event.

2.4.2. Dynamic Collaborations of Civic Technologies

Much of the CSCW research has studied the non-routine, temporary collaborative work involving cross-organizational boundaries. Traditional CSCW research usually leveraged (Johansen, 1988) model to investigate various sociotechnical factors that influence the collaborative work, and influence the design of technologies in supporting collaboration. Strauss (1988) defined "articulation work" as the distribution of work, such as resources, negotiation of actions, allocations, assignments, schedules and interdependence. He also described a spectrum of work, from routine to non-routine work and from simple to complex. Recently, Lee and Paine (2015) extend Johansen's matrix of collaborative work with two dimensions of synchronicity and physical distribution to a model of coordinated action (MoCA) to describe more diffuse, high turnover and highly dynamic coordinate actions. Their model included seven dimensions of complexity: synchronicity, physical distribution, scale, the number of communities of practice, nascence, planned permanence, and turnover.

Scale is the number of participants involved in the collaboration. Large-scale collaboration is considered to be more complex in coordination. This dimension describes the diversity of the community practice, which is defined as a social group that shares common experiences, knowledge, and common goals (Wenger, 1999). The number of communities of practice pertains to the cultural diversity in norms, practices, tools, and language. Nascence refers to whether the coordinated actions are unestablished (new) or established (old) coordinated actions for actors. Planned permanence refers to the intended permanence of a coordinated action. It ranges from short to long term. Turnover refers to the participant makeup stability of a given collaboration.

Collaborative work, when designing and implementing civic technologies in public organizations, faces many challenges in the various dimensions of complex collaboration. For instance, multiple stakeholders lead to communities of practices that differ in languages, expertise, motivations, and work practices, which creates challenges for establishing common ground. The temporality of the collaboration leads to high short-term planned permanence. The dynamic workforces that we discussed in 2.1.2 also create challenges of high-turnover workforces to the collaborations.

Some CSCW research also revealed helpful practices that could support the complex collaborative work. For instance, Lee (2007) suggested the boundary negotiating artifacts, which, defined as temporary and unstandardized artifacts, were useful in supporting collaboration work with *low nascence*. In a study of collaborative design cases, (Yasuoka, 2015) revealed that the local project jargons facilitated the interdisciplinary collaborative design work across various professional boundaries by achieving mutual understanding. Steinhardt and Jackson (2015) proposed the "anticipation work" that cultivated expectations of the future and preparation for future work, which is insightful for the cooperative work with low planned permanence. Other studies revealed the importance of brokers in bridging the collaborative work of cross-organizational boundaries. Brokers are people who serve as a boundary spanner or bridge within an organization; like IT professionals, they are considered to play important roles in organizations in terms of knowledge brokering, by crossing boundaries, surfacing and challenge assumptions, translation and interpretation, and relinquishing ownership (Robey & Sahay, 1996). Recent research also found that brokers facilitate the collaborations between the various stakeholders of civic technologies. Hellmann, Maitland, and Tapia (2016) explored the collaborative analytics during a digital humanitarian response project, noting the important roles of brokers in helping to build the common ground between community and GIS professions during collaborative analytics.

The design and implementation of civic technologies face many challenges of dynamic, temporary collaborations between various stakeholders, and it calls for research on understanding such collaborations to support the successful development and implementation of civic technologies in public organizations. In this dissertation, we investigate the unanswered questions related to dissertation RQ3: *How do the relationships between stakeholders influence collaborations during the design and implementation of civic technologies? How do the critical factors of complex collaborations (e.g., brokers) facilitate collaborations during the design process of civic technologies in public organizations?*

CHAPTER 3. SOCIAL MEDIA EFFECTIVENESS FOR PUBLIC ENGAGEMENT: EXAMPLES OF SMALL NONPROFITS

3.1. Objective and Background

Recently, social media have also been increasingly adopted in small organizations such as charities, small businesses, and community groups. Social media are especially beneficial for these small organizations in providing cheap and easy ways to allow their campaigns to go viral online and reach a global audience—something previously only available in large organizations with more resources to devote to such efforts. When using social media for public engagement, all organizations face certain shared barriers, such as dealing with different stakeholders and needing social media training and expertise. As new social media sites appear and evolve, another challenge is to efficiently manage multiple social media sites. For small organizations, this becomes even more challenging because they are unable to confront the overhead involved in learning and managing multiple social media systems.

During the research with a group of small environmental NPOs that focus on advocacy work related to local water and environmental issues, we found that they well represent small organizations in social media use. They face a unique set of needs and constraints distinct from those of large organizations. First, small NPOs are constrained by limited financial resources that affect long-term technology planning and access to technical expertise. Second, small NPOs often involve various stakeholders who are more loosely connected to the organization overall (Powell & Steinberg, 2006). Small NPOs are also tight in human resources and depend heavily on volunteers to fulfill their day-to-day operations, creating a cooperative dynamic that is different from that of corporate organizations where paid employees do all work. Third, small NPOs face competition with large NPOs and organizations, both in terms of getting public funding and capturing attention on social media sites (Thrall, Stecula, & Sweet, 2014). Finally, small

environmental NPOs have missions to improve local communities and thus actively involve in both online and offline interactions with community residents. All of these factors lead to a complex assortment of coordination and communication challenges in resource-limited public organizations.

By studying how a group of small environmental NPOs use multiple social media sites, we aim to answer the first question of the dissertation:

RQ1: How do public organizations (e.g. small NPOs) use social media for public engagement?

In particular, we aim to answer four central questions in regard to social media use for public engagement in small organizations:

RQ1-1: *What are the factors that influence small NPOs' decision-making regarding social media adoption?*

RQ1-2: *How do small NPOs use various social media sites to achieve different public engagement goals?*

RQ1-3: *How do small NPOs assess the effectiveness of different social media for public engagement?*

RQ1-4: *What are the organizational challenges that influence how social media support their public engagement goals?*

Close examination of these challenges can enable small organizations to use different social media tools more effectively for public engagement, and provide design implications for complex social media management in an organizational context. Although we specifically focused on small NPOs, the need to develop social media strategies with organizational constraints is an issue that all small organizations intend to leverage civic technologies for civic engagement face.

3.1.1. Social Media Use in Organizations

Social media sites have been used widely within organizations as tools for building social capital by providing access to new people and knowledge (Steinfield, DiMicco, Ellison, & Lampe, 2009), sharing knowledge (Treem & Leonardi, 2012), and building relationships (DiMicco et al., 2008). Diverse affordances of social media sites such as visibility, editability, persistence, and association have provided rich opportunities to

support organization communication (Treem & Leonardi, 2012). Recently, others have also found that organizations use multiple social media sites to complement each other for communication and knowledge sharing across different work role boundaries (Matthews, Whittaker, Badenes, & Smith, 2014; Yuan, Zhao, Liao, & Chi, 2013). Social media use in organizations has also evolved over time, with the trend being that more social media sites are used to support different aspects of organizational work (Zhang, De Choudhury, & Grudin, 2014).

Not all social media channels used in the organizational context exist entirely within the organizations. Previous researchers have also explored the value of social media sites in terms of communicating and engaging with stakeholders outside of organizations. Many public sectors such as government agencies actively use social media to engage with citizens to enhance government openness and transparency (Bertot, Jaeger, & Hansen, 2012). Business sectors are also interested in making use of social media to promote sales (Hoffman & Fodor, 2010).

Compared with traditional organizations, small organizations face more challenges in leveraging social media sites to fulfill their organizational goals, such as building networks and mobilizing actions. For instance, Robson et al. (Robson, Hearst, Kau, & Pierce, 2013) used Facebook and Twitter to promote a citizen science project, but the contribution of these sites to the effort was less than that of face-to-face communication. Self-organized small organizations were also constrained by limited experience and informal networks when they used social media for action mobilization (Anduiza, Cristancho, & Sabucedo, 2014).

3.1.2. NPOs and ICTs Use

NPOs are a critical component of civil society because they serve the public good and social welfare, organized around such issues as healthcare, shelter, and environmental protection. There are 1.5 million NPOs in the United States, about three quarters of which are small NPOs whose annual budgets are under 1 million dollars a year. These small NPOs share and cultivate knowledge and caring for localized areas and they impact and engage local communities. Like other organizations, NPOs have adopted information and communication technologies (ICTs) such as email, databases, websites, etc., to facilitate

and improve activities such as volunteer management, internal information management, public relations and fund-raising activities (Merkel et al., 2007; Nah & Saxton, 2012). On the other hand, small NPOs have relatively limited budgets to purchase technology and training (Le Dantec & Edwards, 2008; Merkel et al., 2007), while their dynamic and fluid information needs, stakeholders, and work contexts pose various challenges for how ICTs can support their coordination and information management (Stoll, Edwards, & Mynatt, 2010; Voida, 2011).

3.1.3. Social Media Use for NPOs Public Engagement

Recently, many NPOs have started to use social media sites to reach out directly to their audiences around the topics and activities associated with their missions. Social media sites provide many useful affordances for public engagement, such as low-cost platforms, rapid information dissemination channels, and rich interactive features (Obar et al., 2012). As a result, social media sites, especially Facebook and Twitter, have been broadly used by NPOs and may have great potential to support NPOs in relationship building and collective action mobilization (Miller & Miller, 2011).

Public relations researchers have analyzed the content of large NPO social media sites and derived several categories of engagement-related content strategies and categorized them into three main public engagement functions: information, community, and action (Guo & Saxton, 2014; Lovejoy & Saxton, 2012a). Nevertheless, NPOs lack proper strategies to make use of the technology affordances in their social media platforms to enact these public engagement goals and NPOs often do not fully employ the interactive affordances of social media, instead treating social media as a one-way broadcasting platform rather than a two-way interactive tool (Lovejoy & Saxton, 2012a; Uzunoğlu & Misci Kip, 2013; Waters & Jamal, 2011).

One contextual factor is how NPOs perceive and assess the effectiveness of social media sites in achieving their initial communication and engagement goals. In fact, evaluating social media outcomes and utilities is not as straightforward for NPOs as it is in enterprise sectors, where outcomes can be assessed directly using the standard return of investment (ROI) metrics. In NPOs, on the other hand, assessment is conducted within a context of uncertain and there are various outcomes that are hard to measured or quantify,

such as awareness, volunteers, and funding. A survey conducted by Idealware (Using, 2011) showed that about only half of US NPOs measured their social media performance; but that for all of those who did, they found a correlation with positive social media outcomes. However, it was still unclear what exact metric NPOs relied on, and whether these measurements accurately reflected their public engagement performance.

Another group of contextual factors tie to several organizational factors that influence NPOs' social media adoption and use. Previous literature has revealed that the adoption and performance of social media sites in large NPOs is related to organizational strategy, capacity and governance (Nah & Saxton, 2012). In addition, resource limitations, mis-coordination, blurring between personal and organizational accounts, as well as low media literacy may prevent NPOs from actively using social media (Briones, Kuch, Liu, & Jin, 2011; Obar et al., 2012; Quinton & Fennemore, 2013). However, it is unknown which factors influence small NPOs' social media adoption, and how these organizational factors directly influence their efforts at public engagement via social media platforms.

3.2. Methods

3.2.1. Participants

We recruited 27 social media "point persons" (9 males) from 26 small environmental NPOs in the United States (2 participants were from the same NPO). The average age of participants was 41 (SD=14.7). 15 participants were communication and marketing specialists, 6 participants were project or executive directors, and 6 participants were technical specialists. All of the NPOs had an average of 15 staff numbers (SD=12.3). To protect the anonymity of participants, we refer to all participants using number IDs.

We used a purposive sampling strategy based on a sampling frame (N=107) generated by a group of environmental conservation researchers and the response rate was 25.2%. Most of the NPOs we interviewed focus on issues surrounding waterways and watersheds, though some take a broader environmental approach, in which water issues are only one facet of their work. The nonprofits fall into three general categories: affiliate and university (6), network and policy (11), and community NPOs (12). Affiliate and university organizations are programs associated with larger governmental agencies or universities. Network and policy organizations primarily advocate for policy change

surrounding environmental issues on a statewide or regional level. Community organizations are often dedicated to their local waterway(s) and organize at a community level.

We invited people who worked directly with their NPO social media sites to participate in our interview. We identified the individual participants from the NPOs' website or through referral by their coworkers who were listed as the NPO contact. Participants were recruited through emails, organizational website contact pages, phone calls, and private messages sent through Facebook. We continued recruiting participants until we achieved saturation regarding their use of social media sites. By looking at one group of NPOs with similar missions, we were able to identify and analyze common patterns of social media practice without introducing uncertainty related to the effects of highly different missions, scale, or geographic regions.

3.2.2. Data Collection and Analysis
3.2.2.1. Semi-Structured Interview

We conducted semi-structured phone interviews (Bernard & Bernard, 2012) with each NPO social media point person. The average interview lasted 45 minutes. We conducted all interviews singly or in a team of two, and all researchers used the same interview protocol, which was designed around the following areas of interest (see Appendix A): (1) The background and goal of the NPO and the participant's role in the organization; (2) The nature of the work undertaken by the participant, with emphasis on how they managed their social media sites; (3) The strategies that the participant and the organization utilized for different social media sites; (4) How participants perceived and assessed the effectiveness of social media sites for their organization; (4) Who constituted their audience on social media sites and how they reached out to that audiences; and (5) The challenges that they had in their organization when using social media.

The interview data were collected from Nov 2013 to March 2014. The interviews were recorded and transcribed verbatim and coded using NVivo 10 (NVivo, 2012). Using a constant comparative coding strategy, we iteratively and inductively developed a coding scheme related to NPOs' use of social media sites. We used coding strategies such as initial coding, process coding, and in-Vivo coding. We initially developed a set of codes

inductively merged from data related to different social media sites (e.g., Facebook, Twitter, YouTube, LinkedIn), social media strategies (e.g., scheduling posts, multimedia, initiating conversation) and organizational factors (e.g., resource allocation, teamwork, multiple roles). During the initial coding, we used analytical memos to examine themes and patterns (e.g., control over social media, fluid workforce). After the coding, we used data analysis tools such as the case-ordered descriptive meta-matrix and the variable-by-variable matrix to further describe and explain the data (Miles & Huberman, 2013), and deductively categorized NPOs' social media strategies into three key functions of public engagement: information, community and action (Lovejoy & Saxton, 2012a).

3.2.2.2. Content Analysis

To further understand the strategies that small NPOs articulated in the interview, we conducted a content analysis of their Facebook public page and Twitter account during Sept 2014. We sampled the 30 most recent posts for each NPO's Facebook and Twitter page. Two coders coded 26 Facebook accounts and 23 Twitter accounts. Deductively drawing on the previous literature about the three key functions of NPOs public engagement: information, community and action (Lovejoy & Saxton, 2012a), we developed a coding schema that contained 9 social media post categories in 3 overarching categories (Table 1).

Table 1. Content Analysis on NPOs Facebook and Twitter

Engagement goals	Code type	Facebook (N=25)	Twitter (N=23)
Information	News and updates	218 (29.0%)	171 (24.8%)
	Education, tools	113 (15.1%)	84 (12.2%)
	Media	47 (6.2%)	29 (4.2%)
Community	Other organization	29 (3.8%)	73 (10.6%)
	Conversation	24 (3.2%)	54 (7.8%)
	Giving recognition and thanks	44 (5.8%)	59 (8.6%)
	Live posting	37 (4.9%)	46 (6.7%)
Action	Event	162 (21.6%)	74 (10.7%)
	Call for action	78 (10.4%)	100 (14.5%)

3.3. Results

3.3.1. Overview of small NPOs social media use

In our research, we found that small NPOs used a wide range of social media sites. Many NPOs (13/26) had their own blogs built from WordPress or Drupal, which were an important place to update organizational news, policy issues, and educational resources. Almost every NPO used social networking sites such as Facebook (25/26, followers: 2747±952), Twitter (23/26, followers: 1871±498), LinkedIn (7/26, followers: 180±87) and Google+ (4/26, followers: 41±26). Finally, many NPOs also explored media sharing sites such as Pinterest (4/26, followers: 83±29), Flickr (4/26), Instagram (2/26, followers: 269±75), YouTube (12/26, followers: 130±92), Podcast (2/26) and Vimeo (1/26) to post multimedia content to engage with their audience.

3.3.1.1. Adoption of Social Media Sites

Small NPOs' decisions regarding the adoption of social media sites were driven mainly by the needs of different stakeholders. First, they considered if their existing members or potential audience were already on the sites. Facebook, for example, was perceived as the platform that most of their targeted group used: *"When we launched our Facebook page, tons of our members liked our Facebook page. And I did our Twitter account within the exact same week, and people were making Twitter accounts to follow me" (P8)*. Second, NPOs were compelled by the social comparison with peer organizations to adopt these platforms; as P3 put it, *"otherwise you're just gonna get left behind"*. Third, they were motivated to demonstrate to funders that they were making efforts to reach out to people to satisfy their funders' expectation. Finally, NPOs selected social media in the hope of expanding their reach to include audiences gathered in different social media channels. For instance, P13 told us the reason that their organization wanted to use Pinterest was to *"attract people who are just kind of interested in healthy living or just interested in nontoxic products… at least get people to use it not for advocacy purposes, using it for kind of lifting the general knowledge about what green living would be like"*.

3.3.1.2. Engaging with a Diversity of Stakeholders

NPOs worked with a variety group of stakeholders through social media sites, and the interaction with different stakeholders segmented based on the affordances of social media and the popularity of social media among the stakeholders.

NPO Members: NPO members are local citizens who show an interest in the NPO's cause and sign up for membership, which usually includes sharing their contact information with the NPO. Membership size among the NPOs ranged from 450–17000, and members were the most reliable sources for financial support and event participation. As a consequence, one of the most vital motivations for using social media was to expand membership. For daily communication, however, NPOs mainly used email and newsletters to communicate directly with the members.

Volunteers: Volunteers are important workforces for NPOs, supporting their organizational activities. Social media sites enabled NPOs to post about volunteers recruitment information and give recognition and thanks to volunteers who helped with previous events or activities. In addition, they also frequently posted photos of volunteer activities in Flickr, Instagram, and Facebook albums, and shared these images through social networking sites like Facebook and Twitter.

Funders: NPOs used social networking sites to engage with funders by posting donation information and giving recognition and thanks to donors. Nevertheless, as financial donors are usually older adults who are relatively less active on social media sites, NPOs felt the most effective way to contact and engage with funders was still traditional via communication channels such as email lists and face-to-face meetings.

Other organizations: NPOs (9/26) frequently use social media to strengthen existing partnerships with other organizations by cross promoting one another on social media—for example, liking each other's content, reposting each other's posts, promoting each other's events, sharing news and tools from other's sites, and recognizing and congratulating each other's work. NPOs saw this as a way to "scratch each other's back" (P11), to support and build relationship with other organizations, get updated about each other's working progress, and especially "double the poll of viewers" (P11) and expand the follower influence on social media sites. At the same time, some NPOs did feel as though they were

primarily connected to other organizations, and still didn't reach out to the general public enough.

Reporters: Building a positive relationship with reporters and media has long been an important outreach and communication goal for NPOs (6/26), as reporters can help to attract press attention and disseminate information. Twitter was perceived as the primary platform for media reporters to reach out to NPOs. Based on our interview, reporters frequently use Twitter features such as retweet, favorite and @ to interact with NPOs, pick up their tweets as news sources, or ask questions on Twitter, which greatly increased NPOs' online influence. Additionally, NPOs' social media point persons proactively interacted with reporters to strengthen the relationship. As one interviewee explained, one might use the NPO's social media to *"post [reporters'] work, credit their work, try to generate discussions with the individual reporters, and say to them by name"* (P20)

3.3.2. Diverse Stakeholder and Engagement goals: Information, Community, and Action

Small NPOs leveraged multiple social media sites to engage with a variety of stakeholders and their social media practice and activities fell into three engagement goals discussed in previous literature (Guo & Saxton, 2014; Lovejoy & Saxton, 2012a): disseminating information about their causes and the organization; building community and engaging with different stakeholders; and mobilizing action like donation and volunteering work. NPOs actively leveraged different social media sites to fulfill these engagement goals and connected with diverse stakeholders, yet the actual effectiveness of social media for public engagement remained unclear and insufficient.

3.3.2.1. Increasing Awareness of Information

NPOs shared a huge amount of information regarding environmental issues and organizational updates via a variety of social media sites to increase awareness of their organization and its mission. A content analysis (Table 1) of NPOs' Facebook and Twitter pages illustrated that about half of their social media posts were related to an information goal: news and updates of their website and organization, educational resources and environmental tools, as well as multimedia content such as photo or videos.

NPOs commonly used multiple social media sites together to support the information engagement goal. NPOs frequently shared updates from their websites and blogs, tutorials or educational videos from YouTube, and photos from Flickr or Instagram. NPOs also used blogs to aggregate information from the social networking sites and provide longer form content on interesting topics:

"The features that primarily go into the blog site actually originate on the day to day news items that I tweet out. And then I compile those in the weekly blog summary under various headings, such as agriculture or water quality or biodiversity. So it's an aggregate. If there are more, what I see as more significant issues, then I'll do a separate article about those significant breaking issues and then sometimes summarize those in a paragraph or two within the weekly issue. " (P2)

Multimedia content was also a popular strategy among NPOs. Most participants (13/26) told us that the most effective strategy to solicit shares and comments was to post appealing photographs, usually containing cute animals or beautiful nature scenes. NPOs frequently posted such media content on Flickr, Pinterest, and/or Instagram and shared through social networking sites. Participants felt that the practice helped to provide "a better entry point" (P20) for the public to learn more about NPOs.

3.3.2.2. Building Community

While the purpose of the first engagement goal is to disseminate information, another set of social media practices involve building stronger ties with existing stakeholders and local communities. Content analysis (Table 1) illustrates the types of community posts tied to this goal: interaction with other organizations, conversation with the public, giving recognition and thanks, and live posting about volunteer events, especially on Twitter. The community NPOs proactively posted questions and discussion topics to prompt interaction and conversation with their audience. For instance, P26 described their experience of posting questions online: *"We ask a question, and when they respond, we can become close to them through being actively engaged with what they're saying. You have to build up to a point where people feel almost safe, and that it's going to be alright if they're wrong."*

Many NPOs found that hashtags on Twitter—created using the "#" symbol, with users collaboratively contributing content to the hashtag—were particularly helpful to initiate such discussion, as the hashtag format "speaks in ways a sentence can't" (P20). Nevertheless, many NPOs also said that despite using these strategies in their social media, their followers were still not active in participating in the conversations.

