

Reflecting the Current Practices of Technology Use in Volunteer Data Collection Activities on the Opportunities of Mobile Technology

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August 2014

CMU-HCII-14-107

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This work was supported by National Science Foundation Grant No. NSF-0008147.

Keywords: Public Participation, Volunteer, Environmental campaign, Data collection, Mobile Technology, Technology Adoption

ABSTRACT

Mobile technology is advancing our ability to connect and share information in ways that were impossible before. It offers great potential for people to participate in volunteer activities for data collection at reduced cost and time. Despite its potentials, the organizations that coordinate volunteer activities often do not fully benefit from the capabilities of advanced mobile technologies. In order to understand how mobile technology might support volunteer data collection activities, this study investigated the current use of technology for volunteer activities, reflecting on the opportunities and challenges it brings. We categorized the organizations that coordinate volunteer activities according to goal, and identified perceived challenges that prevent them from leveraging mobile technology: the credibility of public participation, and interference with the field experience. While not an exhaustive list, we believe that these challenges are critical starting points when strategizing the adoption of mobile technologies in volunteer data collection activities. We conclude by discussing the potential for mobile technology use to promote public participation in data collection activities and to foster public engagement in volunteer activities.

1. Introduction

Volunteering is any activity that involves spending time and effort free of charge to do something that aims to benefit another person, group, or society other than, or in addition to, close relatives (Wilson, 2000). Among a wide range of volunteer activities, this work primarily concentrates on volunteer contribution to data collection because proper use of mobile technology can significantly improve its operation. The availability of so many volunteers allows the collection of a large amount of data that could not be obtained with the use of professionals only. Also, it enables to collect over spatial and temporal scales at reduced cost and time. Mobile technology can facilitate volunteer efforts in data collection because it saves resources, reduces risk associated with traditional modalities (e.g., loss of paper forms in transit), and minimizes errors during data entry and analysis. It also can help volunteer activity coordinators keep in touch with volunteers in the field, and improve the ability to respond to issues in real time.

Despite these potential gains, the actual adoption and usage rate of mobile technologies in volunteer activities has been low. Nonprofit organizations, which often coordinate such volunteer activities, are generally known to be slow in adopting and adapting to emerging technologies (Hackler and Saxton, 2007), and advanced mobile technology in volunteer activities is no different. Currently, the common usage pattern of mobile technology in nonprofits' volunteer activities is limited to leveraging its mobility aspect by using information and communication technologies on the fly (e.g., checking email, making a phone call, and searching the internet in the field). Considering the extensive capabilities of mobile technologies that can enhance the process of data collection efforts, namely location detection, photo taking, media recording, digital note taking, wireless network connection, etc., broader application potentials have yet to be fully explored.

Furthermore, our understanding of mobile technology use in volunteer data collection activities remains weak. Most studies have approached these issues from a technical standpoint, suggesting application ideas to employ available mobile technologies (Kim et al., 2010, Mun, et al., 2009), or providing technical solutions to support adopting mobile features (Hartung et al., 2010, Ramanathan et al., 2012, Kim et al., 2013), rather than developing a more holistic understanding of organizational phenomena with regard to mobile technology use in volunteer activities.

Initially, we planned to study the current practices of mobile technology use in volunteer activities, but did not find any local organization using a mobile application for their activities. Therefore, we investigated the current practices of general technology use in volunteer data collection activities, reflecting on the opportunities and challenges associated with mobile technology. To explore these issues,

we conducted a qualitative investigation of eleven organizations in a US metropolitan city. The findings will help bridge the gap between the underutilization of mobile technology and its potentials in pursuit of the goals of volunteer data collection activities, as well as strategizing the adoption of mobile systems.

In what follows, we first describe the study methods and the organizations that participated in the study. Then, we categorized the organizations that coordinate volunteer activities according to goal, and identified perceived challenges that prevent them from leveraging mobile technology: the credibility of public participation, and interference with the field experience.. We conclude by discussing the key implications of the adoption of mobile technology to support volunteer activities in improving the data collection process and promoting deeper engagement with volunteers.

2. Literature Review

Because most volunteer-driven activities are led by nonprofit organizations, we first review existing literature on the use of information technology in nonprofit sectors in general and social media in particular with respect to the role of such technologies in volunteer activities, and the reasons for the slow adoption of innovative technologies in nonprofits. Then, we review the specific domains that have appropriated mobile technology for public engagement in societal services beyond the scope of nonprofit sectors: participatory sensing and citizen science. The intersection of understanding the use of general information technology in nonprofits and mobile technology for public engagement will help establish insights on mobile technology use in nonprofit activities.

2.1. General Information Technology Use in Nonprofit Organizations

Information technology has proven helpful in increasing work efficiency under resource-constraint environments (e.g., Todd and Jones 2001; Nieto and Fernández 2005). Thus, a large volume of literature in information systems research has investigated the effects of information technology use on nonprofits' work processes. In particular, researchers have shown that information technologies can improve organizational efficiency in an extensive scope of nonprofit applications, including recruiting volunteers (Herr and Anderson 2005), fundraising (Goecks et al. 2008), coordinating events (Voida et al. 2011), enhancing inter-organizational coordination (Stoll et al. 2010), supporting general volunteering (Pereira and Cullen 2009), and improving general management practice (Merkel et al. 2007).

Although most nonprofits make use of modern information technologies to some degree with diverse applications, the adoption of new, advanced technology has been very slow (Idealware 2012). A 2011 survey conducted by the Nonprofit Technology Network reported that the average technology budget was less than 5% of a nonprofit's total budget, and over 50% of small nonprofits are not planning to adopt any technology within a year (ntn 2012). As such, nonprofits have generally lagged behind for-profits in investment in and adoption of advanced technology (Schneider 2003). Researchers have identified diverse reasons for such slow adoption, including financial and technical constraints (Saeed et al. 2011), lack of understanding of the social context into which technologies are deployed (Carroll 2004), organizational cost of creating and preserving the knowledge necessary to make effective use of deployed information technologies (Le Dantec and Edwards 2004), imbalance between those who receive the benefit of new technologies versus those who must do the work of using them (Harrison et al. 2004), and diversity in the organizational structure, scope, application area and working of nonprofits (Saeed et al. 2011). Among those, the significant constraints in financial and technological resources are a fundamental factor that determines the strategies for advanced technology adoption in nonprofits (Merkel 2007, Volda 2011).