Lastly, NPOs frequently posted photos taken during about their work and events, such as conferences or volunteer events, which demonstrated their endeavors and accomplishments to their audience. In some cases, they made use of the "real time," live properties of Twitter and Facebook by providing live postings of events, with positive results: *"That issue went to court and there were very few people who could take time off during the day to sit and listen to this court hearing even though everybody was extremely interested in the outcome of this debate, and what the judge was gonna say. So I was able to live tweet that court hearing. The Twitter stream that I was posting got a gigantic spike of followers and people were really tuning in to hear that play." (P18)*

3.3.2.3. Mobilizing Actions

For most NPOs, the ultimate goal of social media use was to mobilize an audience by providing enough information and building a sufficient sense of community to spur people into potential actions, such as becoming a volunteer member, donating money, or signing a petition. For instance: *"The bigger question becomes, are they going to sign the letter to congress, or are they going to sign the letter to the Wisconsin legislature when there's an issue going on that they can take action on? Or are they more of just a casual supporter? And that's something we're trying to get a handle on but we don't quite know." (P20)*

In the content analysis, we also found that NPOs frequently posted about actionable items: event information, fund-raising, advocacy, social media campaigns, or direct calls for action (Table 1). But while NPOs have tried to mobilize actions through social media sites, they typically remain disappointed with the ability of such sites to transform online engagement into "real" action, whether in the form of attending an event or providing financial support, particularly when the NPO has directly asked for such actions. They noted that "liking a Facebook page is not an engagement" (P9), and felt it did not lead to

actual action outside the site. They thought the problem was that the social media audience was not "tuned to hear the message" (P7), and seemed to lack the motivation to take real actions: *"We invited people to participate on social media. They loved the pictures and the quotes that people were sending in about the river. But we didn't get a single person to print out the form and put a check with it and send it to us from any of the platforms we used electronically. " (P7)*

Instead of social media sites, many NPOs (21/26) mentioned that traditional communication tools like email lists or even face-to-face interactions are still more effective in mobilizing people, especially previous volunteers and donors, into action like fund-raising and signing a petition. They reported usually getting pretty good results with such "traditional" calls for action. P3 described one example when they asked people for an advocacy action: *"More recently we did ask people to call their local congressmen about the Water Resources Development Act. I was sort of surprised the emails I got. People were forwarding to me the responses they got from the congressman, when they did call. "*

3.3.2.4. Evaluating Social Media Effectiveness: Mismatch with Real Engagement

One challenge for small NPOs is to define and measure the "success" of social media sites in terms of public engagement. NPOs paid close attention to basic metrics like number of followers, shares and likes, and growth trends of their social media sites. These metrics reflected the size of audiences and how much interaction occurred on their social media sites, and thus spoke to the information and community goals of public engagement. *"I think people like some of the news stories that we post and if we post something fun like, "We just got a million dollar grant from the EPA," a lot of people tend to like those things. Sort of a "Yay. Congratulations." The like button's like a virtual high five." (P19)*

Many participants (13/26) also noted that they had been using social media analytics tools like Facebook Insights, Klout, and Urchin to further track the demographics and behaviors of visitors to social media sites. However, they generally did not have formalized routines or strategies for using these analytic tools, and only looked at anecdotal information rather than tracking numbers systematically. Participants repeatedly tell us that although such analytic tools provide numerous metrics, they are too complicated to

interpret: *"Facebook is crazy. They measure every little click that anybody does. But it's hard for me to capture that information and present it to our board members to explain whether the performance of our social media are improving or needs boosting. " (P18)*

Furthermore, participants noted that the analytical tools gave them little information about their performance in terms of achieving the action goal. They had no idea whether social media visitors were being effectively transformed into highly engaged members or donors. Even if they were succeeding in this goal, there was no way for them to compare the list of social media visits with the lists of volunteers, members, or donors. Without having clear methods in place to match these sets of information, they felt it was extremely hard to further engage these audiences. For instance, P9 noted that it was hard for their NPOs to compare their Facebook audience with their existing membership list, and that the data from Facebook itself was not quite useful: *"For this post the people that like the thing 20 people out of the 329 likers we have here, I don't know who they are. They don't show up on email lists. I know that they're mostly local, which is good, because that means that they saw us somewhere, or picked up one of our bookmarks somewhere, and liked the page. But we need to figure out how to connect these people with our organization. They're disconnected from other parts of communication that you have. ... "*

3.3.3. The Organizational Context of Small NPOs Social Media Use

Small NPOs seek to achieve a complex assemblage of public engagement goals with different stakeholders. However, distributed coordination with multiple sites, a diverse and fluid workforce, time, funding, expertise constraints, and organizational policy all factored into decisions about which social media to use and how social media sites were used by small NPOs for public engagement.

3.3.3.1. *"All hands on deck" for Social Media Management*

In small environmental NPOs, there was usually a shortage of labor for social media management. Participants noted that they commonly "wear a lot of hats" (P14) and were responsible for a variety of communication and public relation tasks. Social media management work, though important, was only one small component on the long list of such tasks. As a result, most NPOs did not have one person wholly dedicated to social

media management, but rather distributed the responsibility across a group of staff members.

This "all hands on deck" approach to social media management took several different patterns. The first mode was that each staff member would manage one official social media page that he or she was familiar with. The challenge, as a result, was to coordinate between different social media pages. In the second mode, multiple staff members had administrative access to the official social media page(s) and anyone could edit and maintain the sites' content. When there were multiple people working collaboratively on these social media sites, the challenge became how to coordinate among people and conduct quality control. Nevertheless, most organizations did not have a rigorous policy about coordination and quality control; instead, staff members just had to trust that each person would be responsible when posting something: *"We don't have a process of running something by the whole team because that's too slow. We just have to trust each other's judgment, and each of us does it. If there's something that I do have a question about, it's easy for me to run it by somebody if I want, but it's not required. "* *(P14)*

In the third mode, small NPOs encouraged certain staff members such as outreach specialists to create a personal account separate from the official account, usually on Twitter, to post about their work, expertise, and experiences related to the NPO's causes. The official account and the specialist accounts frequently reposted each other's content and attracted their own audience, which expanded the overall NPO's influence "like a big web" (P16). This strategy was also perceived as effective way to make the organization feel more real and accessible: *"So it does allow you to peek behind the curtain of our organization, kind of humanize people. But again, not in a frivolous way, and then I think that builds the interest that we naturally have. We're just naturally curious about other people. "* *(P16)*

In addition to the full-time staff, NPOs often relied on their temporary workforce, such as interns or volunteers, to manage their social media sites. These short-term workers were temporary, their schedule frequently changed, and their work discontinued after they left the job. For instance, P9 told us that her organization's use of Twitter was based

entirely on one worker's expertise: *"We used Twitter for nine months that we had the social networking intern last year. And then when she left we didn't use Twitter."*

3.3.3.2. Constraints in Time, Funding, and Expertise

The work of social media management is characterized by pragmatic constraints in terms of time and human and financial resources. Time constraint was the primary concern of most NPOs. Even though social media were initially perceived as an easy, low-cost way to communicate, most NPOs (15/26) still felt that social media sites were very time consuming and that they lacked the time to make use of them fully. Consequently, NPO point persons normally only focused on only one or two social media channels, even when they saw other new or alternate social media sites as potentially useful: *"As a smaller organization, a Twitter and a Facebook Page is pretty much all we can handle at this moment. I think as far as social media go, that we have to devote our time to quality over quantity when it comes to that."* (P26)

Social media management was also limited by financial resources in small NPOs. NPOs cannot afford to hire dedicated staffs to manage social media channels, nor can they hire social media or marketing firms to help with social media management techniques. Many participants (6/26) also complained about Facebook with regard to its new Newsfeed algorithm, which charges NPOs to promote their posts in users' newsfeeds. Because NPOs did not have the budget for social media advertising, this dramatically limited the organic reach of their Facebook page: *"Facebook also has its sharing algorithm which is very different than it used to be a few years ago. And I think that its limits to how many of your supporters see your post. Their promote scheme where they're trying to charge for increased visibility of your post, I think is absolutely killing the platform for non-profits. I just really think that Facebook should have an exemption for 501 [c] [3] recognized non-profits that our pages shouldn't have to be subjected to promote functions. We should be able to have all of our supporters be able to see all of our posts at all times for free."* (P18)

Finally, NPOs' social media channels were constrained by their internal lack of expertise in differentiating their use of different social media sites. Several participants (9/26) noted that they posted the exact same content in both Facebook and Twitter pages

and used automatic synchronizing tools to link different sites, despite the significant differences between the two sites in terms of audiences and features. Other participants, however, pointed out problems in using such auto-link strategies across different sites: *"But the one thing that we never ever do for any reason, ever upon penalty of me being very angry is, you never, ever, ever, post on Facebook what's on Twitter. Facebook and Twitter are not synonymous. The platforms don't work together, so stop trying to make them work together." (P10)*

3.3.3.3. The Politics of Social Media Management

Small NPOs had their own organizational policy or guidelines that regulated their social media use regarding the approval of content, ownership of social media sites and interaction with social media followers. However, these organizational norms and routines did not always work collaboratively with their social media practice and public engagement goals.

For many small NPOs, the decision to adopt social media sites required approval or was decided by higher-level organizations or managers. P22 worked for a local branch of a national NPO, and explained that the former was strictly constrained by the latter's rules regarding which sites could be used by each level: *"Twitter goes to our Ohio account. Facebook, we're not able to do that. We have a blog, but we don't have any control over that, we just submit things to it once in a while. Flickr, we can't have one of those. So those are national, I don't think we're allowed to. We don't have very much available to us. Instagram is another one." (P22)*

In addition, many participants noted that they had a complex approval process regarding the content strategies and actions in social media sites, to make sure that posts were considered "appropriate" and without any typos, errors, or mistakes. Furthermore, this approval process regarding which features or content strategy to use has greatly influenced their interaction and engagement with social media audiences. For instance, P26 talked about how their director's preference and approval processes limited the organizations' ability to use social media for public engagement: *"Our main director doesn't like hashtags for some reason. I think they're a great tool to use when you're using Twitter. Now, on my personal account, I use them a lot. When it comes to responding to*

different posts from other organizations, it's kind of hard to go through that approval process. We'll like on Facebook or favorite something that somebody says on Twitter, but we won't necessarily respond in words." (P26)

3.4. Discussion

Our findings provided a background for understanding the challenges for small organizations in using social media to engage with diverse stakeholders and enact different public engagement goals. Small organizations need to better understand and evaluate the success of their social media performance, especially given the lack of awareness and information regarding their social media audiences and whether social media can foster long-term, productive relationships with those audiences. Small organizations also face several within-organization challenges that sometimes hinder their engagement goals. These all call for significant design and research trajectories to support complex social media use for public engagement in small organizations.

3.4.1. Managing Social Media Multiplexity for Engagement

The challenges of engaging diverse stakeholders for small organizations involve not just one single social media platform but also a complex social media ecosystem. In this research, we provided evidence of how small NPOs perceived the effectiveness of different social media sites: Facebook was seen as effective at engaging general public audiences, Twitter was seen as particularly useful for engaging other organizations and reporters, and blogs were seen as effective at aggregating diffused information scattered across other social media platforms. These insights extend prior work examining NPOs' use of social media in understanding their practices in a single social media platform (Guo & Saxton, 2014; Lovejoy & Saxton, 2012a; Waters & Jamal, 2011) and discussion about the effectiveness of different social media sites in advocacy (Obar et al., 2012).

However, using multiple social media sites requires time, a relatively stable workforce, proper collaborations between organizational staff, and expertise to be usable to small organizations. Most small organizations are constrained in their capacities to be able to manage and fully maximize the power of multiple social media platforms. These findings indicate that social media platforms such as Hootsuite, Sprout, and Storify should

better support heterogeneous content strategies, audiences, and stakeholders of organizational social media sites. Social media management systems should be designed not only to provide tools to manage multiple sites, but also to provide guidance on how to make use of the unique affordances of each site to engage with different stakeholders. Visualization tools should provide straightforward and integrated summaries of individual and overall performance of different social media platforms. In addition, there is also a need for tools to track interactions with different stakeholders, such as the number of RTs, @s, and conversations with other organizations, reporters, and donors.

3.4.2. Connecting Information, Community, and Action

We found that, like large NPOs, small NPOs seek to fulfill different engagement goals through social media sites. Social media are seen as promising for increasing information and awareness, but less effective at engaging with community, or mobilizing people into the types of action that the organizations want to engender. These results echo previous literature, which found that NPOs failed to utilize social media for dialogic communication (Sommerfeldt et al., 2012) and faced the challenge of "slacktivism" (Christensen, 2011), in which participants only take minimum support efforts online without devoting real actions.

In addition, another challenge for small organizations is the lack of accurate feedback regarding their social media performance. Though social media analytic tools exist that aim to measure social media success, these tools primarily target business sectors that measure the return on investment (ROI) of technology use such as sales and brand value. Most of these tools are also not free, which limits small organizations' ability to use them.

These findings have many implications for the design of social media analytic assessment tools for public engagement. There is, in particular, an absence of metrics that assess social media's connection to important outcomes such as fund-raising and volunteer recruitment. In addition to measuring the ROI of social media sites, it is also critical to support connections between social media performance and public participation performance. There is a need to connect social media analytics tools with more situated traces and records of which social media followers are really engaged and motivated to

actions, possibly through organizational information system and metadata of volunteers and donors' information, such as linking to online volunteer recruitment management tools (e.g., VolunteerMatch.com) and fund-raising sites (e.g., giveforward.com), as well as existing volunteer or donor email lists. These tools should also help aggregate detailed demographic and background information of participants to help small organizations better target and filter highly motivated audiences and mobilize them from "likers" to engaged actors.

3.4.3. Supporting Organizational Social Media Management

In this section, we also highlighted several organizational factors that influenced social media use in small organizations' public engagement practice. It is crucial for HCI researchers to acknowledge these constraints when aiming to design social media tools for small organizations. It is also important pragmatic information for small organizations that want to facilitate their social media sites' engagement with diverse communities.

We found that there were typically multiple people involved in NPOs' social media management, either through dividing work between staff members, or sharing responsibilities with multiple staff, specialists, and volunteers. This strategy poses potential problems related to coordination and quality control; it can also blur the boundaries between personal and organizational accounts (Skeels & Grudin, 2009). In addition, existing social media sites are usually designed for one account per organization or person who manages the public account. As a result, there is a need for social media management tools that support multiple users and multiple accounts, and provide the necessary links or distance between official and unofficial organizational social media accounts. To support efficient social media management within small NPOs, the design of organizational social media platforms should also effectively incorporate the organizational internal workflow with different social media sites, such as drafting, editing, approval, and scheduling posts.

Additionally, organizational norms and routines, such as unwieldy, slow, and/or hierarchical approval processes also prevented small organizations from being creative in content strategies, being interactive in communication strategies, and, in some cases, even adopting useful social media channels. In general, participants expressed a desire for greater flexibility and autonomy regarding social media sites decision and strategies. The

influence of organizational norms and culture reflected the influence of power-oriented structures on the use of technology in the adaptive structuration theory (DeSanctis & Poole, 1994) and was found in social media use in other organizational contexts (Foster, Lawson, Wardman, Blythe, & Linehan, 2012; Le Dantec & Edwards, 2008). This suggests that small organizations should identify and resolve tensions between different constituents and coordinate to find the best strategies to use social media for public engagement goals. Our findings also indicate that the design of organizational social media management tools should provide proper editing or management rights to certain aspects of work and organizational staff, e.g., which type of work should be approved by which group of people, to mitigate conflicts between the organizational power and efficiency of social media management.

3.4.4. Limitations

There are several limitations of the current study. First, the study was based on 26 small environmental advocacy NPOs. We did not compare their social media performance (i.e., number of followers) with the general population of US NPOs. This means that the results may not be directly applicable to other small NPOs. Another limitation is that we only interviewed the social media point person in small NPOs, and thus it is mainly the viewpoints of social media point persons that are represented. We did not look, for example, at the viewpoints of managers, activists, or outreach specialists, which could vary based on their power status in the organization (Foster et al., 2012); nor did we talk to the recipients of messages, such as volunteers, other organizations, or the general public. Future work should investigate the perceptions of these other stakeholders to identify shared and divergent experiences and perceptions.

CHAPTER 4. SUSTAINABLE HACKING: CHARACTERISTICS OF THE DESIGN AND ADOPTION OF CIVIC HACKING PROJECTS

4.1. Objective and Background

Civic technologies are broadly defined as "the design and use of technology to support both formal and informal aspects of government and public services" (Boehner & Disalvo, 2016). Many public organizations have adopted civic technologies not only through the traditional information technology (IT) development process, but also through "civic hacking" projects, i.e. short-term collaborations among public organizations, citizen experts, and private sectors to develop digital solutions to public issues (Schrock, 2016). The recent U.S. Open Government Initiative, which encourages federal and local governments to make more public data available online, further encourages emerging civic hacking projects such as Code for America (CFA) (www.codeforamerica.org), Open Data Day hackathons (www.opendataday.org), and various city "app contests." Civic hacking demonstrates public organizations' efforts to promote innovation, transparency, accessibility, collaboration, and citizen participation (Frecks, 2015; Gregg, 2015). Regardless of the growing enthusiasm about civic hacking, researchers have challenged the effective changes and the long-term sustainability of these projects (Irani, 2015; Johnson & Robinson, 2014; McMillan et al., 2016; Townsend, 2013). As a result, this chapter is trying to answer the second question of this dissertation:

RQ2: What strategies do participants in civic hacking projects use to improve the sustainability of civic technologies for local public organizations?

Human–computer interaction (HCI) researchers have been interested in environmental, financial, and community sustainability (Dillahunt, 2014b). Here we define sustainability as the feasibility for public organizations to adopt, maintain, update, and develop civic technologies (Gurstein, 2001; Taylor et al., 2013). Although civic hacking projects could contribute to problem deliberation, design exploration, and ideation (Lodato

& DiSalvo, 2016), their sustainability ensures a more direct impact on public organizations' day-to-day work, civic engagement, and citizen participation, especially for public organizations that lack internal technical expertise and resources to develop and manage civic technologies.

The information technology adoption theories like of the diffusion of innovations (DOI) (Rogers, 2010) has provided some insights in technology adoptions in organizations. Recent HCI research on the deployment of innovative community technologies "in the wild" — the design process within the actual setting of user activities and communities in situ (Crabtree et al., 2013) — has provided inspirations for the long-term sustainability of civic technologies during the design process. However, most of this literature addresses the sustainability of community technologies created through long-term collaborations between researchers and communities, whereas civic hacking projects usually involve short-term commitment with civic-minded technologists without the responsibility to maintain or deploy the projects after the temporary collaborations. While civic volunteer technologists understand the technical details, they lack the comprehensive understanding of the complex operational and political factors that govern public organizations' actions. Few studies have investigated how to make these civic hacking projects succeed given the limited time and resources for development and collaborations.

This paper contributes to the civic hacking literature by investigating factors that influence the sustainability of civic hacking projects in resource-limited public organizations. Our analysis focuses on a set of civic hacking projects that are distinct from previous civic hacking projects that promoted innovations and problem deliberations (Lodato & DiSalvo, 2016). First, the civic hacking projects in this study are organized through a course on civic technologies at a Midwestern college in the United States rather than through community volunteers. Second, the civic hacking program in this study emphasize the sustainability of the civic technologies throughout the design process. Lastly, We studied sustainability by focusing on the considerations of design process to improve the potential endurable impact in community, and evaluated sustainability based on the assessment provided by stakeholders and the status of civic hacking projects (implemented) between 6 months to one year after the projects.

By examining the design choices during the iterations and handover process of these civic hacking projects, we find that a variety of off-the-shelf technologies yield better sustainable results than customized developed software. We also identify the critical roles of relationships between volunteer technologists and stakeholders as well as intra-stakeholders for the sustainability of the civic hacking projects. Last, we demonstrate the importance of mutual learning between volunteer technologists and communities during the civic hacking process. We present recommendations for HCI researchers and practitioners to create civic hacking projects that make an enduring impact on communities.

4.1.1. Uncertain Impact of Civic Hacking

Increasingly, many cities are partnering with civic-mind volunteer technologists, private sectors, and public organizations to create technologies that solve public issues through civic hacking projects. Civic hacking benefits public organizations by bringing innovations, replacing procurement processes, and encouraging civic engagement (Johnson & Robinson, 2014). Lodato and DiSalvo (2016) noted that civic hackathons construct "proto-publics" that engage in problem solutions and foster problem deliberations by creating prototypes. Maruyama, Douglas, and Robertson (2013) noted that CFA fellows acted as change agents in governance culture: they employed participatory design that involved organization staff and citizens, demonstrated innovation processes using the lean startup model, developed concrete examples of successful changes, and created an alliance of supporters for city innovations.

However, some have critiqued the adoption rate of civic hacking projects as too low and argued that civic apps fail to solve real public issues (Badger, 2013; Gregg, 2015; Johnson & Robinson, 2014). Irani (2015) noted that the civic hackathon represented an entrepreneurial citizenship that celebrated Silicon Valley values of social change through an agile process. However, prototypes generated during civic hackathons were rarely implemented and hackathon participants had no time for "real footwork" to build coalitions and trust with partners and citizens. As a result, it is necessary to examine how to enhance the enduring impact of civic hacking projects in public organizations and communities.

4.1.2. Sustainability of Civic Technologies

The theory of the diffusion of innovations (DOI) (Rogers, 2010) is a popular model in information systems research to explain the adoption of new technologies. According to DOI, the rate of innovation diffusion depends on relative advantage, complexity, compatibility, trialability, and observability. This means technologies that are advance predecessors, easy to use and understand, compatible with existing experience, easy to experiment with, or have a visible impact would be more likely to be adopted. Organizations with more proficiency and experience with technology and more resources tend to be more innovative. A recent study (McNutt et al., 2016) on civic technologies adoption in municipalities in the U.S. showed that larger governments and communities are more likely to adopt civic technologies and get involved in civic hacking. However, questions remain on how to enhance the possibility of adoption through the design process in civic hacking.

Growing HCI research on developing community technologies "in the wild" through action research and participatory design (Carroll & Rosson, 2013; Crabtree et al., 2013; Hearn, Kimber, Lennie, & Simpson, 2005) inspire us to investigate factors that facilitate a sustainable hacking process. Through long-term research collaborations with community organizations, these studies provide deep insights on how to balance technology innovations with sustainable changes in the target environment (Hayes, 2011; Merkel et al., 2004).

First, existing literature emphasizes the importance of both technical and social infrastructure (Carroll & Rosson, 2013; Le Dantec & DiSalvo, 2013). These authors argue that community technologists should build a technology infrastructure that supports community innovations and new social–cultural practices that support the maintenance of technologies in communities.

Second, prior work has indicated the potential of off-the-shelf technologies to reduce the costs and learning curve of innovative technologies. For instance, on reflection of the handover of an innovative digital noticeboard and bespoke system to communities, Taylor et al. (2013) discussed replacing the innovative components with mainstream off-the-shelf technologies to enhance the sustainability of the technologies in the community as those were easy to maintain and fix. Balestrini et al. (2014) also discussed

leveraging off-the-shelf tech (mobile phones) and infrastructure (3G) to support sustained community engagement with a community heritage preservation system.

Last, many studies have emphasized the importance of building partners' ownership of the technology (Balestrini et al., 2014; Merkel et al., 2004; Taylor et al., 2013) as they feel legitimate to own and control the technology. Le Dantec and DiSalvo (2013) discussed not only building the ownership of the material product but also the ownership of the future attachments and social relationships around the civic technologies. Existing literature also emphasizes the importance of building technical skills of community partners to maintain civic technologies (Merkel et al., 2004; Taylor et al., 2013). Recent information and communication technologies and development (ICTD) researchers have also discussed building researcher skills to work with communities. For instance, Winschiers-Theophilus et al. (2015) organized a workshop to educate novice and guest researchers to build and maintain relationships with rural communities.

However, prior work is primarily based on long-term research projects and mainly focuses on the roles of designers in the design process. The question remains whether these strategies are applicable in short-term collaboration between civic-minded volunteer technologists and public organizations during the civic hacking process, and how sustainability can be encouraged as part of the short-term collaboration.

4.1.3. Developing Civic Technologies with Public Organizations

Emerging HCI research has investigated ICT use in public sectors and NPOs to support existing practices and provide better public services (Hou, 2016; Hou & Lampe, 2015; Merkel et al., 2007; Voida, Harmon, & Al-ani, 2012). These studies reveal unique public organization characteristics that may interplay with the sustainability of civic technologies and hacking projects.

Recent research has identified several challenges in developing civic technologies with public organizations. Through the development of a public issue reporting system, Harding et al. (2015) observed that the perceived value and sustained use of civic technologies remains low in public organizations, and they called for more attention to the needs and concerns of the administrators. Kim et al. (2015) revealed that the adoption of a

citizen science mobile data collection app faced barriers such as individual beliefs, organizational structure, and the relationship with volunteers.

Boehner and Disalvo (2016) also noted several organizational challenges when building civic technologies, such as the difficulty in accessing data, the fragmentation of public organizations, the problem of business innovation as a metaphor for the civic technologies, and the general lack of literacy for data, design, and civics in public sectors. McMillan et al. (2016) found that public organization leaders worried that data openness would harm the reputation of the city and government. In that study contractors caused damage to city practices by manipulating access to the data and charging extra money for repetitive reported issues. Additionally, government bureaucracy, such as the procurement process, constrained the effectiveness of civic hacking apps. These studies inspire us to focus on public organization cultural and structural factors during the development of sustainable civic hacking projects.

4.2. Methods

4.2.1. Project Context

We investigated a collaborative civic hacking project of local government and community organizations in a small Midwestern U.S. city and a nearby university. The details of the project were discussed in a previous paper (Lampe, 2016). The city sustained both economic and social issues. For example, the median household income was about $30,000, 19.6% of the population was below the poverty line, and the crime rate was 12.8‰ (the state median was 4.2‰ and national median was 3.8‰). The goal of the project, which was conducted by technologist students during a 13-week course, was to develop information tools that the community partners could use and maintain. The program manager, who was a citizen of the partner city, helped the class advisor select the partner organizations. The university funded some civic hacking projects through an innovative teaching grant, and others were funded by the community partners.

At the beginning of each project, two to four volunteer technologists – mainly students who enrolled in the class – formed a team to work with a partner from local interest groups, NPOs, or city departments. The organizations experienced varying constraints in terms of technical skills, equipment, and financial resources. During the

design process, technologist teams conducted user interviews with various stakeholders in the community, user testing, and iterative design. Then, they created two prototypes for the project, one at the second week and the other at the ninth week. The tutoring team and partners provided feedback on the two prototypes, and the student teams presented the projects at the City Hall to all the partners and city residents. At the end of the semester (13th week), each team handed over the project and a sustainability report to the partners. The partners were to take over the project and decide whether to implement the civic technology in their organization. The students were graded based on whether the student teams created a finished product that was useful and usable, and was adoptable and sustainable by the partners. The adoption status in Table 2 was decided by whether partners implemented the project at the time of the study.

Over the 3 years of collaboration from 2014 to 2016, the project created 23 information tools for various municipal departments, NPOs, and community groups. In this study, we focus on 16 projects (Table 2) that were developed from September 2014 to December 2015. We chose these 16 projects because the volunteer technologists and partners were accessible at the time of the research. The project partners included seven city government departments (P1 to P8) and eight community organizations and nonprofits (P9 to P16). These projects also covered the various major categories of city issues such as business, community network, historical property, safety, and health. Six projects have been adopted and used by the partners, while four projects are being planned for implementation by the partners.

4.2.2. Data Collection and Analysis

We collected and triangulated multiple data sources such as direct observation, semi-structured interviews, and document analysis to understand the design practices of volunteer technologists and partners as they made sustainable civic hacking projects. Over 3 months, we observed the design process of 16 civic hacking projects, taking detailed field notes during approximately 50 hours of observations from September 2015 to December 2015. We also collected outputs of the 16 civic hacking projects, including sustainability reports, the two prototypes, and the presentation materials. Sustainability reports aimed to help the partners implement solutions after the class was over, which included a problem

Table 2: The Civic Hacking Projects Problem Statement, Partners, Actual Solutions, and Implementation Status

Problem Statement	Partners	Actual Solution	Adoption
P1-2. Welcome to the City. How to make new citizens feel welcomed, be aware of the tools and services, and encourage them to engage in the community.	The City Council	P1. A crowd-sourced mobile app that helps current residents share and newcomers find city resources. P2. A web portal of city resources on the city website. Postcard with the web portal information.	Yes
P3-4. Downtown Construction. How to maintain customer engagement with the city downtown during the downtown construction on a main avenue.	The City Downtown Development Authority	P3. A website for downtown construction information. P4. Infographics cards that incentivize citizens' engagement with downtown businesses and educate about city history.	Yes
P5. Farmer's Market. How to increase the awareness of the local farmer's market.	The City Downtown Development Authority	A volunteer platform that connects citizens and local organizations with the farmer's market. A logo for the farmer's market.	No
P6. Distressed Property. How to increase the understanding about and the report of distressed properties.	The City Department of Neighborhood and Economic Operations	An infographic that explains how to report signs of distressed properties, which is distributed on city website and postcards.	Yes
P7. Historic Property. How to increase historic district property owners' awareness of the historical status of their property.	The City Historic District Commission	A web portal on city website that allows citizens to search and verify whether their home is a historical property, a plan to disseminate a promotional mailer.	Yes
P8. Bus Map. How to help riders to know bus route information.	The City Area Transportation Authority	A web portal that contains route information. A pamphlet that betters the demonstration of the bus route information.	No
P9. Business Info. How to ease the current process to start a small business.	The City Chamber of Commerce	A medium fidelity prototype of a website about how to start a new business.	Planning
P10. Community Health. How to foster community members' physical activities.	A locally governed health system	A mobile smartphone fitness app to foster citizen interaction.	No
P11. Access Nature. How to enable a blind person to experience the nature center.	The City Community Nature Center	A Guide App and beacon system that guides blind people with audio messages about location-specific information.	Planning
P12. Historic Museum. How to engage citizens with community's history by collecting and sharing community stories.	The City History and Art Museum	Postcards that community members are invited to respond. A Pinterest page that holds the written reflections on the postcards.	No
P13. Accessibility Info. How to share accessibility information in the community.	A local disability nonprofit	A WordPress site through which people could search, request, and comment on local accessibility information.	Planning
P14. Homeless Shelter. How to help homeless residents without ID and documents to verify their identity.	A local homeless shelter	A Google form for shelter residents to verify if they have certain ID and a checklist.	Yes
P15. Snow Removal. How to keep walkways clear of snow and encourage residents to report non-shoveled sidewalks.	The City Walkable Community Coalition	A website on which residents can report blocked sidewalks, register to volunteer, and access important information.	Planning
P16. Crime Watch. How the neighborhood crime watch group can better reach and serve local residents.	A neighborhood watch group	A Facebook page and a bulletin board that present neighborhood information. A logo for the community group.	Yes

statement, discovery process, parameters that shaped the solutions, description of the solutions, the implementation plan (timeline, cost, owner of the project, success measures), and recommendation for long-term solutions.

We conducted 19 semi-structured interviews: one interview with the program manager, seven interviews with volunteer technologists, and 11 interviews with partners, from February 2016 to June 2016. Five partners were from the city hall and seven from the community organizations. The interviews took an average of 50 minutes and focused on the following areas of interest (see Appendix B): the design process, the nature of the collaboration between volunteer technologists and partners, the changes and iterations, the factors for sustainability, the handover process, and the current status of the project. During each interview, we used the two prototypes and sustainability reports as prompts for the discussion of the design process to get richer data. In the following section, we use Partners, Students, and name initials to represent the type of interviewee and different interviewees.

We performed an inductive thematic analysis (Braun & Clarke, 2006) of the field notes, interview transcripts, and documentations using coding, memos, and affinity diagramming. The data were coded for emerging phenomena using TAMSAnalyzer. After the initial codes, we undertook subsequent iterations of the coding scheme until we had a list of codes that were then grouped into higher-level categories, which led to the finalized themes presented.

4.3. Results

4.3.1. Building Sustainable Civic Technologies

The goal of a civic hacking project is not to build innovative technologies but rather to build sustainable solutions that partners can easily maintain and use to solve a public issue. As a result, volunteer technologists and partners made strategic decisions to build on existing infrastructure, leverage low-cost and off-the-shelf technologies, and make low-tech interventions during the civic hacking process.

4.3.1.1. Don't Build an App, Build it on Our Website

Some volunteer technologists naturally start with building standalone mobile apps because they are primed by the city apps idea — and it makes their portfolios look great.

However, these mobile apps do not help with the community issues and can be hard to maintain with limited financial and technical resources. On the other hand, many sustainable hacking projects are built based on the existing technical infrastructures, like city websites, or contribute to new digital infrastructures. The benefits are a plethora of city resources such as domain servers, existing heavy traffic from residents, and dedicated staff for the maintenance.

The first team on the Welcome to the City project planned to create a mobile app similar to Yelp where people could share and search city places to benefit newcomers. However, the partner lacked the resources to maintain the app and did not implement the tool. On the contrary, the second team did more research of existing resources, discussed the issue with various stakeholders, and created a city services web portal built on the city website. The partner appreciated the second group, who did not have "any preconceived ideas" about the mobile app and therefore created a more sustainable solution.

New mobile apps can also easily fail when the community has already adopted a pre-existing, well-developed app. For instance, the Community Health team designed a mobile app to track community physical activities, yet was hardly competitive and useful compared with existing health-tracking apps: *"The app that goes along with it are the Fitbits, Map My Walk, and SparkPeople … that's what we found people are already utilizing with family, friends, and coworkers, and it is hard to compete with those that are on such a grander scale and with bigger budgets." (Community Health, Partner S)*

Civic hacking teams also need to find proper servers to host the digital tools, and it is more sustainable to leverage existing infrastructures. The Accessibility Info team originally planned to build the WordPress site on the partner's server without any costs. However, the organization had no IT staff and paid a third-party IT vendor to maintain the server; the vendor charged them extra to maintain the website. The team ended up building the site on a school server and then moving it to a new server space that the organization purchased. On the other hand, although the Snow Removal team's community partner had a website, the volunteer who built it had already left, and the organization did not have any capacity to host the new website. Thus, the organization hosted it on the city website server.

Sustainable hacking teams not only drew on existing infrastructure, they also built new infrastructures that led to new innovations. For instance, the Downtown Construction team provided a good template for other city public services websites: *"We have a slate of infrastructure projects and street projects for this summer, we wanna continue to use the Downtown Construction moniker, website and some of the tactics, our weekly updates, and emergency updates. We'll completely change how we do our city infrastructure projects going forward." (Downtown Construction, Partner J)*

4.3.1.2. *Appropriating Off-the-shelf Technologies*

Civic hacking teams used a variety of open-source off-the-shelf web portals and tools to build interventions for different public issues. By appropriating these off-the-shelf web portals and technologies, the teams provided tools that community partners who lacked digital expertise could easily maintain without the management and training overhead.

Web Portals. Volunteer technologists considered WordPress as a sustainable web platform because of its free features and easy-to-manage interface. Three teams (Accessibility Information, Small Business, Welcome to the City) suggested the partners replace the existing third-party web services with WordPress. However, the lack of funding resources also limited the WordPress functionality, and they had to choose free templates and features and discard some plugin features like maps.

Social Media. Many teams built their interventions on social media sites due to the familiarity and ease to maintain of these sites compared with web portals like WordPress. Four projects leveraged social media (e.g., Facebook, Pinterest, Facebook comments) as the primary solution space, while other projects used social media to promote their projects. For instance, the Crime Watch team initially designed a WordPress page for the partner to share crime watch information. The team later found that the crime watch group already had a private Facebook group with 100 members and she frequently managed it through her mobile phone. Also, WordPress had frequent updates that disrupted the template layout that made it difficult for partners to manage. As a result, the team changed Wordpress site to a Facebook page in the second prototype.

Databases. Five teams built databases to record data collected through the interventions, but the maintenance of the databases was a big concern. Formal database software requires high costs and technical skills, and community partners were only familiar with tools like Excel. As a result, most of these teams chose Google spreadsheets as the operational database instead of regular database software: *"Our partners were not tech-savvy so an SQL database would be very difficult for them to handle. A spreadsheet would be the easiest way because she knew how to use an Excel spreadsheet." (Homeless Shelter, Student S)*

Infographics. Many teams planned to make infographics to illustrate complex information, such as starting a business (Small Business) or getting identification documentation such as birth certificates or social security IDs by clicking on tabs of the infographics on a tablet (Homeless Shelter). However, making digitally interactive infographics was challenging for sustainability. The Homeless Shelter team gave up on developing a digital infographic after visiting a shelter and replaced it with a Google form: *"We realized that the residents of the shelter are not tech-savvy. It would be very difficult to have that many options on a cell phone. You would need a dedicated machine like a tablet. The shelter did have a tablet, but it was not functional." (Homeless Shelter, Student S)*

Maps. Six project teams, such as Welcome to the City, Snow Removal, and Community Health, built digital maps to illustrate community information. To reduce the complexity of building and maintaining the map features, they mostly chose the simplest map features or used Google Maps API.

Surveys. Many project teams chose Google Forms to collect survey data about community issues to enhance the sustainability of the project. In the Homeless Shelter team, volunteer technologists wanted to use a survey to collect the homeless shelter residents' information to decide the type of identification homeless people needed. Because the shelter residents and shelter managers were not tech-savvy, volunteer technologists decided to choose Google Forms: *"Everybody has probably taken some survey on Google Forms. It just looks [more] familiar than other surveys like Qualtrics. Qualtrics is very complicated for an average person who doesn't take surveys every day." (Homeless Shelter, Student S)*

4.3.1.3. Building Sustainable Low-tech Tools

Contrary to the initial goals of building digital solutions to community issues, many teams found that traditional offline tactics and physical presence are equally effective in solving the issues and engaging residents. These low-tech tools are also easy to sustain without the overhead for maintenance and training. Many teams thus designed low-tech tools such as postcards, logos, and printouts alone and with digital interventions. A Snow Removal team member expressed this surprising, yet critical, lesson: *"I don't think we need to create something fancy like a website or a mobile app. The best solution is something that can help them solve the problem, so if a flyer is something that we need, you need to do that." (Snow Removal, Student B)*

Postcards. Many teams (Welcome to the City, Historic Museum, and Distressed Property) designed postcards inspired by their community partners as a low-cost, easy to maintain, and engaging method. Historic Museum team volunteer technologists used postcards as cultural probes for the museum archive by asking citizens to write their reflections on the postcard and mail it to the museum, and to archive the stories on Pinterest. Postcards printed with the community pictures, infographics of city information, and website URLs were also easy to distribute through local community organizations. For instance, the Welcome to the City team collaborated with many community organizations like the City Water Department to deliver the postcards to new residents when they registered for water bills (Figure 2).
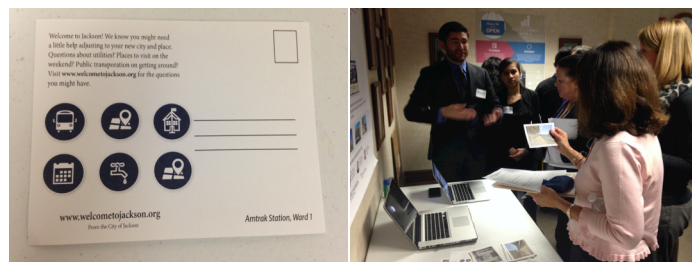
Figure 2: Postcard and Logo of The Welcome to The City Team (Left). Volunteer Technologists and Community Members Discuss the Postcards (Right).

Logos. Three teams (Welcome to the City, Crime Watch, and Farmer's Market) designed logos as an effective information tool to increase the awareness of the organizations and projects. To make it more sustainable, the teams considered whether the logo fit the community culture and was understandable by community members and suitable for various mediums such as volunteer t-shirts, letterheads, presentations, social

media, and signage. The Crime Watch team discussed extensively how the logo could be clear on volunteers' t-shirts during crime watch at night and chose a design with the letter "B" instead of one with a city silhouette.

Printouts. Some teams created printouts such as pamphlets, brochures, and posters to make the city information more accessible and promote the digital tools. These printouts were sustainable because partners with little technical skill could easily maintain and distribute them to community residents. Bus Map team volunteer technologists found that the city bus information system was problematic: there was no bus route or map information in the bus shelters, the bus information brochure was confusing and costly (25 cents), and the transportation authority website was not mobile-friendly, with scattered schedule and map information. After discovering these problems, the team changed its initial goal of building a digital real-time bus tracking system to redesign the bus map brochure by enlarging the map, showing the big community destinations, color-coding the map, and building the schedule into the map.

4.3.2. Building Sustainable Partnerships With various Stakeholders

Sustainable partnerships between various stakeholders were found to be critical for successful handover and maintenance of the civic hacking projects. Moreover, besides building a good relationship between volunteer technologists and community partners (Balestrini et al., 2014; Taylor et al., 2013), it was equally important to extend this sustainable relationship to third-party vendors, indirect stakeholders, and service providers.

4.3.2.1. Building Relationships between Volunteer technologists and Partners

For most projects, multiple stakeholders were involved in different stages of the design process, and it was challenging to find one dedicated partner to take over and maintain the civic technology. Volunteer technologists selected partners who had the resources to maintain the project, were highly motivated and engaged, and whose mission aligned with the project. Overall, civic hacking projects that partnered with a city government department or agency had a higher chance for adoption than those partnering with community organizations and groups (Table 2). For instance, the first team of the Welcome to the City project handed over the mobile app to the City Business Chamber,

who lacked both interest and resources and thus did not implement the tool. The second team, however, collaborated with a City Council member who was going through the election process and was enthusiastic about the project, which led to a successfully implemented website. This result echoes previous participatory design (PD) research about the importance of involving politically strong actors (Bødker & Zander, 2015).

Volunteer technologists and the partners also built a friendly, supportive, and mutually beneficial relationship that positively impacted the long-term development of interventions. Seven partners described their experiences as dramatically different from working with the third-party IT vendors for infrastructure, hardware, and websites. Partners were constrained by financial resources and had to hire vendors with the lowest budget and unsatisfying IT services. On the other hand, volunteer technologists were more accessible even after the project was handed over: *"[With vendors] we don't have a clear understanding of where the contract starts and stops. We had a pretty significant problem and had to open up another contract to fix it because it wasn't in the things that they were going to take on. The students were more accessible; they answered questions more readily, and they were easier to get in contact with than a typical vendor would've been."* *(Community Health, Partner S)*

Volunteer technologists also acknowledged the existing efforts of other community organizations and made sure the new interventions would not duplicate existing tools or interfere with others' work. For instance, the Welcome to the City team noted that they leveraged, rather than interfering with, the work of a community tourist website: *"We interview with them not just because they have valuable information for us, but to make sure they were aware of our project, and we weren't stepping on any toes, so they won't ask our team, 'What are these projects? What are you doing?'"* *(Welcome to the City, Student J)*. Recognizing the existing efforts in the community enhanced the unique value of the project for communities and prevented wasting resources to build redundant interventions.

4.3.2.2. Building Relationships Between Stakeholders

Our results demonstrate the importance of building relationships among stakeholders, community members, and organizations. The overall buy-in and involvement

of these stakeholders allowed civic hacking to be sustained not only in the organization but also in the community.

Many projects involved multiple stakeholders to maintain different aspects of the civic technologies, which required forming new collaborations before volunteer technologists left the community. For instance, the Crime Watch project required the crime watch group leader and the recreation services coordinator of the community parks to work together to post community information on both the public Facebook page and the bulletin board. Many teams also collaborated with other community organizations such as the library, schools, and local small businesses to distribute postcards and brochures and promote civic technologies.

More important, direct stakeholders needed to coordinate with the actual public service providers to ensure that offline services could be sustained in the community. To sustain the Snow Removal project, the Walkable Communities Coalition monitored and collected the reports of non-shoveled sidewalks, and the Department of Public Works cleaned the sidewalk after receiving the reports. *"The challenge is having a regular system in the city to look at the reports, respond to the reports, and get sidewalks cleared. They get so backlogged, and it takes weeks before they clear. The snow melts sometimes, and people give up within the time it takes to get cleared." (Snow Removal, Partner L)*

4.3.3. Mutual Learning Between Volunteer technologists and Community Partners

In this study, volunteer technologists and partners often learned from each other to design and sustain interventions that fit community practices. Volunteer technologists learned from the community partners about the community practices, and the partners learned from civic hackers about how to update and engage through civic technologies and digitally driven work practices.

4.3.3.1. Volunteer technologists Learn from Community Partners about Community Characteristics

Volunteer technologists often lack the knowledge about community characteristics that critically determine whether civic hacking projects can fit in and be sustained in the community and organizational work practices. The community partners in this study

played important roles in bringing the insights about community characteristics into the iterative design process.

4.3.3.1.1. Defining Community Boundaries

Partners provided accurate information about community boundaries that helped organizations easily maintain the tools and make it convenient for residents to navigate the websites. Students on the Accessibility Information team combined the accessibility information of all three counties together in the first prototype. However, the partners pointed out that the counties were 45 minutes away, and so it did not make sense to put the information together. In the second prototype, volunteer technologists incorporated community boundaries by building three separate but connected websites and an option to select different counties.

Partners also noted the importance of setting a "virtual" community boundary to exclude people outside the community out of the privacy and safety concerns. For instance, the Crime Watch partner tried hard to scope the community watch Facebook group: *"If someone said 'Can I join your group?'... I look at their Facebook page and make sure they are in our section or city. I deny quite a few people because they are not from the section. It's important to me that it's only our neighbors." (Crime Watch, Partner C)*

4.3.3.1.2.Keeping a Positive Community Image.

The partners often hoped to keep a positive community image, especially for projects that addressed negative issues, such as non-shoveled sidewalks and crime. Snow Removal team partners considered the fine information in the first prototype indicated a negative message about the community and were concerned that citizens might become fearful of getting fines and less likely to report non-shoveled snow (Figure 3, left). As a result, volunteer technologists replaced the fine information with a benefit statement (Figure 3, right). *"Information was lacking about whom does it benefit, so it's going to be you, friends and loved ones, and here is the way to report it if you have an issue, and this is why" (Snow Removal, Student C)*. Similarly, the Crime Watch team changed the Facebook page name and scope from "Neighborhood Watch Group" to "Neighborhood Group" due

to the fear that the name "crime watch" indicated a negative impression of high-crime rate in the community.
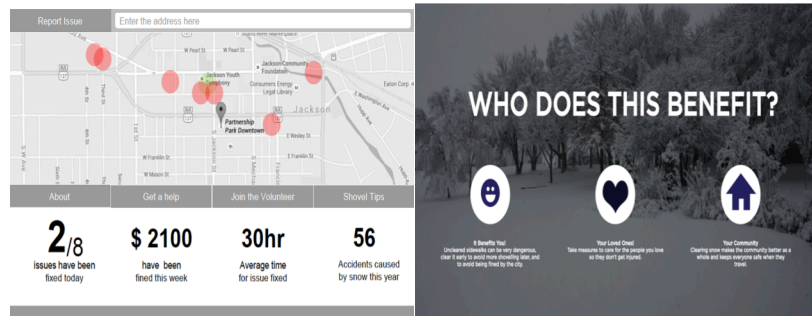
Figure 3: The Design of the Snow Removal Project Before (Left) and After (Right) Discussion of a Positive Community Image.

4.3.3.1.3. Seasonal Issues

The community activities, informational needs, and organizational practices vary in different seasons, and some community issues are season-specific, such as leaf pickup and snow removal. As a result, civic hacking teams need to accommodate these seasonal community and organizational characteristics to ensure the technologies are designed, sustained and implemented at the proper time.

For instance, the Snow Removal team addressed an issue that would only happen during winter: non-shoveled snow. Due to a lack of snow during the winter, the team could not test and implement the website. The Crime Watch team faced a similar challenge because the neighborhood watch group usually met during summer, whereas the project happened in winter. The team thus had difficulty in engaging stakeholders, interviewing residents, testing the tools, and handing it over to the partner.

To alleviate the negative impact of season discrepancies and make the best use of the civic hacking projects, many teams considered appropriating the tools for a wider range of community issues. For instance, the city could appropriate the Snow Removal web portal for a weed/lawn mowing report system in summer and a leaf pickup report system in fall. Many teams also suggested the partners update content in different seasons and set up calendar reminders for seasonal updates.

4.3.3.2. Community Partners Learn from Volunteer technologists about New Skills and
  Mindsets

Community partners learned how to use, maintain and update civic hacking technologies, engage with the public, and think about community issues from an information perspective. These new skillsets and mindsets are beneficial to sustain the civic hacking in the long run.