Contrary to the extensive studies on information technology use in nonprofits (e.g., (Burt 2003, Waters 2007, McPhail 1998, Volda et al 2011)), there has been very little exploration of mobile technology. Mobile technology is beginning to dominate web functionality, and some nonprofits that have tapped into this trend are seeing the benefits. For example, a research report on mobile technology's impact on fundraising in 2013 revealed that donations made through mobile devices have increased by 205 percent within a year, and that nonprofits who have integrated mobile technology into their fundraising practices have raised 2.95 times more contributions (Artez Interactive). It demonstrates the potentials of mobile technology in enhancing the work process in nonprofits. Soon, mobile technology will become an essential part of how nonprofits engage with volunteers and expand their reach of the public (Westmoreland 2014). However, the actual use rate of mobile technology in nonprofits is still marginal (Kim et al., 2013), and thus nonprofits have a long path to utilize the full potential of mobile technology.

2.2. Social Media Use for Public Engagement

Social media have opened up greater possibilities for improving interpersonal and inter-organizational communication among stakeholders, as they are free of charge and have built-in

interactivity through supporting two-way exchange of information, network creation, and open public dialogue (Lovejoy and Saxton 2012). From an analysis of over 400 tweets sent by 100 nonprofit organizations, Lovejoy and Saxton demonstrated that the effective use of social media strategically engages their stakeholders via dialog and community-building practices compared to traditional websites (2012).

Scholars have identified diverse ways in which social media may empower nonprofits, including forming a sense of community (Jave et al. 2007), fostering and maintaining social capital in community members (Ellison et al., 2007), supporting information-sharing (Hughes and Palen 2009), building and fortifying relationship among members (Briones et al. 2011), and furthering dialog among stakeholders (Rybalko and Seltzer 2010).

Studies into social media use for public engagement have been highly informative in the domain of community crisis management. From a holistic review of social media use in crisis management, Starbird and Palen (2011) asserted that even small technical features in social media could increase individual capacities for collective action. Latonero and Shklovski (2012) found that the affordances of social media allow emergency managers to better communicate, interact with, and respond to the public, and Shklovski et al. (2010) showed that online spaces are vital to connect people with their local communities.

As such, these studies have shown that social media can enhance public engagement in volunteer activities. Combined with mobile technology, social media become even more powerful, as the benefits of social media are available at any place at any time. We will reflect upon these benefits to explore the opportunities of mobile technology to leveraging its full capacity in volunteer data collection activities.

2.3. Mobile Technology Use for Public Engagement

Whereas mobile technology is relatively underutilized in nonprofit contexts, there are specific domains that leverage the power of mobile technology in data collection: participatory sensing and citizen science. They are not nonprofit organizations, but can also be a group of individuals, for-profits, or public sectors that extensively rely on public participation to collect data which makes our focus a subset of these groups. Examining the practices of mobile technology use in these domains can help better project the potential benefits and opportunities.

2.3.1. Participatory Sensing

The basic concept of participatory sensing is to utilize embedded sensors and other hardware features in smartphones to automatically collect in-situ contextual information (Cuff et al. 2008; Willet et al. 2010). In other words, smartphones become distributed sensor nodes to automatically collect a large volume of data. Using sensing-equipped smartphones, it is possible to monitor a wide range of socio-environmental factors, such as urban air quality (Aoki et al. 2009), noise pollution (Lane et al. 2010), real-time prediction of public transportation arrival (Zimmerman et al. 2011), and traffic patterns in metropolitan areas (Hull et al. 2006). An aggregation of such information is used to assess urban living-quality conditions without the deployment of large-scale systems.

The difference between participatory sensing and volunteer data collection activities is that participatory sensing does not necessarily require human actions but often captures a stream of data automatically through mobile technology. Though the processes of data collection are different, both heavily rely on voluntary participation of the public to achieve their goals. Mobile technology use in participatory sensing demonstrates how proper use of the extensive technical capabilities in mobile technology can be facilitated in diverse applications.

2.3.2. Citizen Science

Citizen Science is a way to harness the power of the public to solve real-world problems or to answer scientific questions (Silvertown 2009). Citizen science is different from participatory sensing in that it emphasizes the roles and characteristics of volunteers. Citizen scientists conduct data collection without much specific scientific training in performing or managing tasks, whereas participatory sensing refers to a process of automatic data collection through personal mobile devices (Estrin 2010).

Citizen science leverages the diffusion of personal mobile technology and its technical capabilities to lower the threshold for the public's systemized participation. Because citizen science relies on the efforts of non-experts for systematic data collection and analysis, the ease of use of the tools often determines its success. Smartphones equipped with embedded sensors may support such activities without an additional device, which improves the quality of the data collected. Several ongoing citizen science projects have adopted mobile applications to facilitate citizen science, such as eBird, Great Sunflower, and Creek Watch (Sullivan et al. 2009; Prestopnik and Crowston 2012; Kim et al. 2011).

While mobile applications can be a powerful tool to promote public engagement in citizen science, there are also limitations and hidden costs (Wiggins et al. 2011). These include poor usability when inappropriately designed, and lack of proper functionality that target users – citizen scientists – seek. These limitations have to be carefully considered when exploring mobile technology in volunteer data collection activities.

2.4. Summary

In this section we reviewed the extensive literature on general information technology and social media use, as well as two specific domains that use mobile solutions for public participation, participatory sensing and citizen science. As such, a large volume of work has been conducted to understand technology use in nonprofit contexts, hinting at the opportunities and challenges of mobile technology use in volunteer activities. We believe that our work can expand the scope of existing knowledge related to the relationship between technology use and volunteer activities from general information technology to mobile technology.

3. Theoretical Framework: Activity Theory

Activity Theory is a framework used to analyze social and cultural issues, because it provides a language to describe what people do in context as a holistic approach for the study of organizations (Hashim & Johns, 2007). Activity Theory is particularly useful for the study of organizational work, since the collective nature of activities by multiple stakeholders in context should be represented in the system's development process. We use Activity Theory as a lens to explore the organizational context where members in an organization manage their activities. Also, Activity Theory will guide the structure of a survey and an interview that we conducted in this study.