4.3.3.2.1. Learning Skills about Updating and Engagement.

An important strategy for sustainability is to ensure partners know how to update information and engage with residents through civic technologies. Many teams provided detailed tutorials, templates, and screenshots: *"They gave us cheat sheets on entering the information in that was easy to follow. It was a step by step, and they did screenshots. They were really good about training us how to keep it active" (Accessibility Information, Partner L)*. Many volunteer technologists also provided partners with update schedules and guidance about show to monitor and engage with local residents: *"Paying attention to what the engagement is, how many likes, shares, comments ... and also the time of day when you're posting, and the type of posts that people are interacting with." (Farmer's Market, Partner N)*

4.3.3.2.2. Developing a Data and Information Mindset.

An important factor that ensures the success and sustainability of the civic hacking projects is the development of a data and information mindset across the City Hall and community organizations. The city's vice mayor described this cultural change using the example of the civic hacking project office in the City Hall. The project office was rebuilt from the city clerk's office, and people could see it even before entering into the first-floor city offices. City leaders wanted to use it as a testament to the city's investment in a new way of doing business, connecting with citizens, and welcoming outside opinions using new information technologies.

The civic hacking projects helped eliminate the "silo problems" in both the City Hall and community organizations. Initially, key stakeholders who controlled information had concerns that their jobs would be taken, and they refused to share information with

other people: *"We also have the typical silo problem and gatekeeper ... Someone is in control of that, and their job is to generate reports of that data. If you talk about making that data available to everybody that develops concern around, (they ask) 'If my job is to share with everybody and you're creating a system that does that, is this taking away my job?'" (Program Manager S)*

The civic hacking teams helped break the silo effect by bridging the direct partners and other community partners and creating an alliance of problem solving. In the Crime Watch project, the community group leader was initially a gatekeeper and controlled all the information and decision-making of the private Facebook group. Other community members who were willing to contribute ideas and technical skills felt frustrated and closed off from having their voices heard. Through interviews and prototype discussions organized by volunteer technologists, the group leader became more open-minded to suggestions, and other members could contribute their skills to the design: *"[C] and [L] don't tend to care for the person that was sitting over here, but I feel like between the students and myself, we could help [C] and [L] to open up their minds a little bit." (Crime Watch, Partner L)*

Initially, partners found it difficult to relate their work to information and data: *"Government departments and community organizations don't think of their work regarding information flows, tools, and services around information and data. We asked departments about the types of data they use and the information they share, and we got feedback like, 'I don't use data.'" (Project Manager S)*. As the civic hacking projects evolved in the city, the partners began to see a closer connection between information, data, and their work. In the Distressed Property project, city staff realized that they had a lot of useful data: *"The city discovered that they have all this water billing data, and the person who manages that data said, 'Hey, you are looking for vacant properties. We have water bill data, and we could tell you who hasn't paid a water bill in 6 months.'" (Program Manager S)*

4.4. Discussion

After examining 16 civic hacking projects that emphasize sustainability, we suggest design strategies that can change civic hacking from temporary solutions (Lodato &

DiSalvo, 2016) to those with more sustainable impact on resource-limited public organizations and communities. We propose a set of recommendations for HCI researchers and civic technology practitioners who are interested in building sustainable hacking projects for resource-limited public organizations.

4.4.1. Characterizing Sustainable Civic Hacking Interventions

Although many civic hacking teams intend to build an app for the problem initially, they realize that making a gradual improvement to the existing technologies or even adopting low-tech interventions are more sustainable than building apps. This echoes the argument made by Baumer and Silberman (2011) that the low-tech solutions sometimes work better than high-tech ones, and it is important to evaluate the appropriateness of high-tech solutions to HCI problems.

We further illustrate how volunteer technologists leverage off-the-shelf or low-tech artifacts to solve community issues. Previous studies reveal the importance of using off-the-shelf technologies like 3G and mobile phones to bypass the challenges of experimental technologies for community heritage and citizen journalism (Balestrini et al., 2014; Taylor et al., 2013). Another work studied how low-tech artifacts such as bulletin board support community practices (López & Farzan, 2014). Here we extend prior work by characterizing the appropriation of off-the-shelf technologies (e.g., web portals, social media, databases, infographics, maps, surveys) and low-tech solutions (e.g. postcards, logos, and printouts) for various civic issues such as accessibility, crime, and public services. Our results present open opportunities for future work to investigate the implications of off-the-shelf and low-tech tools for civic technologies.

Our findings are in line with the DOI theory (Rogers, 2010) about complexity and compatibility. Civic hacking projects with low complexity (e.g., low-tech solutions) and high compatibility (e.g., city websites) have a higher potential to be adopted by community partners, which extends previous work on the positive relationship between organizational resources and civic technologies adoption (McNutt et al., 2016). We argue that the pervasive passion for civic apps (Gregg, 2015; Johnson & Robinson, 2014) and the Silicon Valley utopianism about innovative technologies for civic issue (Irani, 2015) ignore the real problems and impair the sustainability of civic hacking, and civic hacking should focus

more on problems and explore opportunities to leverage off-the-shelf and low-tech solutions.

We present sustainable projects leveraging existing infrastructure, such as city websites, to improve civic information services within a limited period, complementing previous work on community informatics infrastructures (Carroll & Rosson, 2013; Le Dantec & DiSalvo, 2013). More important, we argue that cities should prioritize civic hacking projects that could become a new infrastructure that benefits similar community issues in different seasons, such as the Downtown Construction website template and the Snow Removal reporting system.

4.4.2. Facilitating Relationships with Various Civic Hacking Stakeholders

The relationships between the volunteer technologists and the community stakeholders are critical for sustainable hacking. Previous literature has emphasized the importance of ownership and relationships with direct stakeholders of individual projects (Balestrini et al., 2014; Merkel et al., 2004; Taylor et al., 2013). By examining multiple civic hacking projects across government departments and community organizations, we extend prior work by identifying the complex relationships between volunteer technologists and various stakeholders in the city.

Enlisting proper partners prevents the civic hacking projects from being "orphaned" (McMillan et al., 2016) and ensures their continued provision, maintenance, and development within specific organizations. We demonstrate that a trustful relationship between volunteer technologists and community partners is distinct from traditional client–vendor relationships with third-party vendors, which will benefit other future civic hacking projects.

We also show the importance of building rapport with indirect yet relevant stakeholders outside the organizations. For the city-level projects, it is critical to identify key community stakeholders who could support multiple civic hacking projects. For instance, although the city water department was not an official partner of any project, it was actively involved in the Welcome to the City and Distressed Property projects by helping distribute postcards and providing water-billing data for detecting distressed properties. Volunteer technologists also need to acknowledge existing efforts in the

69

community to avoid offending potential partners and to create an overall buy-in of the projects in the city. Overall, having multiple projects happening and increasing their visibility (e.g. the city hall presentation) fosters relationship building and resources sharing, which benefits the long-term sustainability of projects.

Community partners find that volunteer technologists are more trustful than third-party IT vendors who create big barriers to civic technologies (McMillan et al., 2016). Volunteer technologists have an advantage compared with the third-party vendors in developing tech solutions for resource-limited public organizations, a finding that echoes the recent discussion about replacing traditional organizational procurement processes with civic hacking (Johnson & Robinson, 2014). This good relationship derives from the matching needs of the two sides: the organizations need technical expertise and volunteer technologists need project experience. This free labor devoted relationship might underscore some recommendations and considerations, and future work could explore more dynamic labor relationships during civic hacking projects that involve other stakeholders such as private sectors.

4.4.3. Fostering Mutual Learning during Civic Hacking

Prior work notes that building the skills of community partners can foster sustainability by ensuring the maintenance of technologies, encouraging technology use, and enhancing the confidence and enthusiasm in technologies (Merkel et al., 2007; Taylor et al., 2013). We suggest two skills that community partners can learn from the civic volunteer technologists besides the knowledge of technology usage. First, they can learn how to engage citizens by actively updating timely information and monitoring conversations, which has been a big barrier for public organizations' use of civic technologies (Harding et al., 2015; Hou & Lampe, 2015). Second, partners can learn from the civic hacking process to increase overall literacy and awareness of using data and information to problem-solve community issues. This finding echoes a previous study about CFA design teams working as change agents in government to showcase the innovation process (Maruyama et al., 2013).

We argue that the learning process is bi-directional as civic technologists can learn about the community culture and practices from their partners. For instance, volunteer

technologists should be more aware of the community boundaries, community images, and seasonal community challenges during the civic hacking process. These learning processes can shift the Silicon Valley utopianism on public issues (Irani, 2015) and help volunteer technologists incorporate more concrete community constraints and practices into design. Our previous paper (Lampe, 2016) also discusses how the current civic hacking projects have pedagogical benefits for students to get practical user experience in real-world situations, using professional communication skills, and rethinking digital citizenship. Recent ICTD research has suggested to provide training programs community practices and relationship-building to novices, guest researchers (Winschiers-Theophilus et al., 2015). Future work should further explore ways to educate volunteer technologists on community practices, possibly through hacking workshops and classes on community engagement.

4.4.4. Limitations

This paper focuses on the sustainability considerations of the design and handover process of civic hacking projects, thus we focus on volunteer technologists and community partners rather than citizens. However, many citizens participate in user studies of civic technologies so their opinions are reflected in the design. We will investigate the citizens' perception of the civic hacking projects in future work. Volunteer technologists are also students rather than residents, who go into the community with an outsider's perspective and less community knowledge. Future studies could investigate how to enhance the sustainability of civic hacking projects driven by local citizen hackers.

The civic hacking projects' success is defined in multiple ways. For the course, student projects are evaluated whether they are "usable, useful, adoptable, and sustainable", which shapes the eventual products design. Student teams provide suggestions on the measurement of success for the actual deployment and acceptance of user populations in the sustainability plans. However, we do not measure the projects' success based on the long-term deployment of systems or satisfaction of different user groups. Future work needs to track the long-term sustainability of these projects and assess the success of the civic technologies for different stakeholders.

4.5. Conclusion

We reflect on the design process of 16 short-term collaborative civic hacking projects that prioritized sustainability in a small city, examining how short-term civic hacking can go beyond temporary solutions and be more sustainable and better handed over to community partners. We found that sustainable hacking should consider the off-the-shelf technical platforms and features, as well as low-tech tools. Additionally, the civic hacking process should facilitate relationships among various civic hacking stakeholders. Last, civic hacking should not only focus on the creation of technologies, but also on the education of both community partners and volunteer technologists about the data mindset and community practices.

CHAPTER 5. HACKING WITH NPOS: COLLABORATIVE ANALYTICS AND BROKER ROLES IN CIVIC DATA HACKATHONS

5.1. Objective and Background

NPOs play important roles in our society and communities as they actively advocate for community wellbeing and social change. In recent years, many NPOs have moved to data-driven decision making to improve the work efficiency of the organization and increase the accountability of organizations (Alexander, Brudney, Yang, LeRoux, & Wright, 2010). Recently increasing open data initiative in the national and state government agencies further provides opportunities for NPOs to fulfill various organizational goals such as community development and grant application by compensating its information deficiency (Lenczner & Phillips, 2012). However, NPOs often lack the data expertise and financial/time resources, which restricts their ability to collect or analyze the data (Merkel et al., 2007).

To compensate the lack of resources and expertise in collecting or analyzing data, NPOs often collaborate with external data experts to support their data-driven work. Such collaboration between NPOs, data volunteers, and other stakeholders can be defined as a type of collaborative analytics where groups of people generate data analysis and interpret the produced results together (Erete, Ryou, Smith, Fassett, & Duda, 2016; Heer & Agrawala, 2007). Recently, many NPOs got involved in a new form of collaborative analytics, *Civic Data Hackathons* (e.g., Data Dive[1] and Open Data Day[2]), which are hackathon-type events where NPOs collaborate with data volunteers to analyze their internal and open data to support their data-driven decisions or to address civic issues.

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[1] http://www.datakind.org

[2] http://opendataday.org

Civic data hackathons also attract public participants with various skillsets and backgrounds in addressing public issues collaboratively with NPOs. In this paper, we aim to understand how civic data hackathons can help NPOs' data-driven work, and how can we better support the collaborative analytics through the civic data hackathons.

Though there is not much work on civic data hackathon, recent research on general civic hackathons questioned what actual benefits civic hackathons can bring to NPOs and communities other than superficially deliberating problems or engaging the community (Johnson & Robinson, 2014; Lodato & DiSalvo, 2016), and how to meet different stakeholders' expectations such as civic hackers, community, and public organizations (Irani, 2015). In this paper, we expand this growing body of work on civic hackathons by examining the type of impactful collaborative analytics and practices during civic data hackathons that benefit NPOs' data-driven work.

CSCW researchers have identified several challenges in collaborative analytics that may hinder the collaboration work in civic data hackathons. For example, Choi (2017) noted that civic collaborative analytics projects face challenges such as a variety of communities of practices (e.g. domain expert and technical expert), uncertain outcomes, and openness of projects. These challenges make it difficult to build common ground between NPOs and volunteers, and may result in mismatched expectations for civic data hackathons (Irani, 2015).

To better explore and support the emerging collaborative analytics practices in civic data hackathons, we use the Broker framework (Paepcke, 1996; Wenger, 2003) as a lens to examine our data. Such use of the Broker framework has been exemplified by previous CSCW research (e.g., Hellmann et al., 2016); Brokers refer to the people who sit between different communities of practices and serve as bridges for these communities to build common grounds and facilitate the collaborations. This framework fits our needs in examining the collaborative analytics practices between different stakeholders in civic data hackathons. So in this chapter, we will address the third research question of this dissertation:

RQ3: What are the roles of brokers in successful collaborations between public organizations and volunteer technologists?

In this study, we examine various types of data (e.g., observation, survey, and interview) collected from two civic data hackathons in a Midwestern city in the U.S. The stakeholders of the hackathons include NPOs and three different types of volunteer technologists: data volunteer technologists (hereinafter referred to as "data volunteers"), hackathon organizers, and client teams. The client teams are a unique type of volunteer technologists in this study. Their responsibilities are to facilitate the collaboration work between NPOs and data volunteer, such as preparing datasets before the event and coordinating collaborations during the event. We argue the client teams serve as brokers in these civic data hackathons, and thus, we examine how they support the collaborative analytics through the lens of the Broker framework.

Specifically, we contribute to CSCW literature with an understanding of the following aspects of collaborative analytics during civic data hackathons:

RQ3-1: *What kind of collaborative analytics practices are useful for NPOs' data-driven work before, during, and after civic data hackathons?*

RQ3-2*: How do civic data hackathons succeed or fail to meet NPOs' and data volunteer' expectations?*

RQ3-3*: How do brokers (i.e., client teams) support the generation of successful collaborative analytics throughout civic data hackathons?*

In summary, we find that civic data hackathons benefit NPOs data-driven work not only with various impactful and actionable outputs generated by data volunteers, but also with the practices that improve NPOs' data literacy. We also identify the tensions between NPOs and data volunteer due to the mismatch of their separate expectations. Most importantly, we identify four brokering activities that the client team perform to support the successful collaborative analytics between NPOs and data volunteers: *translation, coordination, alignment,* and *contact brokering*. We draw upon these findings to propose practical implications for future civic data hackathons and design opportunities for open data collaboration systems.

5.1.1. NPOs' Data-Driven Work and Collaborative Analytics

Many CSCW researchers have found that NPOs struggled with adopting new information technologies due to limited resources in finance, time, and human expertise

(Hou & Lampe, 2015; Merkel et al., 2007). The limited resources have also shaped NPOs practices around information work. For instance, Voida et al. (2011) characterize the assemblages of information systems in NPOs as "homebrew databases" due to the fluidity of volunteers and work.

Recently, NPOs start to adopt data-driven work similar to private sectors to support their practices, decision making, and performance tracking (Bopp, Harmon, & Voida, 2017). Recent open data initiatives provide a lot of benefits for NPOs to support productive data-driven work (Alexander et al., 2010). With the increasing open data available in the public sphere, more and more NPOs are embracing open data for their practices and use it as sources for innovations (Lakomaa & Kallberg, 2013).

However, NPOs often lack the technical skills, financial, and time resources to conduct the analyses to fully utilize the internal and open data. A recent survey on NPOs' capability of data-driven decision making finds that while organizations collect a large quantity of data, they are not adept or confident in analyzing that data (Maxwell, Rotz, & Garcia, 2016). Concerns about this lack of expertise become more critical as Bopp et al. (2017) find many stakeholders and funders "disempower" data-driven work and lead to datasets that are fragmented in various dimensions in NPOs.

To compensate for the lack of expertise and resources, NPOs often rely on external data experts and volunteer technologists to assist their data-driven work through collaborative analytics. Recent CSCW researchers use "collaborative analytics" to describe the collaborative data analytics work that brings different stakeholders together for the shared purposes (Hellmann et al., 2016). It is an extension for the collaborative visual analytics studies about how to support data sharing and analytics in distributed team (Heer & Agrawala, 2007), but focuses more on the social aspects of the collaboration.

Although previous researchers have demonstrated many benefits of collaborative analytics for NPOs, they also raise concerns about the complex collaborative work during these collaborative analytics projects. For instance, Erete et al. (Erete et al., 2016) studies the collaborative analytics through an open data portal that provides storytelling to make data consumable for internal and external stakeholders. Furthermore, NPOs have other constraints in accessing open data subscriptions, privacy issue of the datasets, and limited skills in interpreting data visualization and reports. Choi (2017) sheds light on the high

complexity of open data collaborative analytics: diverse communities of practices (government, journalism, activism, social services, and NPOs), openness of projects, and unpredictable outcomes. Understanding the collaborative work during these collaborative analytics becomes more critical to better support NPOs' data-driven work as more external data experts and volunteer technologists get involved through civic hacking and hackathons.

5.1.2. Civic Data Hackathons

Hackathons are events where people collocated and collaborate for a short period of time (usually one or two days) to write codes together. Private sectors and scientific communities have organized hackathons to facilitate innovations, educate software users, and recruit talents for the organizations (Trainer, Kalyanasundaram, Chaihirunkarn, & Herbsleb, 2016b). Recently, many NPOs and public sectors involve in civic hackathons to collaborate with volunteer technologists to create technologies to solve public issues (Johnson & Robinson, 2014; Lodato & DiSalvo, 2016). In this study, we specifically focus on civic data hackathons where NPOs collaborate with external data experts and community volunteers to analyze data in support of NPOs data-driven work (Disalvo et al., 2014).

There are generally two lines of HCI research on hackathons. First, previous design literature argues civic hackathons are innovative design processes for community members to engage in expressing matters of concerns and creating conceptual work for public issues (Disalvo et al., 2014; Johnson & Robinson, 2014). However, few studies have examined how the civic data hackathons could leverage open public data to benefit NPOs and social goods. Following this line of research, our results contribute to the knowledge on how civic data hackathons support the NPO's data-driven work and compensate lots of NPOs constraints.

In the second line of research, CSCW researchers recently investigate the unique characters of collaborations in the time-bounded, collocated hackathons compared with other traditional group collaborations (Morgan, Foundation, Dailey, & Hill, 2017). For instance, Trainer et al. (2016b) explore the time-bounded, collocated collaborations happened in science hackathons (i.e., hackathons focus on scientific software development).

They found that science hackathons benefit from the radical collocations and situated familiarity between the participants. They also characterize how different technical domain, community structure, and expertise interplay with the collocation advantages on collaborations.

However, civic data hackathons face more collaboration challenges than general hackathons do. As discussed in Choi (2017), first, NPOs and data volunteer come from distinct communities of practices that share little common ground and work practices; second, the civic collaborative analytics projects are frequently open-ended and without clear goals; and finally, civic data hackathons inherit the purpose of community engagement and attracting public participants with various skillsets and backgrounds. Thus, in this study, we want to contribute to existing knowledge about collaborations in hackathons by exploring how to support the collaborations between different community of practices in civic data hackathons, and how current civic data hackathons succeed or fail to meet NPOs' and data volunteers' expectations.

5.1.3. Brokering Activities in Collaborations

A good practice to support the collaborations across multiple distinct communities of practice (i.e., NPOs and data volunteers in this context) is to have someone who plays the *Broker* role. In CSCW and organizational studies, brokers are the people whose position is a boundary spanner or bridge between different social groups (Pawlowski, Robey, & Robey, 2004; Wenger, 2003). Brokers have knowledge about different community practices and thus served as a mediator of common grounds (Convertino, Mentis, Slavkovic, Rosson, & Carroll, 2011). Brokers also bring together disparate actors with complementary skills, goals, or resources through boundary objects (Pawlowski, Robey, & Raven, 2000). All of these activities are important for the emerging interdisciplinary collaborations such as civic data hackathons.

Previous research has identified several activities that brokers may perform across organizational boundaries. An important lens of brokers comes from Wenger's theory of communities of practices (Wenger, 2003), in which brokers are defined as individuals who provide connections and transfer knowledge between communities of practice. Brokers are involved in processes of *translation, coordination,* and *alignment between perspectives*.

Translation refers to the process of framing elements of the one community's worldview in terms of the perspective of another community. *Coordination* is defined as the process of bringing different perspectives to a state where communities of practice achieve a cohesive vision and purpose. *Alignment* is the process to reconcile different and possibly conflicted views of different communities of practice to achieve a common purpose.

Paepcke (1996) describes another concept, *contact broker,* in a large company setting. The contact broker's role is to help group members find experts in other groups, match problems with experts, and send novices to experts with an interest in teaching and mentoring. Their ability to discover and select resources is especially valuable when organizational resources are heterogeneous. McDonald and Ackerman (1998) describe a similar role of expertise concierge in organization who routes people to others with the necessary knowledge and expertise.

In this paper, we combine the uses of the Broker concepts from Wenger (Wenger, 2003)'s and Paepcke (1996)'s work as a lens to analyze the data. Previously, Pawlowski et al. (2004) apply the broker framework as a lens to study the IT professionals' broker roles in a large manufacture company. IT professionals frequently cross organizational boundaries (IT and business) to share information and leverage resources. They surface and challenge assumptions that simulate reflection and improvement, translate organizational jargon by interpreting and explaining meaning of terms, and gain a good understanding of perspectives of different communities of practices.

A more relevant and recent work of utilizing the broker concept is Hellmann et al. (2016)'s work that noted the important roles of brokers in collaborative analytics during a digital humanitarian response project. The brokers help to build a common ground between community and GIS professions during the collaborative analytics. However, this work only generally discusses the brokers as an abstract bridge for different communities, yet does not unpack the specific brokering activities during the collaborative analytics process, which we will address in our study.

As we introduced earlier, there are client teams serving as the bridge between data volunteers and NPOs in civic data hackathons in our study. We argue that these client teams play the broker roles in the civic data hackathon context. Thus, we will explore how

client teams help address the collaboration challenges in civic data hackathons through the lens of the broker framework.

5.2. Methods

5.2.1. Background of Civic Data Hackathons

We studied two civic data hackathons in a Midwestern city (which we will refer to city X) in the U.S. in 2015 and 2016. The civic data hackathon program was organized by a student organization. The organization held a one-day, open-to-all, and free hackathon every year in city X. The program aims to help NPOs to accomplish data analysis projects and promote volunteers' peer learning on data collection, analysis, and presentation.

The hackathon stakeholders included hackathon organizers, NPOs, client teams, and data volunteers. The organizers were all graduate students who served as the committee of the organization and organized the hackathons. NPOs applied to be the hackathon partners and the organizers made decisions about which NPOs would participate every year based on the value of hackathons to the NPO to and the quality of the datasets provided by NPOs. Client teams were students who applied through an open call for client teams and were selected by the hackathon organizers. Each client team was comprised of four students (mostly majored in Information Science) worked with a specific NPO partner throughout the event, such as communication with NPOs, data preparation, data cleaning, and project management. Data volunteers voluntarily attended the event and were recruited from multiple emails lists, social media channels, and local civic hacking groups.