3.1. Basic Principles

Activity Theory is formed by a set of principles that constitutes a general conceptual system (Kaptelinin, 1997, Nardi, 1996). The basic principles are as follows:

The unit between activity and consciousness: Activity and consciousness are treated in an integrated way. Consciousness means the human mind as a whole, and activity means the human interaction with its objective reality. This principle states that the human mind emerges and exists as a special component of the human interaction with its environment. The mind is a

special organ that appears in the evolution process to help organisms to survive. Thus, it can be analyzed and understood only within the human activity context.

Object-orientedness: This principle focuses on the environment-centric approach. People live in an environment that consists of objective features that influence the ways people interact with those objects.

Internalization/externalization: This principle describes the basic mechanisms about the source of mental processes. Mental processes are derived from external actions through internalization. Internalization is the information absorption process of the human mind, which derives from the environment. Externalization is the inverse process.

Mediation: Human activity is mediated by tools, both external (or material) and internal (or immaterial). Tools are created and transformed during the development of the activity itself and carry with them in a particular context. Tool use influences external behaviors and also the mental functioning of individuals.

3.2. Elements in Activity Theory

The framework starts from the elements of a mediated action by an individual (the subject), the object of the action, the instruments or means (tools, both mental and physical) needed for the action, as well as the goal (Vygotsky, 1978), all taking place within a work process.

Subject (member): The subject is part of an activity, doing his/her work and focusing on a shared goal, based on the motive of an activity. In practice it requires several actions by several members to produce any useful service or product.

Tool: Subjects work on their objects using specific tools (e.g., facilities, artifacts and also mental skills, knowledge). There is a need for information about how to use the tools, and it is important to consider where subjects get the information needed in the work process, how they use that information, and where they record or save new information. There are many kinds of information, e.g., formal information and tacit information, as well as professional skills.

Object: An object is the target of actions as part of the shared goal, and subjects should recognize the object of the work. The first experiences of the object are based on external features, which are transformed into deeper knowledge of the object as the work process continues. In the work process the subject (or collective subjects) and the object are in interaction, mediated by the tool.

Work process: The work process is a transformation towards an outcome. The object is where the subjects aim to contribute, to create a transformation process to achieve an intended outcome. The primary focus is on work processes by professionals within an activity, the information flows, and information management. It is crucial to create a collective understanding among subjects about how they are working, what kind of tasks are being carried out, what information tools are used and how, who are the other actors involved, and so on. A subject has a goal, tools, colleagues, and rules when s/he is working on the goal and transforms it into the intended outcome.

4. Methods

We conducted a series of studies to investigate the current practices of technology use in volunteer activities. To gather data on organizations, our first step was to determine which organization to recruit for an interview. To obtain the initial pool of local organizations for interview recruitment, we ran a survey asking questions about the structure of an organization and its technology use in volunteer activities. Among the initial pool and on/offline repositories of volunteer activities, we recruited eleven organizations to conduct in-depth interviews. This section describes the procedure and the participating organizations of each study.

4.1. Survey

We sent out survey invitation emails to over 900 organizations listed in a directory of local nonprofit organizations¹. Because the directory only listed the names of organizations, we searched their websites to retrieve email addresses, and sent invitations to those addresses.

4.1.1. Recruitment

The target of recruitment was organizations that collect data from volunteer activities. However, the organizations listed in the directory included charities, educational, and research associations that do not involve volunteers, as well as organizations that rely on volunteers to collect data, but were not categorized. Thus, we were not able to filter out in advance the organizations that were out of the scope. Instead, we described the scope of the study and asked for those who were eligible to answer the survey: we said “Please answer our survey if your organization coordinates a volunteer activity of any kind and collects data from volunteers”.

¹ <http://pittsburghgives.org/>

4.1.2. Survey Questions

Based on the four elements in Action Theory, we set up a framework of four categories to structure survey questions. The four categories and example questions are as follows:

- Subject: Organization and its members
 - Goal and mission
 - Structure (the number of staff)
- Object: Data collection
 - Data to collect from volunteers
 - Process to collect data from volunteers
- Work process: Volunteer activities
 - Size and frequency of a volunteer activity
 - Role of volunteers in the activity
- Tool: Technology used to work with volunteers
 - Technology/tool used in volunteer activities
 - Social media used in volunteer activities

Most questions in the Tool category allowed selecting more than one answer.

4.1.3. Participating Organizations

We kept the survey live for two weeks, and received 46 responses in total. We assume that the number of responses was low because an email address on their websites might be poorly maintained or outdated in some organizations. Other organizations might be either too busy to respond to the survey or deemed themselves beyond the scope of this study, such as not collecting data from volunteers or not running volunteer activities at the time.

4.2. In-Person Interviews

4.2.1. Recruitment

Often, at the center of the underutilization of mobile technology lie resource-constrained environments (Hackler & Saxton 2007). Generally, small organizations hold limited resource capacities while having greater needs for effective capitalization of available resources. Thus, hypothesizing that the gap between the opportunities and challenges in mobile technology adoption would be wider in smaller organizations than larger, our primary criteria for the recruitment were small organizations (around ten staff members or under) that collect data from volunteer activities.

In addition to conducting a survey, we spoke with some local organizations contacted in prior research, and asked them to introduce other organizations that might be relevant to the study,

following the snowball method of recruitment. Lastly, we looked up on/offline repositories where organizations post their activities and advertise volunteer recruitment, such as local newspapers, community bulletin boards, meetup.com, websites, and mailing lists. From all these and survey respondents, we made an initial list of over thirty local organizations that fulfilled our recruitment criteria, and then contacted each of them. Among them, ten groups were filtered out because they did not have any active volunteer activities at the time of recruitment, and ten other groups did not show interest in participating in the study. As a result, we recruited eleven organizations (See table 1).

Table 1. A list of participated organizations

Type	Site ID	Description of site's programs	The title of the interviewed staff	The number of staff	The number of volunteers
Environmental Activism	EA1-birds	Bird counting	Leader*	7	1,000
	EA2-birds	Bird counting	Leader*	5	1,500
	EA3-dumping	Cleaning up illegal dumping	Executive director	3	2,000
	EA4-water	Water quality monitoring	Outreach manager	6	300
	EA5-water	Water quality monitoring	Watershed protection manager	7	500
Community Mobilization	CM1-reuse	Waste reclaiming	Executive director	5	200
	CM2-dev	Community development	Executive director	9	500
	CM3-bike	Bike-safe community building	Advocacy director	7	3,000
	CM4-dev	Community development	Executive director	11	300
	CM5-shale	Protest against Fracking	Executive director	4	2,000
	CM6-food	Eliminating hunger in a community	IT director	87 (12)**	14,000

* Two organizations do not have an executive director, but have a leader representing the organization.

** Among 87 staff, only 12 staff worked for the general administrative tasks, and the rest 75 staff worked for warehouse management in food distribution.

4.2.2. Participating Organizations

The eleven organizations fell under one of two thematic areas based on their goal: (1) environmental activism and (2) community mobilization. We did not initially set out to recruit organizations based on these two types, but rather the types emerged organically through our analysis process. While these two categories do not cover the more broad domain of volunteer-driven organizations, they are representative of popular community groups within this space..

In fact, all recruited organizations were not exclusive to a single type, and often did work in both types. For example, the waterfront cleanup group focused not only on keeping water habitats healthy (environmental activism) but also contributed towards a livable community (community movement). We grouped the organizations by their primary goals. Therefore, we believe it to be a legitimate starting point to explore ways to make use of mobile technologies in volunteer activities.

The number of full-time staff in the organizations ranged from three to eleven with an average of 6.4. One exception was a group with eighty-seven staff members. This group was much larger because it operates a warehouse to stock and distribute food, and seventy-five staff members work in food distribution. Only twelve members do general work to operate volunteer activities that nonprofit organizations commonly do, which is similar to the size of other groups. All organizations handled a large volume of volunteers, especially in relation to the number of paid staff. Six organizations had thousands of registered volunteers, with active participation numbering in the hundreds. And, seven organizations had hundreds of registered volunteers, with active volunteers varying from tens to hundreds depending on the kind of activity.

To protect anonymity, we refer to each organization with the type acronym and a randomized number (e.g., EA1-birds for environmental activism group 1 for bird counting, CM2-dev for community mobilization group 2).

4.2.2.1. Environmental Activism Organizations

Environmental activism organizations aim to protect wilderness, monitor environmental conditions, and promote eco-friendly activities. We recruited five such organizations.

- EA1-birds organizes bird watching field trips and conservation-related activities. Also, they connect people in southwestern Pennsylvania to birds and nature through their programs. This organization has seven staff.
- EA2-birds organizes local outings and gatherings in the metropolitan area. Through these outings, they aim to educate people on nature and birds, engage people in conservation and data collection for birds, and socialize among members. They have five staff.
- EA3-dumping's goal is to create healthy community, healthy neighborhoods, and healthy green space. They pursue their goal by cleaning and monitoring abandoned dumpsites. This organization has three full-time staff.
- EA4-water provides a sustainable environment for its residents and businesses, and preserves clean and healthy natural habitats in the area. They work to improve water

quality in areas such as wastewater treatment, the sale of drinking water, and recycled water. This organization has six full-time staff.

- EA5-water protects drinking water source and watershed. They also do dangerous species act compliances and related regulatory compliances as part of drinking water management programs, and manage compliance with state and federal regulations. They have seven full-time staff.

4.2.2.2. Community Mobilization Organizations

The ultimate goal of community mobilization organizations is to improve the quality of living in the community. These organizations strive to improve or protect various aspects of the community. We recruited six such organizations.

- CM1-reuse promotes resource conservation, creativity, and community engagement through material reuse. They pursue their goal in two primary ways: operating a store where people can obtain reclaimed materials for creative projects, and hands-on educational outreach on creativity and sustainability. The ultimate goal is to contribute to general quality of life in the community through reclaiming materials. They have five full-time staff.
- CM2-dev aims to improve the quality of life in high-poverty areas in their city. They work to eliminate blighted conditions in the community, addressing educational deficits, and bringing social stability to the area. They have nine full-time staff and about a dozen part-time staff.
- CM3-bike makes the streets safer for biking and walking in the city. Their work falls under three categories: advocacy, safety and community. For advocacy, they work to make the environment better for cycling. For safety, they produce a bike map to help people find the safest bike routes. For community, they build up the community so that people get together to go biking. They have seven full-time staff members.
- CM4-dev is a group that enhances quality of life by determining the effective and efficient use of its natural systems, infrastructure, cultural assets, recreational amenities, and economic resources. They work for preservation of cultural heritage, parks, the urban design, the infrastructure, and land uses in the city. There are eleven full-time staff members working for this organization.
- CM5-shale is a coalition that aims to end Fracking and drilling for natural gas from shale. They grew out of a one-time demonstration in 2010 to an organization with a permanent structure. Since then, they have become an umbrella organization for smaller grassroots groups in different neighborhoods. This group does not have any paid staff but have four voluntary staff members.
- CM6-food collects and distributes food. They gather food through solicitation, fund raising, special events, and community partnerships. They distribute millions of pounds of food per year through various outlets, such as soup kitchens, food pantries, shelters, after school programs, drop-in centers, neighborhood food assistance agencies,

emergency or disaster-related feeding sites, community centers, and special programs. There are eighty-seven full-time staff members. Twelve among them are involved in general administrative tasks whereas the rest works for operating warehouse for collecting and distributing food.

4.2.3. Data Collection and Analysis

We conducted semi-structured interviews to understand the current practices of technology use in the organizations without limiting the freedom of direction of the conversation (Herr and Anderson 2005). We visited the office of an organization when available. If they did not have any physical office spaces, we either invited them to our laboratory or met them at a place of their convenience.

Based on the four elements in Action Theory, we set up a framework of four primary themes to lead the interview. The structure was similar to those for the survey, but details in each interview varied in order to allow the researcher to bring up new ideas during the interview based on what the interviewee said. The four themes included:

- Subject: Organization and its members
 - Goal and mission
 - Structure (the number of staff)
- Object: Data collection
 - Data to collect from volunteers
 - Process to collect data from volunteers
 - Challenges in data collection
- Work process: Volunteer activities
 - Size and frequency of a volunteer activity
 - Role of volunteers in the activity
- Tool: Technology used to work with volunteers
 - Currently used tools – Technology, mobile, social media
 - Possible mobile technology use
 - Challenges in the current tool use

One staff representing the organization (i.e., executive director, leader or manager) participated in the interview. In the analysis, we refer to them as “staff”. Each interview lasted between one to two and a half hours. All interviews were audio recorded.