There were nine NPOs participating in the hackathons in 2015 and 2016 (Table 3). There were five NPOs attending in 2015 (ID 1-5) and four NPOs attending (ID 6-9) in 2016. The NPOs missions covered various domains such as education (three NPOs), library (two NPOs), environment (two NPOs), art (one NPO) and health (one NPO). 225 people signed up and 150 people attended in 2015 hackathon. 187 people signed up and 94 people attended in 2016 hackathon.

This civic data hackathon's procedure was similar to other hackathons reported in previous literature (Irani, 2015; Trainer et al., 2016b): A couple months before the event, client teams started to work with NPOs to prepare datasets and research questions for the event. Each hackathon had multiple NPOs *groups*. At the beginning of the event, the client

team of each NPO pitched the NPO's background, goals, and data questions. Data volunteers then chose a NPO and went to the NPO group in a dedicated classroom, where they further formed *volunteer teams* to work on a data analysis project. In each NPO's classroom, client teams and NPO staff answered volunteers' questions. At the end of the hackathon, data volunteers submitted their results using Google slides and client teams presented the results to all the hackathon participants.

Table 3: Hackathon NPOs and Interview Participants (*: O=Organizer, N=NPO Staff, C=Client Team Member, V=Data Volunteer)

ID	NPOs Description	Number of Projects	Example Projects	Participants *
1	X District Library: The local district library in X city	6	Holds data	C1
2	X Learning Community: A local K-8 public charter school	6	Student profile data, marketing data, academic data	C2
3	County Literacy: A NPO that provides literacy support to adults through trained tutors	3	National longitudinal survey on literacy data	
4	Arts Alliance: A NPO that advocates for and supports creative sector in the county	5	Occupational employment statistics data	
5	County Integrated Health Network: A NPO and community health center that offers integrated primary, behavioral health and dental care	8	Patient insurance data, patient demographics data	
6	Y District Library: A local district library in Y city	7	Benchmark data, checkout data circulation data, maps	N1-N3, C3-C4, V1-V3
7	Girls after school program: A NPO that serves girls in 3rd to 8th with various fun after school curriculum	4	Financial data, user profile data	C5, V4-V5
8	Natural Area Preservation: A mission driven organization that protects and restores natural areas in X city	7	Volunteer data, frog data, bird data	C6, V6-V7
9	Lakes Observing System: Make real-time data publicly available to V Lakes community	5	Buoy datasets	N4, C7, V8

5.2.2. Data Collection

We collected multiple sources of evidence, including field notes from participatory observation, survey, semi-structured interviews, and artifacts (e.g., agendas, presentation slides, raw datasets in analysis, and data analysis results) to understand the analytics and collaboration practices before, during, and after each hackathon.

5.2.2.1. Participatory Observation

We conducted 22 hours of participatory observation of different NPO groups to understand event dynamics (e.g. How people conduct data analysis) on November 17th, 2015 and November 12th, 2016. We also captured photographs of the event space and artifacts (e.g., data analysis results, presentation, and final output). Informal interviews were conducted with the NPO staff and client teams during the hackathon to make sure we understand the activities in the field. Field notes were taken to record the activities of the event. The observation allowed us to build social connections with the hackathon stakeholders, which further helped us to recruit participants for the survey and interview. The observation and field notes also helped us to build a preliminary understanding of the event and informed us to design the interview protocol.

5.2.2.2. Survey

To understand the demographic and motivations of data volunteers, we designed and conducted a survey after the 2016 hackathon. More specifically, we asked volunteers about their expectations before the event, their experience during the event, and their satisfaction about the whole event, and the usefulness of their projects for the NPOs (see Appendix C). During and right after the hackathon, the organizers distributed and emailed a link to the survey to all registered participants. Some data volunteers completed a hard copy of the survey after the event; others chose to complete the online version.

5.2.2.3. Semi-Structured Interviews

After the event, we interviewed hackathon organizers, client teams, data volunteers, and NPO staff about their experiences with hackathons. We recruited organizers, client teams, and NPOs staff via emails and then interviewed them in person. We recruited data volunteer interviewees from the survey respondents and we aimed to cover volunteers across various NPO groups, across the spectrum of volunteer roles and goals. Interview questions were around how they prepared for data sets, conducted data analysis, and how they collaborated throughout the hackathon based on the observations and survey results (see Appendix C). Lastly, we asked them to highlight the projects that they thought were most useful for NPOs using the presentation slides as prompts.

In total, we interviewed 30 participants, including: seven hackathon organizers (O1 – O3 from 2015 Hackathon and O4 – O7 from 2016 Hackathon), four NPOs staff, seven client team members, and eight data volunteers (Table 3). Interviews lasted between 30min to 1 hour. Each interviewee received $10 gift card as incentive. A professional transcription services firm transcribed all interviews. Throughout this paper, we denote quotations from data volunteers with "V", client team members with "C", NPOs staff with "N", and hackathon organizers with "O", each with a unique number for identification.

5.2.3. Data Analysis

Our qualitative data analysis corpus mainly comprised field notes from observations and interview transcripts. We also used work artifacts and survey to triangulate the qualitative observation and interview data. We first imported these materials into the TamsAnalyzer (Weinstein, 2006) qualitative data analysis software and conducted open coding on the data preparation practices, data challenges, client teams activities, types of data analysis, and learning and mentoring. As Wenger's community of practice theory and broker frame (Wenger, 2003) and Paepcke (1996)'s contact broker concept characterized much of the client teams activities, we then grouped codes through the lens of brokering activities: *translation, coordination, and alignment, and contact brokering*. We wrote, shared, and discussed coded transcript among researchers and descriptive memos about emerging themes in the data, and developed axial codes that surfaced themes about the relationships between data preparation, data challenges, data analysis, learning and mentoring, and broker roles. We applied the resulting set of codes to the remaining data, adding codes when necessary and continuing until theoretical saturation.

In the following sections, we will present our results about collaborative analytics practices throughout the hackathons. In the first two sections, we will describe the collaborative analytics practices following the temporal order (before, during and after the hackathon day) and how they contribute to NPOs' data-driven work (**RQ3-1**). In the last section, we will discuss the mismatched expectations from NPOs and data volunteers, and how brokers help reconcile their expectation conflicts **(RQ3-2)**. In each section, we will also discuss the broker roles during the respective phase of hackathons and how they support the collaborations between various stakeholders (**RQ3-3**).

5.3. Results

5.3.1. Before the Hackathon: Preparation for Collaborative Analytics

Before each hackathon, client teams request data from NPOs. They then prepare the datasets, research questions, and other materials for hackathons. Throughout the preparation phase, client teams perform an important *translation* activity that will later help NPOs and data volunteers reach a common ground during the hackathon.

5.3.1.1. Preparing NPOs Dataset for Hackathons

Before each hackathon, client teams work with NPOs to collect data and create usable datasets for data volunteers to analyze in the hackathon. Due to the lack of data resources and literacy and the unique privacy issues of NPOs, NPOs datasets suffer from various data issues such as dirty data, fragmented data, sensitive data, and aggregated data. Client teams help address these data issues through typical collaborative data analytics such as cleaning and reformatting data, affixing metadata (Heer & Agrawala, 2006).

A common issue of NPO datasets is that the data are inconsistently formatted thus require a lot of data cleaning, such as inconsistency in upper and lower cases, code names, coding criteria, and typos. It is primarily because multiple NPO staff or volunteers manually code data in different time and locations. Client teams help clean these datasets so data volunteers could directly import it into programming software and conduct data analysis.

Similar to previously literature (Bopp et al., 2017), NPO datasets are also scattered and fragmented. The data are not consistently collected or organized during a longitudinal tracking, so the data are distributed in different locations or different data collectors. To help data volunteers understand the data, client teams intentionally hide inherent data heterogeneity by merging multiple datasets to make them appear to have come from a unified source. Client teams merge different but relevant variables into a single variable to avoid potential confusions for data volunteers, or merge multiple datasets to create an aggregated dataset that was easier for volunteer to solve specific research questions.

Many NPOs (e.g. schools, libraries, health organizations) in hackathons have datasets that contain sensitive information such as the identity information of minors,

seniors, and other vulnerable groups. Client teams protect the information by removing identifiable information (e.g. name, zip codes, ids) so they are invisible to data volunteers.

Many NPOs lack the knowledge about how data analysis works and what kind of data are useful for data analysis. As a result, many NPOs provide aggregated or summary data without individual-level data that could not be further processed. Client teams often feel surprised about such "miscommunication" as they thought they delivered the request clearly to NPOs. *"Instead of, 'Here is all our circulation for the whole year, every single swipe, every check-out,' it was, 'We circulated 2,000 DVDs in March, 4,000 in April. 'Well, you already did the analysis and I can't actually draw anything out of it. So that wasn't useful" (V1, NPO6).* To eliminate this problem, many client teams raise the aggregated data issue to NPOs, and asked NPOs to provide disaggregated datasets that can be further analyzed.

5.3.1.2. Broker Roles Before Hackathon: Translation

During the preparation stage, client teams not only help prepare datasets, but also play the *translation* role by explaining and transforming NPOs information to data volunteers. They translate data-related jargon, explain data issues, and transform NPOs perspective to data questions.

There are many jargons in NPOs datasets that are specific to NPOs work and unfamiliar to data volunteers. Client teams play the *translation* roles by creating labels and annotations to explain the variables and jargon in the NPOs datasets so data volunteers could easily understand the datasets. *"The most important part is to create the legend, like creating a section explaining what each column was. Because it was written in jargon like user ID." (C1, NPO1)*

NPOs datasets also have a lot of missing data due to the breakdown of data collection instruments and data collection errors. Client teams *translate* the reasons behind missing values and suggest ways to fix the issue: *"We put a couple of disclaimers in the data to say, 'These columns are missing which means the reporting system didn't pull the data for this year. This particular field wasn't in the form this year so we didn't get any data collected here. You can extrapolate or use a proxy with this column of data.'" (C5, NPO7)*

Besides explaining datasets, client teams also *translate* NPOs' goals and requests to data questions that data volunteers could easily understand and address during available data: *"Just sort of translating what the client wanted, in terms of the goal of what we wanted to achieve with the data set." (C1, NPO1)*

To ensure a good understanding of the organizational goals, many client teams conduct preliminary analyses to make sense of datasets and identify dataset problems: *"Our processing and visualizations were purely for the sake of scoping the data out. Seeing what we have and seeing what we don't have so that when it came time to advising our volunteers, we had a better idea of where the holes in our data were so that they wouldn't get stuck" (C5, NPO7).* The preliminary analysis examples also help data volunteers better understand the NPO goals and problems in the word of data and pay attention to critical datasets and variables.

5.3.2. During and After the Hackathon: Creating Actionable Collaborative Analytics

There were 40 survey respondents and the response rate was 46.8%, which demonstrates the demographics and motivations of hackathon participants (Tables 4). The average volunteer team size is 4.78 (SD=3.49, Min=1, Max=12). The average satisfaction with teamwork is 3.48/5 (SD=1.22), and usefulness of project is 3.28/5 (SD=1.1).

During the hackathon, data volunteers and NPOs collaboratively create data analysis projects that provide actionable suggestions for NPOs practices: *showing performance, comparing with other organizations, identifying outliers*, and *building predictive models*. Volunteers not only create actionable collaborative analytics projects, but also bring in external datasets and suggest ways to improve NPOs data practices. During and after the hackathon, client teams play two important brokering roles, *translation* and *coordination,* to support the collaborations between NPOs and different data volunteer teams.

5.3.2.1. Creating Actionable Collaborative Analytics

During the hackathons, data volunteers create various data analyses with NPOs' data, and NPOs staff constantly provide feedback to volunteers about their primary interests, expectations, and the usefulness of the data analysis results. Overall, NPOs prefer

collaborative analytics projects that lead to actionable results for NPOs practices and decision-makings. Similar to previous findings (Erete et al., 2016), NPOs prefer the volunteer projects with good "stories" and visualizations that could be easily interpreted by NPO staff, community members, and donors. According to our interviews, NPOs staff eventually include some of these actionable and consumable data analysis results into their master plan and reports for community and donors.

Drawing on interview data on highlighting projects that are most useful for the NPOs, we further categorize the collaborative data analytics projects (Table 4) into a typology that more directly support NPOs data-driven work: *showing performance to inform resource allocations*, *comparing with other organizations*, *identifying outliers*, and *building prediction models*. Besides, volunteers provided external data and suggestions for NPOs' work to improve NPOs data-driven work.

Table 4. Survey Results of Hackathon Data Volunteers

Questions	Response (N=40)
Gender	Male (50%), Female (50%)
Ethnicity	White (58/8%), Asian (29.4%), African American (5.8%), Latino (5.8%)
Occupation	Research (70%), Students (67.5%), Engineer/data analysts (17.5%), NPO staff (5%), reporter (2.5%)
Data expertise	Expert (10%), Knowledgeable (30%), Passing knowledge (45%), No knowledge (15%)
Motivations	I want to practice data analysis skills (65%), I want to learn new data analysis skills(60%), I want to help nonprofit organizations (60%), I want to network with other people (42.5%), I am interested in the topic of the event (30%), I want to teach others data analysis skills (20%)
Data Analysis	Data visualization (60%), Data cleaning (55%), Descriptive analysis (42.5%), Data mining (12.5%), Regression analysis (4, 10%)
Data analysis tools	Excel (65%), R (32.5%), Tableau (27.5%), Python (20%), STATA (7.5%), Matlab (5%), Java (2.5%)
Collaboration tools	Google Drive (87.5%), Email (37.5%), Instant messaging tool (Facebook messenger, Skype, etc.) (5%), Github (5%), Text message (2.5%)

5.3.2.1.1. Showing NPOs Performances to Inform Resource Allocations

Many data volunteer teams conduct exploratory data analysis to show NPOs performances in different aspects of their work. Volunteers often use descriptive analysis and visualizations (bar charts, line charts, and bubble charts) to show the NPOs practice

patterns and how the patterns vary in time or groups. These projects help NPOs make decisions about when and where to allocate organizational resources. For instance, V2 used the library transaction data to create bar charts for NPO6 to describe popular book genres and inform their purchasing decisions.

Because most NPOs serve local communities, geolocation data such as zip code become critical for NPOs to understand their performances in different areas. Many volunteer teams use Tableau to create preliminary and exploratory heat maps that show the NPOs activities in different locations to inform the best locations to allocate organizational resources. For instance, one volunteer team worked with NPO7 created heat maps of the number of program participants and funding allocation in different state counties. The project informed the NPO to allocate resources to the regions that are under-served and under-served.

5.3.2.1.2. Comparing Performance with Other Organizations

Three volunteer teams compare NPOs performance with other NPOs or the average performance of national organizations. Such comparison analyses provide a clear benchmark about NPOs performance that leads to actionable suggestions about places NPOs could improve and useful results for NPOs' reports to stakeholders.

For instance, one data volunteer team worked with NPO6 compared the library's performance with other libraries in the state using bar charts, regression models, and Zipf's law model. They found the library did better than most NPOs in many work practices and the NPO staff were satisfied about the results: "*One of my most favorite ones was comparing our library with other similar size and funded libraries, and that was very wonderful to show our board how well our library is used... They were very interested in what the students had found.*" (N1, NPO6)

5.3.2.1.3. Interpreting Outliers Collaboratively

Some data volunteer teams plot NPOs data and identify NPO data outliers that inform further actions. To better make sense of the outliers, volunteers need to collaborate with NPOs to understand the anomalies based on NPO staff' domain knowledge. For instance, V1 plotted the library attendance data across time and found many anomalies in

the dataset, which lead to a discussion about the potential actions that library could take to enhance the attendance rate: *"Can they explain why attendance was so high or low on those outlier days? I sat down with the librarians and we went through. This one ended up being the most actionable. There is a polling place on elections and people come to the library just to go vote. They could set up a booth in the way going to vote and ask, 'Do you have your library card updated?'" (V1, NPO6)*

5.3.2.1.4. Building Prediction Models to Inform Decision Making

A few volunteer teams also build regression or prediction models to explore the relationships between organizational practices and outcomes to help NPOs make decisions and plans. For instance, the NPO7 team tried to build a prediction model on the program revenue based on the time of the year to inform the NPO get prepared for different seasons. However, many teams found it hard to build prediction models due to the limited data available from NPOs. In addition, NPOs staff feel the models are relatively difficult to understand and hard to include in their reports.

5.3.2.1.5. Finding External Datasets

Volunteers not only contribute data analysis projects using existing NPOs datasets, but also brought in external dataset to compensate NPOs limited data sources. Data volunteer teams frequently found external open datasets online about local regions to help NOP evaluate their performances and explain data analysis results. For instance, C6 described a team works for NPO8 used the city pollution data from EPA (Environmental Protection Agency) to explain why the frog observation reduced: *"Water pollution in X had become worse over the years, which is data we got from the EPA. We noticed the number of frogs had drastically reduced, and the reason for that was because of water pollution. They (volunteers) took data from somewhere else on the internet and they combined everything ... Is this a good number? Is this a bad number?"*

Some volunteer teams also found proxy datasets to compensate the lack of proper datasets from NPOs. For instance, we observed that the one team worked for NPO7 wanted to look at whom the program served, but there was a lack of income data. As a result, a group of volunteers who majored in public health leveraged the free lunch and fee waiver

data as proxy variables of income, and compared the demographics and geo locations with the program populations to verify if the program supported social equity and served minority groups.

5.3.2.1.6. Suggesting Ways to Improve Data Practices

Besides bring in external datasets, volunteers also frequently make actionable suggestions to NPOs about how NPOs could improve data practices moving forward. Volunteers provide suggestions such as how to counter data constraints and improve the data collection process, which are actionable for future NPOs' data-driven work. For instance, V1 discussed with NPO6 staff how they could improve their data collection process: *"they're looking at replacing that gadget that measures (library) traffic. And we talked about the different options. 'Could it log timestamp besides logging just an increment? That would tell you the busy hours and so you might change your staff up, accordingly.'"*

5.3.2.2. Broker Roles During and After Hackathons: Translation and Coordination

During and after the hackathons, client teams serve many broker roles that facilitate the collaborative analytics between NPOs and different data volunteer teams. Client teams frequently *translate* the NPOs background and meanings of datasets to volunteers. Client teams also *coordinate* the work among different data volunteer teams by checking in and combining the volunteers' products into a cohesive story.

5.3.2.2.1. Translating "Invisible Knowledge"

Because client teams have gained deep understanding of NPOs data during the preparation process, they play important *translation* roles by explaining data variables, data issues, data collection process, and organizational backgrounds to data volunteers. As one of the client team members said, this "invisible knowledge" about the datasets was most valuable.

Client Teams frequently answer questions from volunteers about the meaning of data variables and point out which variables are useful for their projects. Client teams also help volunteers make sense of datasets issues such as missing values and inconsistent

values and the potential challenges for data analysis. For instance, in the NPO9 room, we observed a data volunteer was confused about the several files with different variables in the datasets provided by the NPO. The client team explained that each data file was from one observing station, and different station may have different parameters. The client team suggested the volunteer to pick some common parameters across the stations to do the analysis.

Client teams also provide background information about the organization missions, priorities, and struggles to help volunteers understand what problems or datasets they should focus on. For instance, C5 mentioned the importance of such information: *"One thing that we did really well was supporting that exploration of the data in a more qualitative sense. Understand the backstory, what is the organization about, where does it come from, what are some of the priorities of the organization, what is the mission of the organization, understanding how the software of the data collection works or the enrollment process works."*

After the hackathon, client teams also play the *translation* role by creating a one-pager summary that explains the data files, data analysis results, and insights to the NPOs. According to the interviews, NPOs are not only interested in the final results and insights, but also interested in accessing the raw data files and steps that volunteers come to the data analysis results so they can easily replicate or continue the data analysis by themselves.

5.3.2.2.2. Coordinating Work from Different Volunteer Teams

During the hackathon, client teams also play the *coordination* roles between different data volunteer teams by checking in with volunteers about their project progress. After the check-in, client teams facilitate the collaborations by encouraging volunteers who work on similar issues to collaborate. They also encourage volunteers to share their data analysis products to Google drive and write down shared questions on the whiteboard. C4 talked about how they moved people who work individually into collaborations: *"After everybody checked in with each other, we made some suggestions of, 'Hey, maybe somebody would like to look at what you just did.' … I think it also was good to get people to say, 'Hey, I put all these Excel files together that had been by month, and now they're*

aggregated'." These coordination practices enhance the awareness (Carroll, Rosson, Convertino, & Ganoe, 2006; Dourish & Bellotti, 1992) of teamwork that helps volunteers understand where to allocate their efforts in the group.

Client teams also play an important *coordination* role by combining the original data analysis into cohesive presentations that are presented to all the hackathon participants and delivered to NPOs. Client teams ask volunteers to submit their data analysis results to the Google Drive, usually on a shared Google Slides file. Then client team create the final presentation by prioritizing the insights that are most relevant to the NPOs missions and create a cohesive story. Finally, the client teams present the results and insights to all the event participants. *"We made sure that at least one person, who was coordinating it, knew what each team was doing, so when it came time to present, we could create a cohesive story about how these things came together, in what order they came together, and then the story that they told with the data." (C5, NPO7)*

5.3.3. Balancing the Expectations of Data Volunteers and NPOs

The civic data hackathons have two goals: one is to benefit NPOs with their data-driven work; the other is to increase the data literacy in the community. However, we found several tensions between these two goals. We also identify how brokers support these two goals through brokering activates such as alignment and contact brokering.

5.3.3.1. Dual Goals of Civic Data Hackathons

The civic data hackathons have two goals that are distinct from typical hackathons: one is to foster data literacy in the community, and the other is to help NPOs who lack data sources for data-driven work. O3 summarized the two goals in the interview: *"One is to increase data and information literacy in our community by bringing together people of different skill sets. A core remains serving non-profits. So we have chosen to keep it as non-profit clients because non-profits lack the resources. The spirit of the event is a little bit different than some hack events, we don't want anyone to feel like they don't belong there."* However, the dual goals of the hackathon cause many conflicts that reduce the effectiveness of the collaborative analytics projects for NPOs.

5.3.3.1.1. Learning New Skills vs. Creating Useful Data Analysis

Based on our survey (Table 4), the majority of data volunteers came to the hackathon in the hope of practicing data analysis skills (65%) and learning new data analysis skills (60%). However, this intention did not align well with the hackathon goal to help NPOs create useful and actionable data analysis within a limited time frame. Many volunteers conduct "cool" data analysis or use data tools that they are unfamiliar with, yet the data analysis products are not useful for NPOs or hard for NPOs to maintain. For instance, C2 worried that volunteers chose what is best for themselves rather than for NPOs: *"They're thinking I want to learn R, so I'm going to do something where I can learn R, even though maybe I'm better at Excel and I can make more of an impact doing it in Excel"*

5.3.3.1.2. Mentoring Beginners vs. Encouraging Experts' Contributions

Another tension happens between the beginners who need a lot of mentoring and experts who could contribute greatly to the data analysis. As we show in the survey (Table 4), 60% of the volunteers said they had passing knowledge or no knowledge about data analysis. These beginners have a hard time involving in the data analysis projects due to the lack of data analysis skillsets, which leads to a high turnover rate of beginners. Although some beginners contribute to brainstorming and communications, the uneven skillsets in the data volunteer teams create difficulties for collaborations.