We transcribed the interviews, and then coded them using inductive and deductive approaches informed by grounded theory and other qualitative analysis methods (Strauss and Corbin 1990; Miles and Huberman 1994). In the analysis, we identified the four themes and the relationships among those, particularly focusing on the interview data that related in some way to how organizations made use of technology in their volunteer activities, and how they coordinated the

activities more broadly. Using inductive qualitative methods, we iteratively developed a coding scheme related to technology use in volunteer activities. Our initial set of codes typically related either to specific kinds of challenges or to rationales for using particular technical tools. Subsequent iterations of the coding scheme helped to link the type of organizations and the kinds of challenges in coordinating volunteer activities. Our final iteration of the coding scheme helped us focus on the challenges and opportunities in mobile technology use for volunteer data collection activities.

5. Findings: Survey

5.1. Subject and Object

The categories of the organizations that participated varied widely. Some examples of responses include those from organizations focused on animal protection, conservation, education, gardening, healthcare, human services, science, welfare, etc.

One immediate interesting finding was that among the organizations that responded, 77% were run by 10 or fewer staff members. In addition only 23% had staff members with skills and capabilities required for basic web programming and database management, while all organizations were extensively using basic IT applications, such as email, spreadsheets, and searching websites.

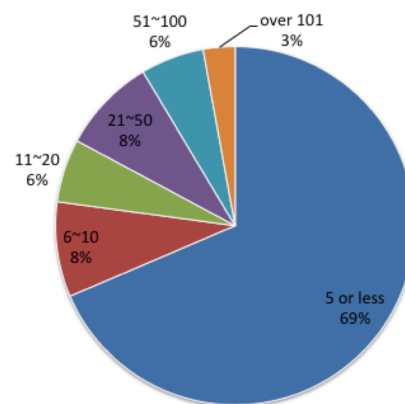


Figure 1. The number of staff in organizations

5.2. Work Process

All organizations sought volunteer efforts in a wide variety of tasks, from fundraising to building their extended community. The predominant channels through which volunteers made contact with an organization were through email, in person, web submissions, and phone calls (See Table 2). Interestingly, 92% of organizations communicated with their volunteers face to face. This might be possible because they are community-based organizations addressing local needs in a neighborhood or city scale.

Table 2. The types of volunteer activities and media used for public engagement (multiple selects)

Type of volunteer activities	%	Media through which an organization communicates with volunteers	%
Fundraising	78%	Email	97%
General office services	73%	In person	92%
General labor	62%	Phone call	79%
Tutor or teaching	41%	Social media	58%
Reporting incidents	24%	Direct mail	37%
Environmental project & research	22%	Other	7%
Building community	19%		

5.3. Tools

Even though a large proportion of the organizations – 40% – mentioned that they were using mobile devices of some sorts for their field activities, the specific use cases were exclusively sending emails and phone calls for communication on the fly (See Chart 5.1). We asked the media that volunteers use to submit data to understand the current trend of volunteer data submission. Among the unsurprising result of conventional communication media being a dominant tool for data submission, a fairly high ratio of in-person submission – 58% – is noticeable (See Chart 5.2). Additional comments explained that in-person data submissions happen during an activity in the field when volunteers hand over their observation records to the coordinating organizer on site. The formats of data that volunteers collect were fairly evenly distributed between descriptive and numeric with a slight skew to descriptive data: 66% vs. 50%. Besides, location information and pictures often come with those data as auxiliary information. Lastly, all organizations said that they wanted to incorporate mobile technologies somehow in their volunteer activities, but none of them clearly described ideas of how to.

5.4. Summary

In all, the findings from the survey resonate that the patterns of how the organizations facilitate technologies in support of volunteer activities have one trend in common: extensively relying on conventional communicating technologies, such as email, phone call, and social media. While mobile technology was mentioned to use in volunteer activities, the extent to which they leverage its capabilities was limited to the mobility aspect of conventional communicating technologies, such as using email, phone call and social media on the go through mobile devices. While strong interests in making use of mobile technologies exist, the concrete ideas of

leveraging mobile technologies further in depth through building custom mobile applications were yet to explore. These findings were used to list up candidate organizations to recruit for in-depth qualitative investigations.

6. Results: Interview

Action Theory guided to determine and investigate elements that are associated with understanding the technology use practices in volunteer data collection activities. The results will be presented primarily around the Tool theme and its relation to other factors.

We first examined the practices of technology use in the organizations in general, and then explored its differences by the type of the organization. Lastly, we identified the challenges that the organizations face with regard to mobile technology adoption in volunteer activities.

6.1. Technology Use in General

Not surprisingly, all organizations were extensively using information technologies and social media, as well as conventional technologies, like landline phone, fax, and pen-and-paper, in combination to coordinate volunteer data collection activities.

First, conventional technologies, such as landline phone, fax, and pen-and-paper, are still widely used by all organizations. Even though those are easy to use at hand, however, the temporal distance between manual data capture and digital sharing poses an issue when used for data collection

Volunteers often do not report their findings back promptly, and may forget to do so afterwards. That is why some program coordinators have to remind volunteers to report through another set of conventional technologies.

*“Our program coordinator calls [volunteers]. Or, they might call or email her without being prompted. But it’s usually the other way around because they forget [to report] and because it’s not their top priority. For now, it’s manageable to call, because it is small, around twenty [volunteers]. But it’s going to grow pretty quickly. And if it gets larger, then that will become really cumbersome to call everyone and to email everyone”
(EA3-dumping)*

In particular, a pen-and-paper mechanism has two significant drawbacks despite its merits of being easy and simple to use; data retrieval is hard (e.g., finding information from a written

document), and data need to be digitized manually (e.g., entering data on a paper into a spreadsheet). Both processes are time consuming and prone to human error.

“Because it uses staff time [to type hand-written data into a database], sometimes the orders are wrong, sometimes they [staff] don't get the date they want quickly [from paper]. So we want to move... drive it to be online. Everything online.” (CM6-food)

“It is a paper report. It goes into a file. Then when we need to find any information for data, it is next to impossible to get any information.” (CM1-reuse)

A website is widely used to distribute information to a wider audience affordably and effectively. All organizations were operating their own homepage as an online repository to post retrievable data and to share information. However, a website is a passive platform, as people must be prompted somehow to access the website. Thus, when information should be viewed immediately, such as recruiting volunteers for upcoming events, email and social media are often used in combination as a trigger for target populations to access the information faster.

“..., putting information [on our homepage] coupled with our social media, which are primarily through Facebook and Twitter, were how we were sending updates and letting people know what's going on.” (CM2-dev)

Also, social media provide a virtual space where people communicate each other and exchange information, and that is why all organizations used social media.

“We want to increase the sense of belonging in our organization, being part of the communities of people who are interested in doing similar things.” (CM1-reuse)

Eight organizations said that they used social media to post news and information about upcoming activities, as well as to communicate with volunteers. Then, a major shortfall of social media lies in a divide between communication dialog content on social media and the internal database of an organization. Even though social media are a powerful tool for communication, all such communicative data is stored on the third-party's database (e.g., Facebook server), making it difficult to have full manipulation of the data. Three organizations were seeking ways to measure the impact of social media on offline activities. However, without a technical intervention or manual, time-consuming data scraping, it is difficult to determine its effects. Thus, all organizations are using social media without any follow-up investigation of its influence.

6.2. Technology Use by the Type of Organizations

A difference in the format of collected data has emerged by the type of organizations; environmental activism organizations were mainly collecting objective measurements or observation data from field observation activities (e.g., monitoring water quality), while community mobilization organizations were mainly seeking public opinion and feedback about the issues of their interest or concern (e.g., feedback about new community facilities). We found that this difference led to a significant distinction in technology use.

6.2.1. Environmental Activism Organizations: Objective, Measurements Data

Environmental activism organizations primarily seek objective, factual, standardized, and sometimes, numeric data about the condition of community environments. The data to collect is predefined by particular protocols or requirements, and volunteers are required to follow set rules when collecting data. Therefore, accuracy was regarded as a barometer of data quality.

“[The collected data] has a chain of custody requirements to follow. So, you have to have hard copy data formats in the field when you are collecting data.” (EA4-water)

Volunteers who monitor or observe the current environmental conditions gather this type of data. The prevalent practice of collecting environmental observation data involves a combination of pen-and-paper for manual data capture and information technology for digital sharing: people write down their observations out in the field, and then send an email of their findings to a program coordinator.

“[Volunteers] write down data and email it to me later.” (EA4-water)

6.2.2. Community Mobilization Organizations: Opinion and Feedback

Conversely, community mobilization organizations usually collect subjective information from their community members about community conditions and neighborhood issues, such as public opinion, feedback, thoughts, reports, and suggestions.

“We want to understand what projects people thought of as priorities, if there were projects people had a problem, concern, or issue with, or if there were certain things that they had comments on” (CMI-reuse)

Local knowledge and community-based information are critical for the organizations to collect from the public, because community members are (often the only) stakeholders who possess or have easy access to such data. This information helps shape a focus of volunteer activities, such

as determining the community living conditions or the problems community members should become aware of.

“We gather data on the conditions in the community. We have a night for the residents of the community to come together... to gather living condition of our community and try to put a plan together that embodies that input.” (CM4-dev)

The complicating matter about collecting subjective information is that it is legitimized when the information is accompanied with specific descriptive data, such as the locality of respondents or demographics. For example, the respondents’ locality helps figure out a geographic region of issue or concern, and demographic breakdown determines community needs by population. To reduce participation cost and promote public engagement, many organizations use free-form communication technologies, such as email and online bulletin board. One issue with these tools is that it is hard to constrain to include specific descriptive data. Thus, most community mobilization organizations have sought ways to require specific descriptive data as part of their submission.

“Location is important. It is good to know if there is a certain parking garage that's getting hit a lot, for example.” (CM3-bike)

“We are looking for more specific data about who the hungry people are, and what legislative districts they are in. If the data has a marked GIS software, we can actually map the data, and if we can get census data, we can map the poverty areas in all counties.” (CM6-food)

While a single content is valuable, data become much more meaningful and representative when the quantity becomes large enough to render a trend. Therefore, the frequency or volume of data submission is considered crucial in community mobilization organizations, and regarded as a barometer of data quality.

“Even if you don't take all suggestions, if you look at a road and if there is, like, a hundred suggestions on this road and only five over there, you know that there are a lot of people using this, and we want to try to make this road better first, not that road.” (CM3-bike)

6.3. Current Use of Mobile Technology

All staff members mentioned that mobile technologies, and smartphones in particular, might be an additional yet effective channel through which the public could easily engage in their activities. The fact that people carry their smartphones everywhere was counted as the significant advantage of mobile devices.

“The thing about being out on a bike is that... when you come into some sort of issue, if you have a mobile device, you can think about it right there and you can report it right there.” (CM3-bike)

However, the actual use of mobile technology was marginal. Among those who participated, only one organization was using mobile technology for their field observation activities. They used an off-the-shelf mobile application for monitoring water quality, designed particularly for monitoring streams and creeks, in which water flow is an important measure. However, this organization primarily monitors lakes, which do not have a flow property. Thus, they wanted to tailor this app, either by changing the label of “flow” field to something else or getting rid of the data entry for “flow” entirely. However, because it is an off-the-self app, they could not make any changes on the app.

“[The water quality monitoring app] has a rating option for flow of the water. The lake [we monitor] is always still, but the app] infers that you are looking at a stream that's not flowing.” (EA4-water)

The rest organizations were merely using conventional communicating technologies on the go through mobile technology. All organizations mentioned sending and receiving emails or using social media in the field to communicate with volunteers real-time as how they were using mobile technologies (Briones et al., 2011, Liu et al., 2010). With them, we conducted an additional session in which participants freely discussed potential use cases and ideas of mobile technology adoption. In the beginning, the conversation was not active in all organizations, because none had ideas of how to facilitate mobile technologies at hand. All said that they had barely thought about using mobile technologies in depth. All organizations are run by a small number of staff members, and all staff members are in charge of more than one task. Therefore, because their resource capacity is already fully loaded, it was hard to allocate time to exploring new ideas of facilitating mobile technology over funded projects or other planned activities. As such, lack of technical expertise and resources prevented the organizations even from exploring the capabilities and potentials of mobile technologies.

“We haven't thought much [of using mobile apps]. The [staff is] overworking right now. We will make it too hard for them to think of something new.” (CM6-food)

“Unless it's related to funding... [It is hard to spend time on it]” (EA3-dumping)

Then, once one idea came up in the middle of discussion, the conversation gradually became active, associating other ideas with diverse functionalities for varying objectives. Following are some example ideas.