On the other hand, 10% of survey participants rate themselves as experts (Table 4). These data experts are willing to teach beginners data analysis skills and answer code questions. Collocation of the data volunteers also provides opportunities for beginners to learn from experts by observing how they conduct data analysis using the laptop and programs. Many experts become the leaders of the data volunteer teams. However, experts need to sacrifice their time to help beginners instead of creating more impactful data analysis for NPOs. *"I probably spent about half of that time just like helping others, like some other people come up to me with Python questions and so, I would show them basic Python stuff. There were a lot of people at the Hackathon that had no coding experience, so I spent a good amount of time helping them. "* (V7, NPO8)

5.3.3.2. Broker Roles for Different Community of Practices: Alignment and Contact Brokering

Client teams not only build common ground between NPOs and data volunteers, but also mitigate the tensions between different hackathons goals through two broker roles: *alignment* and *contact brokering*.

5.3.3.2.1. Aligning Dual Goals of Hackathons

Client teams play an important *alignment* role by reconciling the different expectations of data volunteers and NPOs to make sure the group achieve the common goal to help with NPO data-driven work. Client teams help align these two goals by constantly reminding data volunteers who create advanced data tools that the data analysis product should be actionable, useful, and easy to maintain for NPOs.

In addition, many client teams align the volunteers' goals of learning and event's goal of helping NPOs by generating research questions with different difficulty levels (e.g. beginner, medium, and difficult). Providing different levels of research questions ensure volunteers with different data skill levels could all learn, contribute, and engage in the event.

5.3.3.2.2. Contact Brokering to Identify Experts

As the hackathon involves heterogeneous resources and volunteers with diverse expertise and skill levels, client teams play the *contact broker* role by highlighting experts in the group to increase their visibility to beginners and creating a good atmosphere for volunteers to ask questions. Because the data volunteers are strangers to each other, it is hard for them to identify the experts in the room, and volunteers feel hesitate to ask questions. On the other hand, experts who want to help beginners feel it hard to know who need help.

Client teams have the knowledge about "who knows who" and could route beginners to volunteers with expertise. They are aware of both the data and domain experts in the room and help identify experts in the room, which has positively impact the collaboration. For instance, C6 talked about the opportunity to facilitate collaborations between beginners and experts in the group of NPO8: *"The people who worked on the bird*

data set had a lot of people who had a lot of experience with working in data before. Volunteer and frog was both done by who don't have as much experience. If we had taken some of the experts from the bird data that might have helped better."

5.4. Discussion

Our study reveals various collaborative analytics practices in civic data hackathons and actionable analytic results that can benefit NPOs' data-driven work. We identify several brokering activities that client teams perform to facilitate collaborative analytics. Lastly, we identify the tensions between the stakeholders (volunteers and NPOs) due to their divergent expectations, and further examine how the client teams ease such tensions. In the following sections, we will discuss practical guidelines and design implications that could make civic data hackathons more helpful for NPOs' data-driven work.

5.4.1. Design Civic Data Hackathons that Benefit NPO Data-Driven Work

Our results suggest that collaborative analytics practices in civic data hackathons benefit NPOs' data-driven work in various ways. Data volunteers produce a variety of data analysis results that lead to actionable recommendations to NPOs' practices and decision-making. The collaborative analytics process itself helps NPOs acquire new data sources and knowledge about data analysis. Our research extends previous work that focuses only on the civic hackathons' benefits of civic engagement and problem articulation (Disalvo et al., 2014; Lodato & DiSalvo, 2016). Our results illustrate that civic data hackathons can directly impact NPOs by addressing data challenges such as the difficulty to identify reliable and useful open data sources (Erete et al., 2016) and data fragmentation (Bopp et al., 2017).

Previous literature has constructed a few typologies for categorizing civic and open data analysis based on data format. For instance, Choi (2017) categorizes civic open data analysis projects into exploratory, inferential, and predictive analysis. Erete et al. (Erete et al., 2016) categorizes NPOs usage of open data into heterogeneous data stories, homogeneous data stories, and data context to strengthen stories. We contributed to the literature by proposing a new typology of collaborative analytics results based on their impacts on NPOs' work, rather than the types of analysis. We suggest that these

collaborative analytics are especially suitable for time-bounded data hackathons by NPOs and volunteers. How well the NPOs adopt these collaborative analytics projects and what kind of projects benefit NPOs' data-driven work in the long term is an open question and future research is needed.

In addition to the direct benefit on NPOs' data-driven work, civic data hackathons also help NPOs with improving their data literacy. For instance, the client teams surface the problem of aggregated data during the preparation phase, which helps NPOs understand how to analyze the data. Client teams and data volunteers also teach NPOs several ways to collect higher quality dataset. NPOs report that these learning experiences would carry on to their continuous practices in future data-driven work. These results provide practical implications that NPOs should utilize the above-mentioned opportunities to fill up their data literacy gaps (Erete et al., 2016).

5.4.2. Broker Roles in Civic Collaborative Analytics

Our results suggest that client teams played vital broker roles to facilitate the collaborations between NPOs and different data volunteer teams. Before the event, client teams prepare the datasets to ease the data analysis work for data volunteers. During the hackathon, client teams play the *translation* roles by explaining NPOs' organizations goals, the dataset, and the organizational background as researchable questions for the volunteers. And once the hackathons end, the client teams again translate volunteer teams' analysis results into consumable insights for NPOs. Client teams also play the *coordinated* role by facilitating collaborations between different volunteer teams and synthesizing their data analysis products.

By presenting how these brokering activities benefits the collaborative analysis during civic data hackathons, we extend previous CSCW literature on broker roles in large, static organizations (Paepcke, 1996; Pawlowski et al., 2004) and digital humanitarian program (Hellmann et al., 2016). We also contribute to the emerging CSCW research on the collaborative work during time-bounded, hackathon-type of events (Morgan et al., 2017; Trainer et al., 2016b). The findings are also relevant to the collaborative analytics research in open data analysis projects, as these projects shared several common challenges with the civic data hackathons, such as diverse community of practices, openness, and unpredictable

outcomes (Choi, 2017). Our findings also contribute to previous research on anticipation work (i.e. the invisible work that happens before and prepares for the visible work (Hellmann et al., 2016; Steinhardt & Jackson, 2015), by illustrating how brokers handle the anticipation work through various brokering activities in a resource-limited, time bounded working context.

We argue that brokers roles are important particularly in the context of dynamic, transient, and interdisciplinary collaboration situations such as civic data hackathons. Brokers can quickly build the common ground between different communities through *translation*, synthesize distributed work through *coordination*, reconcile diverse groups goals through *alignment*, and quickly allocate disparate sources through *contact brokering*. Thus, one of our practical suggestions is that civic data hackathons and other similar events organizers should pay extra attention on setting up the brokers roles or training some volunteers as brokers, which could increase the efficiency of the programs.

Beyond theoretical and practical contributions, we also aim to provide design implications for CSCW systems to support the emerging open data analysis practices. Many government agencies and NPOs are sharing their data or relying on public open data for their data-driven work. However, existing open data platforms mainly focus data publishing, downloading, filtering, and visualization (Erete et al., 2016). However, as Gurstein (2011) suggested, open data analysis requires not only infrastructure such as internet, computers and software, but also content and formatting, interpretation/sense making, and advocacy.

Our results show that the client teams performed brokering activities that supported the collaboration success between domain experts and data experts by facilitating data cleaning, data formatting, and data interpretation. We propose that the open data analytic systems can incorporate some of the brokering activities to support the collaborative analytics process between domain experts and data experts. For example, the domain knowledge about organizations are important for data analyses but are often "invisible" in the dataset. Open data portals can actively inquiry background information from the organizations that provide datasets, such as organizations missions, priorities, struggles, and how the data are collected. It is all about awareness of the collaborators' different

expertise and domain knowledge, and the system can server as a broker to translate, coordinate, and align the different vocabularies, processes, and goals.

Another design implication could be that the system should have customized views for different stakeholders, such as NPOs, brokers, and data volunteers. NPOs may find a dashboard with accessible visualizations and translated insights more useful; whereas for data volunteers, the dashboard may focus on non-aggregated and cleaned datasets so that volunteers could easily run various analyses on it; the dashboard for brokers could have features such as annotating datasets and synthesize analysis results from the volunteers. These features can help NPOs and data volunteers to collaborate on the open data analysis, and to interpret the collaborative analytics results.

5.4.3. Designing Civic Data Hackathons for Both NPOs and Community

Our results show that civic data hackathons serve two intertwined goals: one is to help with NPOs' data-driven work; the other one is to create opportunities for community members to learn data skills and get involved in the NPOs' missions. There are tensions between the two goals, and in our study, the brokers diminish the tensions by playing the *alignment* activities to reconcile different expectations and the *contact brokering* activities to identify experts. Although previous literature on hackathons have discussed the learning and teaching practices between hackathon participants (Trainer et al., 2016b), our research context in a civic data hackathons dominated by students reinforce the learning component. Although not all hackathons involve data volunteers with diverse skill levels, our results could be generalizable for hackathons that emphasize on community engagement and peer learning.

Based on our results, we suggest that providing learning opportunities for beginners can improve the experience for both NPOs and volunteers. First, civic data hackathons could include data analysis projects with different difficulty levels to enable beginners to engage and contribute to the hackathon. Second, tutoring programs such as bootcamps can also prepare beginners for such time-bounded hackathon event. Actually, the civic data hackathon in this study has several bootcamps about R, Tableau, Python, and GIS tools before the event, and data volunteers spoke highly about the impact of these bootcamp activities.

Our results on the *contact broker* roles suggest the need of a CSCW system for expert allocation and knowledge sharing during the civic data hackathons. Prior CSCW research has studied Q&A (Richardson & White, 2011; Wang, Hou, Luo, & Pan, 2016) and expert allocations systems (McDonald & Ackerman, 2000) in enterprise and distributed teams context, but little work has been done in designing Q&A and expert allocation systems to support knowledge sharing and collaborations in hackathon events; that is another future direction of research.

5.5. Conclusion

Civic data hackathons serve critical roles for NPOs by helping them leverage data volunteers' knowledge and expertise to support NPO's data-driven work. In this paper, we identify some of the best strategies for the collaborative analytics practices and collaborations in civic data hackathons. We extend research work on hackathons by providing insights on how civic data hackathons support NPOs' data-driven work in various ways. We also find that a good civic data hackathons should address the tensions between benefiting NPOs' data-driven work and helping volunteers learning expectations. We contribute to the broker research with a rich case study of applying the broker framework as a lens in examining the client teams' facilitation practice. More specifically, we identify four important brokering activities that hackathon client teams performed to support collaborative analytics: translation, coordination, alignment, and contact brokering. In addition to the practical and design implications, we call on CSCW community's attention to further study collaborative analytics and civic hackathons.

CHAPTER 6. DISCUSSION AND CONCLUSION

This dissertation work proposes an analysis of the design and implementation of civic technologies in resource-limited public organizations. It reports on three studies that investigate the practices of three forms of civic technology adoption approaches in public organizations: the appropriation of social media for public engagement in NPOs, a civic hacking program that generates innovative ideas and tools for community issues, and civic data hackathons that create data analytics projects for NPOs. We focus on informing the design of sustainable and effective civic technologies for resource-limited public organizations, and providing best practices for volunteer technologists and public organizations to collaborate more effectively around civic technologies.

This work has several broader contributions beyond each study's context and specific findings reported in the previous chapters, which we will discuss in the following sections. First, we will revisit the research questions about design and implementations of civic technologies in public organizations. Second, we will outline several contributions to HCI and CSCW research on civic technologies and civic hacking, such as reconsidering civic engagement through civic technologies, balancing public organizations' constraints and civic technologies endeavors, and understanding the complex collaboration when creating civic technologies. Third, we will summarize the practical implications for public organizations to better leverage civic technologies for their organizational goals and solving community issues. Last, we will reflect on the limitations of the dissertation such as sample selection and methodologies and summarize the key findings and contributions of this dissertation.

6.1. Revisiting Research Questions

This dissertation research aims to understand how public organizations could better engage community residents through civic technologies and provide design guidelines and practical recommendations for the design and development of civic technologies in public

organizations. To do so, we answer the following research questions regarding three urgent challenges of civic technologies in public organizations:

RQ1: How do public organizations (e.g. small NPOs) use social media for public engagement?

To better understand public organizations' challenges when using civic technologies for civic engagement, we begin with Study 1 to examine a group of small environmental NPOs who focused on local environmental issues in their social media practices (Hou & Lampe, 2015). We reveal various social media strategies that small NPOs leverage to achieve various public engagement goals. We also identify several organizational factors (e.g. all hands on deck, resource constraints, organizational politics, and the difficulty of measurement) that influence the achievement of different engagement goals (information, community, and action).

RQ2: What strategies do participants in civic hacking projects use to improve the sustainability of civic technologies for local public organizations?

To inform the design of civic technologies that public organizations could maintain in the long run, we conduct Study 2 to investigate various factors that improve the sustainability of civic technologies during the design process of civic hacking projects (Hou & Lampe, 2017). We note the importance of leveraging off-the-shelf technologies, low-tech tools, and existing infrastructure. We also highlight the importance of facilitating the partnership between various stakeholders and mutual learning about community practices and data literacy to support the long-term effectiveness of civic technologies in public organizations.

RQ3: What are the roles of brokers in successful collaborations between public organizations and volunteer technologists?

In Study 3, to examine the complex collaboration when creating civic technologies, we investigate the roles of brokers' activities (translation, coordination, alignment, and contact brokering) in facilitating the collaborations between volunteer technologists and public organizations during civic data hackathons (Hou & Wang, 2018).

6.2. Key Contributions to HCI Research on Civic Technologies

In this section, we provide a detailed list of common themes and key contributions from previous chapters to the interdisciplinary fields of HCI and CSCW research on civic technologies. The dissertation reveals public organizations' challenges to achieve civic engagement goals through civic technologies, strategies to balance public organizations' constraints and civic technologies design, and factors that influence the complex collaborative work undertaken by various stakeholders of civic technologies. The dissertation also provides direct design implications for civic technologies (e.g., social media platforms, civic hacking projects, and open data platforms) that could better support civic engagement, improve public organizations efficiency, and lead to long-term impacts on communities.

6.2.1. Supporting Civic Engagement Through Civic Technologies in Public Organizations

This dissertation provides a set of contributions to HCI research on civic engagement (Korn & Voida, 2015; Lovejoy & Saxton, 2012b) by examining how public organizations leverage social media for civic engagement (Study 1) and how public organizations engage volunteer technologists to solve community issues through civic hacking programs (Study 2 and 3). The dissertation fills the gaps of previous research about the concerns of the lack of interactions and in-depth engagement on civic technologies (Harding et al., 2015; Lovejoy & Saxton, 2012b) by suggesting several organizational factors and ways to improve the engagement practices.

First, we reveal how public organizations use various social media strategies to engage with different stakeholders and to achieve the information, community, and action goals. We argue that it is challenging to evaluate engagement goals on existing social media platforms, and there is a need to improve civic engagement outcomes measurement such as the social media analytics tools (Study 1).

Second, we reveal how organizational challenges (politics, limited resources, and low data literacy) influence civic engagement goals through civic technologies and civic hacking processes (Study 1, Study 2, and Study 3). For instance, while the organizational politics (e.g., the approval process) inhibit NPOs from interacting with their social media

audiences in a timely manner. We argue the design of civic technologies should take into account these organizational factors.

Last, we demonstrate the potential of civic hacking programs and civic data hackathons as innovative civic engagement activities that help solve community issues. We note how different stakeholders engage in civic hacking programs to create solutions to community problems (Study 2). We also note that the dilemma of community engagement and project efficiency, and discuss how brokers reconcile different participants' conflicting goals through alignment and contact brokering (Study 3).

6.2.2. Accommodating Public Organizations' Constraints and Facilitating Data Literacy

Previous HCI research noted the challenges of resource limitations in the use and adoption of ICT by public organizations (Merkel et al., 2007; Voida et al., 2011) and the lack of sustainability of civic hacking projects (Irani, 2015; Lodato & DiSalvo, 2016). We build upon previous work in understanding various public organizations' factors that constrain the design and implementation of civic technologies in public organizations. This dissertation also presents opportunities for design with the real-world constraints exposed in these studies.

We argue that civic technologies should accommodate public organizations' internal structures and workflows (e.g., all hands on deck, approval process, community images, seasonal practices). Designers should also counter the resource limitations by prioritizing off-the-shelf technologies, low-tech solutions, and existing infrastructure. In Study 1, we suggest that an NPO's social media tools should support NPOs work practices due to resource limitations such as supporting multiple NPO staff's work of managing different social media accounts. In Study 2, we make several practical recommendations for public organizations and volunteer technologists to build sustainable civic hacking projects, such as appropriating off-the-shelf technologies and low-tech solutions, leveraging existing community resources, and prioritizing projects that have potential to be new infrastructure for different community issues. We also suggest that volunteer technologists should pay attention to community practices such as community boundaries, keeping positive community images, and seasonal issues during the design process. In

Study 3, we suggest civic data hackathon volunteers should better prepare datasets and bring in external datasets to counter NPOs' limited data capacities. Volunteers should also prioritize high impact hackathon projects, such as showing performances, comparing them with other organizations, making sense of outliers, and building prediction models.

We also argue that fostering data and information literacy is critical in facilitating civic technology design and adoption. Both Study 2 and Study 3 demonstrate how organization staff's lack of data literacy inhibits effective civic hacking. On the other hand, the civic hacking help organization staff gain data literacy and skills that are beneficial for their long-term data-driven work and future civic hacking projects. Volunteer technologists should thus create more educational opportunities for public organizations to learn about open data and information technologies. Future research should continue exploring new ways of improving data literacy throughout the design process of new civic technologies.

6.2.3. Supporting Complex Collaboration During Civic Hacking and Hackathons

We contribute to the emerging CSCW literature on complex and transient collaboration (Choi, 2017; Lee & Paine, 2015; Trainer et al., 2016b) and recent HCI research on appropriating hackathons for different topics beyond code generation (Birbeck, Lawson, Morrissey, Rapley, & Olivier, 2017; Taylor, Clarke, & Gorkovenko, 2017). By examining the collaborative work of civic hacking programs (Study 2) and civic data hackathons (Study 3), we argue that building relationships between various stakeholders is important for collaborative work when building civic technologies. We also identify the important roles of brokers in facilitating the complex collaborative work between stakeholders during temporary collaboration like hackathons.

In Study 2, we demonstrate that good relationships between stakeholders and civic hackers benefit the design and implementation of civic technologies in public organizations. We also discuss the importance of building relationships with both direct and indirect stakeholders to leverage existing resources for civic technologies. Study 3 demonstrates various brokering activities (translation, coordination, alignment, and contact brokering) that client teams perform to facilitate the collaborative analytics that partner various community practices (NPOs and data volunteers) during civic data hackathons. We also provide design implications for future civic collaborative analytics platforms, such as

supporting complex collaborative analytics of different stakeholders and identifying experts during hackathons.

6.2.4. Implications for Future HCI and CSCW Research on Civic Technologies

Overall, HCI research on civic technologies should not only focus on creating innovative experiences or technologies that transform civic engagement and the relationships between public organizations and community residents. First, this dissertation suggests that HCI and CSCW researchers should make more efforts to understand the work practices of public organizations and organizational factors that might inhibit interactive engagement. Second, this dissertation inspires HCI researchers to not only explore innovative and friction civic technologies (Voida, Yao, and Korn, 2015) but also civic technologies that better accommodate existing infrastructure and resource constraints in public organizations. Last, the dissertation presents open challenges for future CSCW research to further explore complex and interdisciplinary collaborations between various stakeholders, which will benefit complex collaborations in other situations. In summary, this dissertation represents opportunities in civic technologies and civic hacking events for HCI and CSCW researchers to investigate sustainable, effective civic technologies and efficient collaborations.

6.3. Practical Implications for Public Organizations

Although there are considerable interests in the opportunities for better leveraging civic technologies to support civic engagement and organizational functions, there has also been a lack of applicable legal and policy framework for civic technology adoption in public organizations (Dawes, 2010; Kulk & Van Loenen, 2012). This dissertation provides practical implications for public organizations, especially resource-limited organizations, to better create and implement civic technologies and collaborate with technologists through civic hacking.

Besides factors introduced in traditional technology adoption theory (e.g. usefulness and ease of use) (Davis, 2011), there are many other factors that public organizations should consider when adopting civic technologies. We argue that public organizations should reform organization culture and improve organizational practices to

better accommodate civic technologies. Public organizations should also foster relationships between stakeholders of civic technologies inside and outside of organizations, and take civic hacking programs as an opportunity for community engagement.

First, public organizations should reform internal organizational culture and policies to accommodate the civic technologies adoption, and foster staff's data literacy to better make use of civic technologies. Current public organization policy on social media and open data focus on privacy, security, and accuracy, and previous research calls for more policies on fostering transparent and accountable interactions with public and direct benefits for end users (Bertot et al., 2012; Janssen et al., 2012). This dissertation provides great insights on how public organizations should change to better make use of civic technologies to address public problems. For instance, Study 1 suggests that public organization should improve the approval process of social media posting to increase the effectiveness of the interactive conversation with social media audience. In Study 2, the civic hacking program helps increase data literacy of city staff in the water department, and they realize the value of water bill data. In Study 3, civic data hackathons help NPOs better understand statistical models and became more confident in leveraging data for organizational decision-making. The goal of civic technologies and hacking is not only about creating usable tools but also about enhancing organizational staff's understanding of data and information so they could better design and leverage civic technologies in the long run.

Second, public organizations, communities, and volunteer technologists who are interested in leveraging civic technologies should focus on fostering trustful and meaningful collaborations between different stakeholders inside and outside of public organizations (policymakers, researchers, entrepreneurs, activists, public). Recent HCI studies have discussed the importance of the relationship between researchers and community when designing civic technologies (Balestrini et al., 2014), but there is a lack of discussion about how to manage stakeholder relationships for public organizations (Magalhaes, Roseira, & Strover, 2013). As Study 2 suggests, there are both direct and indirect stakeholders in different organizations that share useful datasets and resources. The new form of partner-technologist relationship also improves collaboration compared with

the traditional technical vendor-client relationship. Study 3 suggests that the organizers should engage brokers who could facilitate the complex collaboration between volunteers and public organizations by translating, coordinating, and aligning the collaborative work undertaken by different stakeholders.

Last, public organizations should go beyond adopting civic technologies and take the opportunity of the design process to engage public participants with different skill sets. Recent studies have suggested public organizations could leverage civic hackathons for civic engagement in addition to facilitation of innovation and replacement of procurement (Johnson & Robinson, 2014). For instance, Study 2 shows that civic hacking program provides an opportunity for public organizations to get feedback from citizens about their working practices and make sure civic technologies lead to proper community impacts. Study 3 demonstrates how civic data hackathons benefit both NPOs with their data-driven work and community participants with their learning goals. Previous research mainly focused on civic hacking as a process for experts to create technical prototypes for community problems (Irani, 2015; Trainer, Kalyanasundaram, Chaihirunkarn, & Herbsleb, 2016a). This dissertation suggests that public organizations could leverage civic hacking programs and hackathons to engage more diverse citizens and volunteers with different opinions and expertise. Future research should investigate how to make civic hackathons more inclusive and benefit participants with different skill sets and needs, so that people with low level or non-technical skills could also engage in the design process and have their voices heard.

Overall, civic technologies do not necessarily result in better solutions and a more democratic way of solving community issues, and the success of civic technologies requires more than the simple provision of access to technologies and a design process. What is also needed is creating and institutionalizing a culture of data and information literacy, improving the relationship building between various stakeholders, and encouraging more active civic engagement in the design process. These broader perspectives need to be taken by the public organizations that are now merely adopting civic technologies or involving in civic hacking programs. Under these conditions, civic technologies could go beyond the current level of adoption and lead to a deeper

engagement between public organizations and citizens and more effective solutions to community problems drawing upon the collective intelligence of the public.

6.4. Limitations and Future Work

This dissertation provides insights into the design and implementation of civic technologies in resource-limited public organizations. However, this work has limitations, proper of any research endeavor. The studies mainly focus on public organizations in the US through qualitative research; the long-term effect of civic technologies needs to be studied in future work. These all influence the generalizability of the dissertation to other forms of civic technology efforts.