“Something like... that people could hold the phone over the paper and then information would come up on the phone screen. If you hover over a section on a map, the device would tell you more about the section.” (CM3-bike)

“If there was some way of including some kind of recycling or reuse data collection on something that you created, so that you can tell yourself like ‘I recycled 20 pounds this month’ or something. That would help us a lot with quantifying activities both creativity-wise and recycling-wise.” (CM1-reuse)

At the end of the session, all staff members commented that they enjoyed the brainstorming sessions and it helped refresh and broaden their views on their activities with regard to mobile technologies.

6.4. Challenges in the Adoption of Mobile Technology

As expected, all organizations mentioned resource constraints as a major barrier to the adoption of mobile technology. All organizations worried about lack of technical expertise and resources even before exploring the feasibility and benefits of mobile technology. All staff members commented that the technical threshold was too high to overcome, and they struggled with resource deficits.

“We really don't have the expertise to build that app and to test that app and to make sure that it feeds into our existing system. I would say probably that's the biggest reason.”(CM2-dev)

“We just don't have the staff or budget to do that (build a mobile app).” (CM1-reuse)

Beyond resource deficiency, we identified two perceived challenges in the adoption of mobile technology for volunteer data collection activities: *questioning the credibility of public participation* and *mobile interaction interfering with field experience*. Compared to various reasons that prior works have determined in the slow adoption of IT in nonprofit organizations, including individual differences, organizational factors, IT capacities, training, performance measurement, and contextual influences (Jelinek, 2006; Hackler & Saxton, 2007; Zorn, 2011) we found fewer challenges with regard to mobile technology adoption. Also, we did not find that the challenges in IT adoption would apply to mobile technology either. We assume that it is not because those challenges do not exist when adopting mobile technology but because mobile

technology has yet to be fully explored until other challenges emerge beyond the perceived challenges posed by staff members.

6.4.1. Questioning the Credibility of Public Participation

Prior works have proved that the quality of novice-collected data is as valid and credible as professional-collected data (Cohn, 2008; Raddick et al., 2010). However, we found that strong distrust regarding the credibility of novice-collected measurements data still exists. This tendency was particularly conspicuous among environment movement organizations that collect measurements data.

The mobility of mobile technology enables anytime, anywhere computing (Davis, 2002). Therefore, when successfully adopted, mobile technology used in data collection activities would result in the increased volume of collected data contributed by autonomous participation. However, the large volume of data may not be considered favorable at all times, because autonomous participation of novice volunteers, especially in the absence of a direct guidance or hands-on instruction, implies lacking the quality of data. One staff member clearly expressed how much he mistrusted the quality of novice-collected data:

“I wouldn't even bother looking at that data if I know that volunteers collected the information.” (EA5-water)

Thus, environmental movement organizations considered most volunteer data collection activities as educational outreach to increase public awareness, change behaviors, and engage the public in protecting the environment, rather than collecting data.

“I see those events mostly as educational events rather than monitoring events. To date, that has been the origin of most of our volunteer monitoring.” (EA5-water)

And, as part of education, they wanted to have a mobile tool to support data capture to sharing in the field. Its main purpose was to provide a quasi-real experience to volunteers in order to increase a sense of achievement and to train novice volunteers for “real” data collection activities.

“It would be nice to show the volunteers that ‘look we are putting your data in to an international database. Your data don't go to a pile of paper on my desk but goes here.’” (EA5-water)

When volunteers participate in the activities for a considerable amount of time, a staff regards them as trusted member with appropriate skills eligible for actual data collection.

“Some of the volunteers became skilled. If they would like to get involved in the bigger stuff, then those volunteers often become dump busters (experts in dump site cleaning).” (EA3-dumping)

6.4.2. Mobile Interaction Interfering with Field Experience

Being able to report on the go has been taken for granted to improve the field experience and enhance the efficiency of the work process in public participation (Newman, 2012). However, we found that interacting with mobile technologies in the middle of work process may cause harm as well as good. People engage in community activities not only to contribute to civic improvement, but also to experience and learn about the issues of concern or interest. One staff volunteer (a staff in the organizations who volunteers too) expressed her negative feelings from past experiences about interacting with mobile devices in the woods:

“Birds are not going to stay dormant. You watch it and take notes on it, and that bird is already leaving. Also, I find it distracting to use my cellphone in the field because then I read emails, and I send text messages. So, I prefer not to actually do any logging in the field on my phone.” (EA1-birds)

When people want to enjoy the moment as part of engaging in the activity, they feel that interacting with technology in the field distracted or interfered with their experience. It indicates that not only is it critical to enhance the efficiency of the data collection process technologically, but also the additional interaction posed by technology adoption should be seamlessly integrated into the existing process.

6.5. Summary: In Person Interviews

In this section, we reported our findings of how local organizations make use of different classes of technologies to facilitate public engagement in their data collection activities. We observed that the ease and simplicity of use directly influence the wide adoption of the tools, and various tools are used in combination to supplement respective shortcomings. However, the currently used tools have several limitations that mobile technology may overcome, although its capabilities and opportunities have been hardly explored. Lastly, we identified the perceived challenges from leveraging mobile technology in the organizations: questioning the credibility of public participation and mobile interaction interfering with field experience. These must not be an exhaustive list, and more challenges might emerge as the adoption and actual use of mobile technologies increase. However, we believe that those are a critical starting point to

consider, since those perceived challenges constitute the initial obstacles to overcome for the first step towards the adoption of mobile technology.

7. Discussion

Based on our findings, this section discusses ways to leverage mobile technology for volunteer data collection activities, focusing on its capabilities to cope with the impediments lingering in the current practices of technology use. We draw from the results across all three studies, online sites, community surveys, and in person interviews.

7.1. Enhancing the Process of Data Collection

The first and foremost goal of public participation in data collection activities is of course to collect data. The appropriate use of mobile technologies through a combination of its wide adoption rate and the extensive technical capabilities can significantly enhance the process of data collection technically through the following three ways.

7.1.1. Increasing the Quality of Volunteer Collected Data

Oftentimes, volunteer-collected data cannot be used until its quality is validated somehow, and thus it is important to have systematic ways to assure or validate the quality of volunteer-collected data (Newman, 2012). We found that the type of organizations determines the barometer to measure the quality of data – data accuracy in environmental activism organizations, and large volume of data in community mobilization organizations.