6.4.1. Limited Sample of Small-Sized Organizations in the US

We have used the sample of public organizations primarily in the US and Midwestern cities, which might not represent public organizations in other cultural and social contexts. We also focus on small-sized public organizations and cities that are more constrained in resources and information literacy, whereas most previous work focused on big cities (Boehner & Disalvo, 2016; McMillan et al., 2016) with more resources and capacity to organize civic hacking and hackathons. However, this may limit the generalizability of our results to mid and large-sized cities and public organizations. Participants in our studies are also biased to white and highly educated population, who may not represent the vast diversity of communities and ethnic groups.

6.4.2. Long-Term Sustainability of Civic Technologies

Both Study 2 and Study 3 focus on the design and development phases of civic hacking and civic data hackathons. For instance, the sustainability of the civic hacking projects in Study 2 is evaluated by the status of the technology about 6-12 months after they are handed over to partners. The dissertation provides insights into factors during the design process that could enhance projects' sustainability based on the feedback from the iterative design. Questions remain about how the civic hacking projects evolve and sustain in public organizations years after the projects, and factors that may contribute to the more long-term sustainability of civic technologies after public organizations fully take over the

projects. Future studies should continue investigating the long-term influence of civic hacking and hackathon projects in the communities, through longitudinal studies of the deployment and an actual usage of civic technologies in public organizations. It would also be interesting to investigate the long-term impact of civic technologies on public organizations work practices and data literacy. Future work could also investigate whether public organizations could provide volunteer opportunities for non-technical community members that could lead to employable skills through civic hacking and hackathons. In summary, understanding the long-term deployments of civic technologies in public organizations remains a significant challenge, and we look forward to future studies that will deepen and expand the findings of the present work.

6.4.3. Non-Citizen Participants of Civic Hacking and Hackathons

We mainly study the perspectives of the volunteer technologists and public organization staff rather than local community residents. Therefore, the opinions might be biased towards the perspective of the public organizations that managed the civic technologies. Though these people are the main stakeholders during the design and implementation phase of civic technologies, we have realized the importance of the perspectives of the end users of civic technologies—community residents. Many volunteer technologists in Study 2 and Study 3 are also students, which distinguish the nature of the design process and collaborations between stakeholders from civic hacking programs that involve professionals or local residents. Further studies are needed to understand the perspectives of different stakeholders (e.g. community residents) to provide a more balanced understanding of civic technologies design.

6.3.4. The Characteristics of Data

We primarily draw on qualitative data (e.g., observations, interviews, and content analysis) to investigate the perspectives of public organization staff on civic technologies. These results underestimate the quantitative relationships between various organizations and civic technology characteristics, design parameters, and civic technology outcomes. Qualitative research is appropriate for addressing our research questions, as we sought to provide a rich context to understand stakeholders' practices and organizational contexts

when designing and implementing civic technologies. Nevertheless, we strive for the triangulation of various data sources (e.g., observations, interviews, and document analysis) to achieve more confidence in interpreting the results reported here. Future quantitative research is needed to verify the effects of factors derived from the qualitative studies in larger samples of civic technologies and civic hacking projects.

6.5. Concluding Remarks

In conclusion, the dissertation reveals a complex relationship between civic technologies and public organizations. The larger goal of this dissertation is to guide future efforts of designing and implementing effective civic technologies in resource-limited public organizations. Overall, the dissertation work contributes to research on civic technologies in public organizations by:

1. Providing a deeper understanding of supporting public organizations' engagement with the public through the design and implementation of civic technologies (e.g., social media, civic hacking, and civic data hackathons).

2. Compiling a set of evidence-based design and practice guidelines for volunteer technologists and public organizations to design and implement civic technologies that better fit the public organizations' and communities' structures, constraints and needs.

3. Examining factors that tackle the challenges of the complex collaboration between stakeholders during the design and implementation of civic technologies in public organizations.

This dissertation contributes to the HCI and CSCW research fields by enhancing our understanding of the design and implementation of effective and sustainable civic technologies for resource-limited public organizations. We believe the results generalize beyond social media, civic hacking, and hackathons to other civic technologies and design processes. Beyond contributing to these HCI and CSCW research fields, our work also makes broader impact of contributing solutions to the challenging problems of facilitating civic engagement and making better use of open data and information technologies for public goods in the digital era.

APPENDICES

APPENDIX A

NPOs Social Media Research Protocol

NPOs Interview Protocol

PART 1: Environmental System
The goal of these questions is to ask about organizations question about their environmental system websites.
SCRIPT: Thanks for taking time to speak with me about how your organization evaluate the effectiveness of many aspects of the environmental system. I have a few questions to get us started.

COSTS
1. Could you please roughly estimate the costs of building your environmental system?
   o How much is the cost to design the system?
   o How much is the cost for implementing management practices?
   o How much is the cost for social media tools?
   o Example of cost: technology, labor, research, equipment
2. What are the sources of funding for your environment system?
   o Do you raise money from the public/government?
3. What are the costs to participate/use the environmental system?

MARKETING
4. What are the other marketing strategies do you employ besides the social media channels? How do you feel about the effectiveness of these marketing channels compared with social media tools?
   o Costs
   o Information dissemination
   o Behavior/attitude changes

GOALS
5. What are the goals of your environmental system?
   o Education
   o Change attitudes/behaviors on certain topic
   o Change certain behaviors
   o Measure environmental impact

CURRENT USE
6. How do you define the success and failure of your environmental system? How do you measure the success?
7. During the development of your tool/website, did you have to overcome any barriers along the way?

8. What could have been done differently for your environmental system?

PART 2: Social Media Tools
The goal of these questions is to ask about participants of organizations/environmental systems who have used Twitter or Facebook in order to change the behaviors of their audience.
SCRIPT: Thanks for taking time to speak with me about how your organization is using social media to promote your message and persuade audiences to change their practices. I have a few questions to get us started.

REFLECTION ON SOCIAL MEDIA DECISION
9. Thinking back to when your organization was first thinking about using social media, what was that discussion like?
    o Why or why not did you choose different social media tools? What are the pros and cons?
    o What were some of the outcomes for social media use that you discussed? For instance, did you set any explicit goals for the channel?

CURRENT USE
10. How do you manage your social media channels? Can you walk me through some typical posts on social for your organization, and describe what the process for sharing that content is?
11. Who are the audiences of your social media channels? Who else do you feel should be your audience but not yet? Why? What strategy do you use to navigate different audience?
12. How do different social media channels benefit your organization/project?
    Attract media attention?
    • Raise funds?
    • Recruiting volunteers?
    • Building relationships?
    • Collect data?
    • Generate interest?
13. How do you feel about the interactive features of the social media channels?
14. Do you use different social media tools differently? E.g. Facebook/twitter/Youtube, how do you perceive their individual utilities?

EVALUATION OF SUCCESS
15. How do you define and measure the success of the social media use?
16. What do you see as your greatest challenges for using social media?

FUTURE SOCIAL MEDIA USE
17. Are there any goals that you expect to achieve through social media, but you fail to? What are the reasons for that?
18. Are you planning to do anything different with social media in the future?

APPENDIX B

Civic Hacking Projects Interview Protocol

Student Technologist Interview Protocol

Introduction
We are trying to understand the collaboration between CID students team and the community partners. I'll ask you some question about the design process of the project, and review some documents. Then I'll ask your feedback on CID project for us to improve future CID projects. Can I record the interview?

Personal experience
- Can you tell me a little bit about yourself?
- What were your motivations for participating in CID projects?
- What is your roles in the design team?
- What were your expectations? Did you have specific goals?

Collaborative Design of CID
- How did you work with your partner during the CID projects?
    - o What was the process look like?
    - o How did you scope the problem? What do you see as their information limitations, problems and needs?
    - o What were the different solutions and iterations? What's their feedback? What kind of change did you make?
    - o Which design methods do you feel most useful? What are the best design practice?
        - ▪ (interview, survey, user testing etc.)
    - o How often do you communicate with the partners?
    - o What kind of ICTs do you use during the collaboration between? How effective are they?
    - o Who are the key stakeholders and how they get involved?
    - o What would you say was the key to success during the collaboration?
    - o What are the big challenges during your collaboration with community partners?
- How do you coordinate the work between your team members?
    - o How often do you communicate with the partners?
    - o What kind of ICTs do you use during the coordination between team members? How effective are they?
- How does CID project differ from your previous design process?
    - o What are the difference in the working process?
    - o What are the difference in the relationship with the community partners?
    - o Why it's important to visit Jackson?

- What you wish you have done differently during the collaboration?

Implementation of CID project
- How would you evaluate the effectiveness of the information tool in solving the problem?
    - *[Feature list here]*
    - Which features do you like the best?
    - Which features do you dislike?
    - How would you assess the effectiveness of the tool?
- How is the tool implemented ?
    - Who is the person who take over the project and why? How did you choose that person?
    - (If not) Why not?
    - What would be the biggest challenge for implementation?
    - Did you follow up after the project? What kind of communication?

Sustainability of the CID project
- How would you evaluate the sustainability of the project?
    - What aspects do you consider about the future of the project?
    - What you wish to have done to make the project more sustainable?
    - What will be the challenges for the sustainability?
- What are the impacts of the CID project on you and your community partners?
- Are you awareness of any collaboration with other CID projects?

Community Partner Interview Protocol

Introduction
We are trying to understand the collaboration between CID students team and the community partners, your evaluation of the process, and how the civic tech is implemented in your organization. I'll ask you some question about the design process of the project, and review some documents. Then I'll ask your feedback on CID project for us to improve future CID projects. Can I record the interview?

Personal background
- Can you tell me a little bit more about your organization?
- What are your roles and responsibilities in your organization?
- What is your previous experience with information technology?
- How did you or your organization/department get involved in this partnership?
- Who are the other stakeholders and what are their roles?

Collaborative Design of CID
- What is the problem that you want to solve though the CID project?
    - How did you decide that was a problem you wanted to work on?
    - What was the previous solution to the problem? What are the ICTs being used?
    - What were your expectations? Did you have a specific goals?
- How did you work with student teams on the CID projects?
    - What was the process look like?

- o What were the different solutions? What's your feedback?
- o Were there any big changes of the design? Why?
- o How often do you communicate?
- o What kind of ICTs do you use during the collaboration? How effective are they?
  - ▪ Google drive? Shared space
- o *Why do you decide to make a non-technical design (Digcards)?*

What would you say was the key to success during the collaboration?
- What obstacles did you encounter during your collaboration with student teams, and how did you deal with them?
- How does CID project differ from your previous technology development in your organization?
  - o What are the difference in the working process?
  - o What are the difference in the relationship with students/vendor?
- What you wish you have done differently during the collaboration?

Implementation of CID project
- How would you evaluate the effectiveness of the information tool in solving the problem?
  - o *[list of features]*
  - o Which features do you like the best?
  - o Which features do you dislike?
  - o How would you assess the effectiveness of the tool?
- How is the tool implemented ?
  - o Who is the person who take over the project and why?
  - o What would be the biggest challenge for implementation?
  - o *How does it differ from the original implementation plan?*

Sustainability of the CID project
- How would you evaluate the sustainability of the project?
  - o How would you evaluate the sustainability plan?
  - o What you wish to have done to make the project more sustainable?
  - o What will be the challenges for the sustainability?
- (If already implemented) How do you use it now?
  - o How does it differ from the original plan?
  - o What you wish you have done during the design of the tool?
- What are the impacts of the CID project on you, your organization and the city?
- Are you awareness of any collaboration with other CID projects? Have you involved with other CID projects?

Feedback on the CID program
- What is CID staff's role during the process?
- What are your suggestions for the CID staff (Scott, Kelly and Cliff) to make it better?
  - Project select, delivery of final project, frequency of communication, the staff's work, mode of new communication, etc.

- What would you do differently for the project? Would you pick the same product, problem and topic?
- Are there any other stakeholders of this project that you think I should talk to?
- Is there anything else you would like to add, or anything that you feel I should have asked you about, but didn't?

APPENDIX C

Civic Data Hackathon Research Protocol

Civic Data Hackathon Survey

1. How would you describe yourself? (Please select all that apply)
- Student
- Designer
- Engineer
- Researcher
- Entrepreneur
- Government official
- Nonprofit organization staff
- Other _____

2. If you are a student, what is your major?

3. What are your motivations to participate in A2 Data Dive? (Please select all that apply)
- I want to learn new data analysis skills
- I want to practice my data analysis skills
- I want to teach others data analysis skills
- I want to network with other people
- I want to help nonprofit organizations
- I am interested in the topic of the event

4. Which type of data analysis did you do in A2 Data Dive? (Please select all that apply)
- Data cleaning
- Data visualization
- Descriptive analysis
- Regression analysis
- Data mining
- Market report
- Other _____

5. Which data analysis tools did you use in A2 Data Dive? (Please select all that apply)
- Excel
- Matlab
- R
- Python

- STATA
- SAS
- Tableau
- Other _____

6. Which of the following data format did you work in A2 Data Dive? (Please select all that apply)
- .csv
- Excel (.xls, .xlsx)
- Raw text file (.txt)
- Database
- HTML scraped from web

7. Which of the following communication and collaboration tools did you use in A2 Data Dive? (Please select all that apply)
- Email
- File Sharing Tool (Google Drive, OneDrive, Box, etc.)
- Instant messaging tool   (Facebook messenger, Skype, etc.)
- Slack
- Text message
- Other

8. To what extent would you rate your expertise in data analysis?
- No knowledge
- Passing
- Knowledgeable
- Expert

9. Which NPO(s) did you work with in A2 Data Dive? (Please select all that apply)
- Girls on the Run
- Natural Area Preservation - The City of Ann Arbor
- Salem-South Lyon District Library
- Great Lakes Observing System

10. How many people are there in your project team?

11. To what extent were you satisfied or dissatisfied with the data analysis project completed in your team?
- Very dissatisfied
- Dissatisfied
- Neutral
- Satisfied
- Very satisfied

12. How useful do you think the data analysis project completed in your team for the nonprofit organization?
- Not useful at all

- Not Useful
- Neutral
- Useful
- Very useful

13. What were the reasons for the extent to which you were satisfied or dissatisfied with the work completed in your team?

14. What are your expectations of the A2 Data Dive event?

15. To what extent did the A2 Data Dive meet your expectations?
- Did not meet my expectations at all
- Met my expectations
- Exceeded my expectations

16. The length of the A2 Data Dive event was
- Too short
- Just right
- Too long

17. The best part of the A2 Data Dive was

18. If I could change one thing about the A2 Data Dive, it would be

19. What is your gender?
- Female
- Male
- Other

20. What is your ethnicity?
- White
- Hispanic or Latino
- Black or African American
- Native American or American Indian
- Asian / Pacific Islander
- Other

21. What is the highest level of education you completed?
- High School
- Some college
- Bachelor's Degree
- Master's Degree
- Advanced Graduate work or Ph.D.

22. We also invite you to participate in a follow-up interview about your experience in A2 Data Dive. Selected participants will receive a **$10 incentive** for your participation.

- Yes, I would like to participate in the follow-up interview
- No, I am not interested

23. If you would like to participate in the follow-up interview, please provide your name and your email address. Thank you!

Civic Data Hackathon NPOs Interview Protocol

Can you tell me a little bit about yourself and your organization?
- a) How do you work with data in your daily work?
- b) What was your motivation to join the data dive event?

How did you work with the client team to prepare for the data dive event?
- a) How did you pick the datasets and the problems? What kind of datasets and problem do you think are suitable for A2D2?
- b) What kind of ICTs do you use to collaborate with client team to prepare for the data dive event?
- c) What do you see as the key to success during the preparation process?
- d) What are the challenges during the preparation process?

Can you describe your experience during the event?
a.   How did you interact with the public participants?
- a) Can you list some projects you think are successful?
- b) How would you evaluate the success of the project for your NPO?
- c) What do you see as the key to the success for the projects to help you?
- d) What kind of challenges for the projects to help you?

How were the projects delivered to you?
- a) What data analytics outputs are you most interested in?
- b) Has your organization made use of these analytics in your work?
- c) Are there any other impact of the A2D2 for your organization?

What would do you have done differently before, during or after the A2D2 event to make the projects more helpful for your NPO?

Have you attended other community engagement project before?
- a) How does A2D2 differ from them?
- b) How do you feel the data dive event different to your ordinary work with data?

Civic Data Hackathon Client Team Interview Protocol

Can you tell me a little bit about yourself?
- a) What was your motivation to join the data dive event and the client team?

How did you work with NPOs before the data dive events?
- a) Can you describe the NPOs and the key person you work with?
- b) What are the roles of your team members?

    c)   How was the data preprocessed for the A2D2 event? How did you select which dataset to work with? How did you come up with the questions? How did you anonymize data? How did you deal with unformatted data? Did you use any external data sources?

    d)   What do you see as the key to success during the preparation process?

    e)   What are the challenges of the preparation process?

    f)   What kind of ICT did you use for the preparation of dataset?

        i.   What kind communication tools did you use? What kind of data analytics tools did you use?

What is your work process during the data dive events?

    a)   How many teams are there in the project? What kind of data analytics did people use to help NPO? Can you identify some most interesting or successful project?

    b)   How did people collaborate in doing the projects? What kind of collaboration and communication tools did public participants use? How did you interact with the public participants? How did the client interact with the public participants?

    c)   What do you see as key to success of the project - To increase the productivity of the collaborative analytics? To help the NPO?

    d)   What do you see as challenges of the A2D2 event - In conducting collaborative analytics? In helping the NPO?

How did you follow up with the NPO after the event?

    a)   What client's reactions to the deliverables?

    b)   Are there particular deliverables they favor?

What would do you have done differently before, during or after the A2D2 event to

    a)   Increase the productivity of the collaboration

    b)   better help NPOs?

Have you participated in other community engagement project before? Have you attended any other hackathons before?

    a)   How does A2D2 differ from them?

    b)   How do you feel the data dive event different to your ordinary work with data?

That's all the questions I have. Is there anything else that you want to share?

BIBLIOGRAPHY

Abzug, R., & Webb, N. J. (1999). Relationships between nonprofit and for-profit organizations: A stakeholder perspective. *Nonprofit and Voluntary Sector Quarterly, 28*(4), 416-431.

Adler, R. P., & Goggin, J. (2005). What do we mean by "civic engagement"? *Journal of transformative education, 3*(3), 236-253.

Alexander, J., Brudney, J. L., Yang, K., LeRoux, K., & Wright, N. S. (2010). Does performance measurement improve strategic decision making? Findings from a national survey of nonprofit social service agencies. *Nonprofit and Voluntary Sector Quarterly, 39*(4), 571-587.

America, C. F. (2016). Codeacross 2016. from https://http://www.codeforamerica.org/events/codeacross-2016/

Anduiza, E., Cristancho, C., & Sabucedo, J. M. (2014). Mobilization through online social networks: The political protest of the indignados in spain. *Information, Communication & Society, 17*(6), 750-764.

Aoki, P. M., Honicky, R. J., Mainwaring, A., Myers, C., Paulos, E., Subramanian, S., & Woodruff, A. (2009). A vehicle for research : Using street sweepers to explore the landscape of environmental community action. In *Proceedings of CHI '09*, ACM.

Argote, L. (2012). *Organizational learning: Creating, retaining and transferring knowledge*: Springer Science & Business Media.

Arnstein, S. R. (1969). A ladder of citizen participation. *Journal of the American Institute of planners, 35*(4), 216-224.

Badger, E. (2013). Are civic hackathons stupid? , from http://www.citylab.com/tech/2013/07/are-hackathons-stupid/6111/

Balestrini, M., Bird, J., Marshall, P., Zaro, A., & Rogers, Y. (2014). Understanding sustained community engagement : A case study in heritage preservation in rural argentina. In *Proceedings of CHI '14*, 2675-2684.

Baumer, E. P., & Silberman, M. (2011). When the implication is not to design (technology). In *Proceedings of CHI '11*, 2271-2274. ACM.

Bernard, H. R., & Bernard, H. R. (2012). *Social research methods: Qualitative and quantitative approaches*: Sage.

Bertot, J. C., Jaeger, P. T., & Hansen, D. (2012). The impact of polices on government social media usage: Issues, challenges, and recommendations. *Government Information Quarterly, 29*(1), 30-40.

Birbeck, N., Lawson, S., Morrissey, K., Rapley, T., & Olivier, P. (2017). Self harmony: Rethinking hackathons to design and critique digital technologies for those affected by self-harm. In *Proceedings of Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, 146-157. ACM.

Bødker, S., & Zander, P.-O. (2015). Participation in design between public sector and local communities. In *Proceedings of C&T '15*, 49-58. ACM.

Boehner, K., & Disalvo, C. (2016). Data, design and civics: An exploratory study of civic tech. In *Proceedings of CHI '16*, 2970-2981. ACM.

Bopp, C., Harmon, E., & Voida, A. (2017). Disempowered by data : Nonprofits, social enterprises, and the consequences of data-driven work. In *Proceedings of CHI '17*, 3608-3619. ACM.

Bozeman, B., & Bretschneider, S. (1994). The "publicness puzzle" in organization theory: A test of alternative explanations of differences between public and private organizations. *Journal of public administration research and theory, 4*(2), 197-224.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology, 3*(2), 77-101.

Briones, R. L., Kuch, B., Liu, B. F., & Jin, Y. (2011). Keeping up with the digital age: How the american red cross uses social media to build relationships. *Public Relations Review, 37*(1), 37-43. doi: 10.1016/j.pubrev.2010.12.006

Bullen, C. V., & Bennett, J. L. (1991). Groupware in practice: An interpretation of work experiences. *Computerization and controversy: Value conflicts and social choices*, 257-287.

Carroll, J. M., & Rosson, M. B. (2007). Participatory design in community informatics. *Design Studies, 28*(3), 243-261.

Carroll, J. M., & Rosson, M. B. (2013). Wild at home : The neighborhood as a living laboratory for hci. *ACM Transactions on Computer-Human Interaction (TOCHI), 20*(3), 16.

Carroll, J. M., Rosson, M. B., Convertino, G., & Ganoe, C. H. (2006). Awareness and teamwork in computer-supported collaborations. *Interacting with computers, 18*(1), 21-46.

Carter, L., & Bélanger, F. (2005). The utilization of e-government services: Citizen trust, innovation and acceptance factors. *Information systems journal, 15*(1), 5-25.

Choi, J. (2017). Characteristics of collaboration in the emerging practice of open data analysis. In *Proceedings of CSCW '17*, 835-846. ACM.

Christensen, H. S. (2011). Political activities on the internet: Slacktivism or political participation by other means. *First Monday, 16*(2).

Convertino, G., Mentis, H. M., Rosson, M. B., Carroll, J. M., Slavkovic, A., & Ganoe, C. H. (2008). Articulating common ground in cooperative work. *Proceeding of the twenty-sixth annual CHI conference on Human factors in computing systems - CHI '08*(September 2015), 1637-1637. doi: 10.1145/1357054.1357310

Convertino, G., Mentis, H. M., Slavkovic, A., Rosson, M. B., & Carroll, J. M. (2011). Supporting common ground and awareness in emergency management planning: A design research project. *ACM Transactions on Computer-Human Interaction (TOCHI), 18*(4), 22.

Crabtree, A., Chamberlain, A., Davies, M., Glover, K., Reeves, S., Rodden, T., . . . Jones, M. (2013). Doing innovation in the wild. In *Proceedings of the Biannual Conference of the Italian Chapter of SIGCHI*, 25. ACM.

Davis, F. D. (2011). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS QUarterly, 13*(3), 319-340.

Dawes, S. S. (2010). Information policy meta-principles: Stewardship and usefulness. In *Proceedings of System Sciences (HICSS), 2010 43rd Hawaii International Conference on*, 1-10. IEEE.

de Lange, M., Verhoeff, N., de Waal, M., Foth, M., & Brynskov, M. (2015). Digital cities 9 workshop-hackable cities: From subversive city making to systemic change. In *Proceedings of Proceedings of the 7th International Conference on Communities and Technologies*, 165-167. ACM.

DeSanctis, G., & Poole, M. S. (1994). Capturing the complexity in advanced technology use: Adaptive structuration theory. *Organization science, 5*(2), 121-147.

Desanctis, G., & Poole Scott, M. (1994). Capturing the complexity in advanced technology use : Adaptive structuration theory. *5*(2), 121-147.

Dewey, J. (1927). *Public and its problems*: Penn State Press.

Dillahunt, T. (2014a). Fostering social capital in economically distressed communities. In *Proceedings of CHI 2014*, 531-540. ACM Press.

Dillahunt, T. (2014b). Toward a deeper understanding of sustainability within hci. In *Proceedings of Workshop on Sustainability, CHI'14*,

DiMicco, J., Millen, D. R., Geyer, W., Dugan, C., Brownholtz, B., & Muller, M. (2008). Motivations for social networking at work. In *Proceedings of CSCW 2008*, 711-720. ACM Press.

Disalvo, C., Lukens, J., Lodato, T., Jenkins, T., & Kim, T. (2014). Making public things : How hci design can express matters of concern. In *Proceedings of CHI '14*, 2397-2406. ACM.

Dourish, P. (2003). The appropriation of interactive technologies: Some lessons from placeless documents. *Computer Supported Cooperative Work (CSCW), 12*(4), 465-490.

Dourish, P., & Bellotti, V. (1992). Awareness and coordination in shared workspaces. In *Proceedings of CSCW '92*, 107-114. ACM.

Ebrahim, Z., & Irani, Z. (2005). E-government adoption: Architecture and barriers. *Business Process Management Journal, 11*(5), 589-611.

Erete, S., Ryou, E., Smith, G., Fassett, K., & Duda, S. (2016). Storytelling with data : Examining the use of data by non-profit organizations. In *Proceedings of CSCW '16*, 1273-1283.

Erete, S. L. (2015). Engaging around neighborhood issues : How online communication affects offline behavior. 1590-1601.

Foster, D., Lawson, S., Wardman, J., Blythe, M., & Linehan, C. (2012). Watts in it for me?: Design implications for implementing effective energy interventions in organisations. In *Proceedings of CHI 2012*, 2357-2366. ACM Press.

Foundation, K. (2013). The emergence of civic tech: Investments in a growing field. From http://www.knightfoundation.org/media/uploads/publication_pdfs/knight-civic-tech.pdf

Fox, S., & Dantec, C. A. L. (2014). Community historians : Scaffolding community engagement through culture and heritage. In *Proceedings of DIS '14*, 785-794. ACM.

Frecks, L. (2015). Citizen participation in digital government: A new model identifying levels of expertise and responsibility in collaborations. In *Proceedings of Annual International Conference on Digital Government Research*, 167-170. ACM.

Freeman, R. E. (2010). *Strategic management: A stakeholder approach*: Cambridge University Press.

Ganapati, S., & Reddick, C. G. (2012). Open e-government in us state governments: Survey evidence from chief information officers. *Government Information Quarterly, 29*(2), 115-122.

Giddens, A. (1984). *The constitution of society: Outline of the theory of structuration*: Univ of California Press.

Gilman, H. R. (2016). *Participatory budgeting and civic tech: The revival of citizen engagement*: Georgetown University Press.

Goecks, J., Voida, A., Voida, S., Mynatt, E. D., Nw, S., & Canada, A. B. T. N. (2008). Charitable technologies : Opportunities for collaborative computing in nonprofit fundraising. In *Proceedings of*, 689-698.

Gregg, M. (2015). Hack for good: Speculative labor, app development and the burden of austerity. *Fibreculture*(25).

Grudin, J. (1988). Why cscw applications fail : Problems in the design and evaluation of organizational interfaces. In *Proceedings of CSCW '88*, 85-93.

Guo, C., & Saxton, G. D. (2014). Tweeting social change: How social media are changing nonprofit advocacy. *Nonprofit and Voluntary Sector Quarterly, 43*(1), 57-79.

Gurstein, M. (2001). Community informatics, community networks and strategies for flexible networking. *Community informatics: Shaping computer-mediated social relations*, 263-283.

Gurstein, M. B. (2011). Open data: Empowering the empowered or effective data use for everyone? *First Monday, 16*(2).

Han, K., Shih, P. C., Rosson, M. B., & Carroll, J. M. (2014). Enhancing community awareness of and participation in local heritage with a mobile application. 1144-1155.

Harding, M., Knowles, B., Davies, N., & Rouncefield, M. (2015). Hci, civic engagement & trust. In *Proceedings of CHI '15*, 2833-2842. ACM.

Hayes, G. R. (2011). The relationship of action research to human-computer interaction. *ACM Transactions on Computer-Human Interaction (TOCHI), 18*(3), 15.

Hearn, G., Kimber, M., Lennie, J., & Simpson, L. (2005). A way forward: Sustainable icts and regional sustainability. *The Journal of Community Informatics, 1*(2).

Heer, J., & Agrawala, M. (2006). Software design patterns for information visualization. *IEEE transactions on visualization and computer graphics, 12*(5).

Heer, J., & Agrawala, M. (2007). Design considerations for collaborative visual analytics. In *Proceedings of VAST IEEE Symposium on Visual Analytics Science and Technology*, 171-178.

Hellmann, D., Maitland, C., & Tapia, A. (2016). Collaborative analytics and brokering in digital humanitarian response. In *Proceedings of CSCW '16*, 1284-1294.

Hirsch, E. A. (2008). *Contestational design: Innovation for political activism.* Massachusetts Institute of Technology.

Hoffman, D. L., & Fodor, M. (2010). Can you measure the roi of your social media marketing? *Sloan Management Review, 52*(1).

Hou, Y. (2016). Understand the design and implementation of civic technologies in public organizations. In *Proceedings of CSCW '16 Companion*, 147-150. ACM.

Hou, Y., & Lampe, C. (2015). Social media effectiveness for public engagement: Example of small nonprofits. In *Proceedings of CHI' 15*, 3107-3116. ACM.

Hou, Y., & Lampe, C. (2017). Sustainable hacking: Characteristics of the design and adoption of civic hacking projects. In *Proceedings of C&T '17*, 125-134.

Hou, Y., & Wang, D. (2018). Hacking with npos: Collaborative analytics and broker roles in civic data hackathons. *PACM on Human-Computer Interaction, 1*(2).

Irani, L. (2015). Hackathons and the making of entrepreneurial citizenship. *Science, Technology & Human Values, 40*(5), 799-824.

Janssen, M., Charalabidis, Y., & Zuiderwijk, A. (2012). Benefits, adoption barriers and myths of open data and open government. *Information Systems Management, 29*(4), 258-268.

Johansen, R. (1988). *Groupware: Computer support for business teams*: The Free Press.

Johnson, P., & Robinson, P. (2014). Civic hackathons: Innovation, procurement, or civic engagement? *Review of Policy Research, 31*(4), 349-357. doi: 10.1111/ropr.12074

Kavanaugh, A. L., & Patterson, S. J. (2001). The impact of community computer networks on social capital and community involvement. *American Behavioral Scientist, 45*(3), 496-509.

Kim, S., Mankoff, J., & Paulos, E. (2015). Exploring barriers to the adoption of mobile technologies for volunteer data collection campaigns. In *Proceedings of CHI '15*, 3117-3126. ACM.

Kingston, R. (2002). The role of e-government and public participation in the planning process. In *Proceedings of XVI Aesop Congress Volos, available at:* http://www. ccg. leeds. ac. uk/democracy/presentations/AESOP_kingston. pdf,

Kling, R. (1991). Cooperation, coordination and control in computer-supported work. *Communications of the ACM, 34*(12), 83-88.

Koch, G., Füller, J., & Brunswicker, S. (2011). Online crowdsourcing in the public sector: How to design open government platforms *Online communities and social computing* (pp. 203-212): Springer.

Korn, M., & Voida, A. (2015). Creating friction: Infrastructuring civic engagement in everyday life. In *Proceedings of 5th Decennial Aarhus Conference: Critical Alternatives*, 145-156. ACM.

Kulk, S., & Van Loenen, B. (2012). Brave new open data world. *International Journal of Spatial Data Infrastructures Research, 7, 2012*.

Kuutti, K., & Bannon, L. J. (2014). The turn to practice in hci: Towards a research agenda. In *Proceedings of CHI '14*, 3543-3552. ACM.

Lakomaa, E., & Kallberg, J. (2013). Open data as a foundation for innovation: The enabling effect of free public sector information for entrepreneurs. *IEEE Access, 1*, 558-563.

Lampe, C. (2016). Citizen interaction design: Teaching hci through service. *Interactions, 23*(6), 66-69.

Lampe, C., & Roth, R. (2012). Implementing social media in public sector organizations. In *Proceedings of Proceedings of the 2012 iConference*, 191-198. ACM.

Le Dantec, C. A., Christensen, J. E., Bailey, M., Farrell, R. G., Ellis, J. B., Danis, C. M., . . . Edwards, W. K. (2010). A tale of two publics: Democratizing design at the margins. In *Proceedings of DIS '10*, 11-20. ACM.

Le Dantec, C. A., & DiSalvo, C. (2013). Infrastructuring and the formation of publics in participatory design. *Social Studies of Science, 43*(2), 241-264.

Le Dantec, C. A., & Edwards, W. K. (2008). The view from the trenches: Organization, power, and technology at two nonprofit homeless outreach centers. In *Proceedings of CSCW '08*, 589-598. ACM.

Lee, C. P. (2007). Boundary negotiating artifacts: Unbinding the routine of boundary objects and embracing chaos in collaborative work. *Computer Supported Cooperative Work (CSCW), 16*(3), 307-339.

Lee, C. P., & Paine, D. (2015). From the matrix to a model of coordinated action (moca): A conceptual framework of and for cscw. In *Proceedings of CSCW '15*, 179-194. ACM.

Lenczner, M., & Phillips, S. (2012). From stories to evidence: How mining data can promote innovation in the nonprofit sector. *Technology Innovation Management Review, 2*(7), 10.

Lewis, S., & Lewis, D. A. (2012). Examining technology that supports community policing. In *Proceedings of CHI 2012*, 1371-1380. ACM Press.

Light, P. C. (1998). *Sustaining innovation: Creating nonprofit and government organizations that innovate naturally*: Jossey-Bass.

Linders, D. (2012). From e-government to we-government: Defining a typology for citizen coproduction in the age of social media. *Government Information Quarterly, 29*(4), 446-454.

Lodato, T. J., & DiSalvo, C. (2016). Issue-oriented hackathons as material participation. *New Media & Society, 18*(4), 539 - 557.

López, C., & Farzan, R. (2014). Designing for neighborhoods: Lessons learned from paper-based bulletin boards. In *Proceedings of Extended Bbstracts of CHI '14*, 1963-1968. ACM.

Lovejoy, K., & Saxton, G. D. (2012a). Information, community, and action: How nonprofit organizations use social media. *Journal of Computer-Mediated Communication, 17*(3), 337-353. doi: 10.1111/j.1083-6101.2012.01576.x

Lovejoy, K., & Saxton, G. D. (2012b). Information, community, and action: How nonprofit organizations use social media. *Journal of Computer-Mediated Communication, 17*(3), 337-353. doi: 10.1111/j.1083-6101.2012.01576.x

Lovejoy, K., Waters, R. D., & Saxton, G. D. (2012). Engaging stakeholders through twitter: How nonprofit organizations are getting more out of 140 characters or less. *Public Relations Review, 38*(2), 313-318. doi: 10.1016/j.pubrev.2012.01.005

Magalhaes, G., Roseira, C., & Strover, S. (2013). Open government data intermediaries: A terminology framework. In *Proceedings of Proceedings of the 7th International Conference on Theory and Practice of Electronic Governance*, 330-333. ACM.

Maruyama, M., Douglas, S., & Robertson, S. (2013). Design teams as change agents: Diplomatic design in the open data movement. In *Proceedings of HICSS '13*, 1860-1869. IEEE
.

Matthews, T., Whittaker, S., Badenes, H., & Smith, B. A. (2014). Beyond end user content to collaborative knowledge mapping: Interrelations among community social tools. In *Proceedings of CSCW 2014*, 900-910. ACM Press.

Maxwell, N. L., Rotz, D., & Garcia, C. (2016). Data and decision making: Same organization, different perceptions; different organizations, different perceptions. *American Journal of Evaluation, 37*(4), 463-485.

McDonald, D. W., & Ackerman, M. S. (1998). Just talk to me : A field study of expertise location. In *Proceedings of CSCW '98*, 1-11. ACM.

McDonald, D. W., & Ackerman, M. S. (2000). Expertise recommender: A flexible recommendation system and architecture. In *Proceedings of CSCW '00*, 231-240. ACM.

McMillan, D., Engström, A., Lampinen, A., & Brown, B. (2016). Data and the city. In *Proceedings of CHI '16*, 2933-2944.

McMillan, D. W., & Chavis, D. M. (1986). Sense of community: A definition and theory. *Journal of community psychology, 14*(1), 6-23.

McNutt, J. G., Justice, J. B., Melitski, J. M., Ahn, M. J., Siddiqui, S. R., Carter, D. T., & Kline, A. D. (2016). The diffusion of civic technology and open government in the united states. *Information Polity, 21*(2), 153-170.

Mergel, I. (2013a). A framework for interpreting social media interactions in the public sector. *Government Information Quarterly, 30*(4), 327-334.

Mergel, I. (2013b). Social media adoption and resulting tactics in the us federal government. *Government Information Quarterly, 30*(2), 123-130.

Merkel, C., Farooq, U., Xiao, L., Ganoe, C., Rosson, M. B., & Carroll, J. M. (2007). Managing technology use and learning in nonprofit community organizations : Methodological challenges and opportunities. In *Proceedings of CHIMIT '07*, 8. ACM.

Merkel, C. B., Xiao, L., Farooq, U., Ganoe, C. H., Lee, R., Carroll, J. M., & Rosson, M. B. (2004). Participatory design in community computing contexts: Tales from the field. In *Proceedings of the eighth conference on Participatory design: Artful integration: interweaving media, materials and practices-Volume 1*, 1-10. ACM.

Microsoft. (2014). Civic tech: Solutions for governments and the communities they serve. from http://blogs.microsoft.com/on-the-issues/2014/10/27/civic-tech-solutions-govern ments-communities-serve/

Miles, M. B., & Huberman, A. M. (2013). *Qualitative data analysis: An expanded sourcebook*: Sage.

Miller, D., & Miller, D. M. (2011). Nonprofit organizations and the emerging potential of social media and internet resources. *SPNHA Review, 6*(1), 4.

Moore, M. H. (1995). *Creating public value: Strategic management in government*: Harvard university press.

Morgan, J., Foundation, W., Dailey, D., & Hill, B. M. (2017). Hacking and making at time-bounded events : Current trends and next steps in research and event design. In *Proceedings of CSCW '17 Companion*, 363-370. ACM.

Nah, S., & Saxton, G. D. (2012). Modeling the adoption and use of social media by nonprofit organizations. *New Media & Society, 15*(2), 294-313. doi: 10.1177/1461444812452411

NVivo. (2012). Nvivo qualitative data analysis software (Version 10): QSR International Pty Ltd.

Obar, J. A., Zube, P., & Lampe, C. (2012). Advocacy 2.0: An analysis of how advocacy groups in the united states perceive and use social media as tools for facilitating civic engagement and collective action. *Journal of Information Policy, 2*, 1-15.

Orlikowski, W. J. (2000). Using technology and constituting structures : Practice lens in for studying technology organizations. *Organization science, 11*(4), 404-428.

Paepcke, A. (1996). Information needs in technical work settings and their implications for the design of computer tools. *CSCW*, 63-92. doi: 10.1007/BF00141936

Pawlowski, S. D., Robey, D., & Raven, A. (2000). Supporting shared information systems: Boundary objects, communities, and brokering. *Conference on Information Systems*, 329-338.

Pawlowski, S. D., Robey, D., & Robey, D. (2004). Bridging user organizations: Knowledge brokering and the work of information technology professionals. *MIS Quarterly, 28*(4), 645-672. doi: 10.2307/25148658

Perry, J. L., & Rainey, H. G. (1988). The public-private distinction in organization theory: A critique and research strategy. *Academy of management review, 13*(2), 182-201.

Plans, O., & Cities, L. (2012). Field scan of civic technology. *Living Cities*.

Powell, W. W., & Steinberg, R. (2006). *The nonprofit sector: A research handbook*: Yale University Press.

Puron-Cid, G. (2013). Interdisciplinary application of structuration theory for e-government: A case study of an it-enabled budget reform. *Government Information Quarterly, 30*, S46-S58.

Quinton, S., & Fennemore, P. (2013). Missing a strategic marketing trick? The use of online social networks by uk charities. *International Journal of Nonprofit and Voluntary Sector Marketing, 18*(1), 36-51.

Richardson, M., & White, R. W. (2011). Supporting synchronous social q&a throughout the question lifecycle. In *Proceedings of WWW '11*, 755-764. ACM.

Robey, D., & Sahay, S. (1996). Transforming work through information technology: A comparative case study of geographic information systems in county government. *Information systems research, 7*(1), 93-110.

Robson, C., Hearst, M., Kau, C., & Pierce, J. (2013). Comparing the use of social networking and traditional media channels for promoting citizen science. In *Proceedings of CSCW 2013*, 1463-1468. ACM Press.

Rogers, E. M. (2010). *Diffusion of innovations*: Simon and Schuster.

Schrock, A. R. (2016). Civic hacking as data activism and advocacy: A history from publicity to open government data. *New Media & Society, 18*(4), 581 - 599.

Skeels, M. M., & Grudin, J. (2009). When social networks cross boundaries: A case study of workplace use of facebook and linkedin. In *Proceedings of CSCW 2009*, 95-104. ACM Press.

Sommerfeldt, E. J., Kent, M. L., & Taylor, M. (2012). Activist practitioner perspectives of website public relations: Why aren't activist websites fulfilling the dialogic promise? *Public Relations Review, 38*(2), 303-312. doi: 10.1016/j.pubrev.2012.01.001

Star, S. L., & Ruhleder, K. (1995). Steps toward an ecology of infrastructure: Design and access for large information spaces. *Information systems research, 7*(1), 111-134.

Steinfield, C., DiMicco, J. M., Ellison, N. B., & Lampe, C. (2009). Bowling online: Social networking and social capital within the organization. In *Proceedings of C&T 2009*, 245-254. ACM Press.

Steinhardt, S. B., & Jackson, S. J. (2015). Anticipation work: Cultivating vision in collective practice. In *Proceedings of CSCW '15*, 443-453. ACM.

Stoll, J., Edwards, W. K., & Mynatt, E. D. (2010). Interorganizational coordination and awareness in a nonprofit ecosystem. In *Proceedings of CSCW 2010*, 51-60. ACM Press.

Strauss, A. (1988). The articulation of project work: An organizational process. *The Sociological Quarterly, 29*(2), 163-178.

Taylor, A. S., Lindley, S., Regan, T., & Sweeney, D. (2015). Data - in - place : Thinking through the relations between data and community. 2863-2872.

Taylor, N., Cheverst, K., Wright, P., & Olivier, P. (2013). Leaving the wild : Lessons from community technology handovers. In *Proceedings of CHI '13*, 1549-1558. ACM.

Taylor, N., Clarke, L., & Gorkovenko, K. (2017). Community inventor days: Scaffolding grassroots innovation with maker events. In *Proceedings of Proceedings of the 2017 Conference on Designing Interactive Systems*, 1201-1212. ACM.

Taylor, N., Marshall, J., Blum-ross, A., Mills, J., Rogers, J., Egglestone, P., . . . Olivier, P. (2012). Viewpoint : Empowering communities with situated voting devices. 1361-1370.

Thrall, A. T., Stecula, D., & Sweet, D. (2014). May we have your attention please? Human-rights ngos and the problem of global communication. *The International Journal of Press/Politics, 19*(2), 135-159.

Townsend, A. M. (2013). *Smart cities: Big data, civic hackers, and the quest for a new utopia*: WW Norton & Company.

Trainer, E. H., Kalyanasundaram, A., Chaihirunkarn, C., & Herbsleb, J. D. (2016a). How to hackathon : Socio-technical tradeoffs in brief , intensive collocation.

Trainer, E. H., Kalyanasundaram, A., Chaihirunkarn, C., & Herbsleb, J. D. (2016b). How to hackathon : Socio-technical tradeoffs in brief , intensive collocation. In *Proceedings of CSCW '16*, 1118-1130.

Treem, J. W., & Leonardi, P. M. (2012). 7 social media use in organizations. *Communication Yearbook, 36*, 143.

Using, F. (2011). Using facebook to meet your mission : Results of a survey. Retrieved June, from http://www.idealware.org/facebook_survey

Uzunoğlu, E., & Misci Kip, S. (2013). Building relationships through websites: A content analysis of turkish environmental non-profit organizations' (npo) websites. *Public Relations Review*, 1-3. doi: 10.1016/j.pubrev.2013.06.001

Voida, A. (2011). Shapeshifters in the voluntary sector exploring the human-centered-computing challenges of nonprofit organizations. *Interactions*, 27-31.

Voida, A., Dombrowski, L., Hayes, G. R., & Mazmanian, M. (2014). Shared values / conflicting logics : Working around e - government systems. In *Proceedings of CHI '14*, 3583-3592.

Voida, A., Harmon, E., & Al-ani, B. (2011, 2011). Homebrew databases : Complexities of everyday information management in nonprofit organizations. In *Proceedings of CHI '11*, 915-924. ACM.

Voida, A., Harmon, E., & Al-ani, B. (2012). Bridging between organizations and the public : Volunteer coordinators ' uneasy relationship with social computing. In *Proceedings of CHI '12*, 1967-1976. ACM.

Voida, A., Yao, Z., & Korn, M. (2015). (infra)structures of volunteering. *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing - CSCW '15*, 1704-1716. doi: 10.1145/2675133.2675153

Wang, D., Hou, Y., Luo, L., & Pan, Y. (2016). Answerer engagement in an enterprise social question & answering system. In *Proceedings of IConference 2016 Proceedings*,

Waters, R. D., & Jamal, J. Y. (2011). Tweet, tweet, tweet: A content analysis of nonprofit organizations' twitter updates. *Public Relations Review, 37*(3), 321-324.

Weinstein, M. (2006). Tams analyzer: Anthropology as cultural critique in a digital age. *Social Science Computer Review, 24*(1), 68-77.

Wenger, E. (1999). *Communities of practice: Learning, meaning, and identity*: Cambridge university press.

Wenger, E. (2003). Communities of practice and social learning systems. *Organization, 7*(2), 76-99.

Winschiers-Theophilus, H., Zaman, T., & Yeo, A. (2015). Reducing white elephant ict4d projects: A community-researcher engagement. In *Proceedings of Communities and Technologies '15*, 99-107. ACM.

Yasuoka, M. (2015). Collaboration across professional boundaries–the emergence of interpretation drift and the collective creation of project jargon. *Computer Supported Cooperative Work (CSCW), 24*(4), 253-276.

Yuan, Y. C., Zhao, X., Liao, Q., & Chi, C. (2013). The use of different information and communication technologies to support knowledge sharing in organizations: From email to microblogging. *Journal of the American Society for Information Science and Technology, 64*(8), 1659-1670.

Zhang, H., De Choudhury, M., & Grudin, J. (2014). Creepy but inevitable?: The evolution of social networking. In *Proceedings of CSCW '14*, 368-378. ACM.