The appropriate use of mobile technology can inherently improve the quality of collected data, satisfying both kinds of quality barometers. Data accuracy will be enhanced by the proper use of extensive technical capabilities of mobile technologies: a cluster of built-in sensors embedded in modern smartphones will turn into personal monitoring equipment for accurate measurements, a pre-defined set of questions to answer in a mobile application will become a reference to collecting data accurately without external guidance, and a simple mobile user interface with large buttons will reduce human errors in data entry. A large volume of data can take place because the high adoption rate of mobile technologies increases the chances for the public to participate in volunteer activities digitally at anytime anywhere.

7.1.2. Bridging the Temporal Distance Between Data Capture and Share

Currently, the prevalent tools used for data collection are a combination of pen-and-paper and email. While easy and simple to use, those tools inevitably accompany with an issue regarding a temporal distance between the time to capture data using pen-and-paper in the field, and the time to share it using email at home, which causes delay or omitting to share the collected data. A Wi-Fi-enabled mobile application can easily bridge this temporal distance by enabling to share the data on site right after capturing it.

One concern is that interacting with technology in the field may interfere with the existing practices of an activity. Especially when an activity involves aspects to appreciate the moment of participation as is, such as an environmental observation or community gathering, having to use technology could be bothersome and incongruous. Thus, it is critical to ensure that the additional step of interacting with mobile technology must be interwoven seamlessly into the current work process of an activity.

7.1.3. Making it Easy to Manage Data

As the amount of the collected data increases, the question of how to effectively manage the large volume of data emerges. Because the intent of involving volunteers in data collection activities is often to collect more data than the amount that a single person could collect, handling a large volume of data should be taken into consideration.

In volunteer activities, an email is used most often to turn in data, and a phone call and hand-written notes are also widely used. Consequently, it requires a substantial amount of time and effort to digitize analog data, to organize the collected data, and to store the data on a database server. A mobile application that allows digital data submission would significantly reduce the efforts for data management, as the data will be organized and stored in a digital format automatically.

In addition, it is important to consider effective ways to make use of the collected data, since the collected data would have no values until used properly. Therefore, a systemized management tool for data storage, control, analysis, and visualization needs to take into account, to operate digital volunteer activities successfully.

7.2. Promoting Deeper Engagement with Volunteers

Another critical goal of volunteer activities is to educate the public, raise their awareness, and promote community engagement in the issues of concerns. Mobile technology could be a

platform to make the experience more engaging, and to foster a sense of community among participants.

7.2.1. Making the Experience Tangible

Engaging actively in hands-on activities can increase knowledge acquisition and general cognitive development, as well as promoting a sense of achievement. Because of the concern about the quality of novice-collected data, many volunteer data collection activities intend for increasing public awareness and involvement in the activities, rather than collecting data itself (Mueller, 2012). Since one's mobile device could be used as a personal tool to manipulate the entire process of data capture and share, using mobile technology can make the experience of participation tangible. And, providing tangible experiences will help increase the public to engage more in activities by making the field experience fun and persuasive.

Through active engagement in hands-on activities, novice participants often naturally turn to trained volunteers who are eligible to conduct more sophisticated, actual data collection activities. Thus, not only does making the volunteer experience tangible improves the activity more vibrant and engaging, but also it becomes a chance to develop expertise to participate in sophisticated data collection activities.

7.2.2. Improving a Sense of Community

Because volunteering normally does not provide direct personal benefits, many volunteer-driven organizations have tried to formulate indirect benefits for volunteer participation. Fostering a sense of community is one form of indirect benefits that many volunteer activities provide (Nov et al., 2011). Furthermore, attachment to other members in a group can increase commitment to the group as a whole (Sassenberg, 2002). As this attachment can be raised easily through communication exchanges among members in a group, social media are frequently used to promote community members to share experiences for community engagement.

While social media are an effective tool to improve a sense of community, it also has a drawback: it is not easy for the organization to obtain the data generated through social media, such as communication dialog and shared media, unless time-consuming, manual data scraping. This is why many organizations were looking for customized, in-house systems to serve the similar needs as of social media, while having the full managerial capabilities in data manipulation. Custom mobile applications to support data collection activities could easily

facilitate simple features for sharing auxiliary information about the collected data. The increased sense of community will ultimately have a positive influence on offline participation to promote public commitment to field activities.

7.3. Considerations

Currently, information technologies are the prevalently used media for electronic data submission, and our discussion proposes that a proper use of mobile technology will fulfill the needs and challenges that those tools pose. However, the technical threshold to freely make use of the capabilities of mobile technologies is in fact very high. It requires technical expertise and skills to create custom mobile applications, and the organizations often lack it. Therefore, it is important to lower the technical threshold in creating mobile data collection tools in resource-constraint environments. Several providers have emerged in the last several years to serve the non-profit market with off-the-shelf solutions for a variety of mobile needs (e.g., Aanensen et al., 2009; Hartung et al., 2010; Ramanathan et al., 2012). Another caveat is that mobile technology is still a supplementary tool to support activities, not an almighty magic wand to solve all problems. Therefore, a thorough understanding of the context in which mobile tools will reside in and a strategic approach to the goal that such tool use will pursue should precede the adoption of mobile technology.

8. Conclusion

Mobile technology is advancing our ability to connect and share information in ways that were not possible before, and offers great potential to promote participation in volunteer data collection activities. Organizations need to prepare for these changes if they are to seize all of the advantages. However, in contrast to its rapid growth and wide spread, the use of mobile technology in volunteer sectors has been negligible. Thus, based on the premise that mobile technology holds great potential to enhance the work process of volunteer data collection activities, this paper examined the current practices of technology use in volunteer data collection activities to explore the opportunities of mobile technology. Our findings confirm that information technologies are widely used to support a wide variety of application areas in volunteer activities, from information sharing, to communication, to fundraising, to general management and operation; but the potentials of mobile technology are yet to be explored.

Two categories in the organizations based on goal of volunteer participation have emerged through the analysis: environmental activism organizations for nature conservation, and community mobilization organizations to enhance the living conditions of a community. We found that these categories determine the opportunities of mobile technology with regard to data quality assurance: environmental activism organizations collect measurement data so that the technical capabilities of mobile technology can support validating data accuracy, and community mobilization organizations seek a large volume of public opinion so that the widespread of mobile technology can expand the channel through which the public can participate in the activities.

We explored how the organizations make use of different classes of technologies, including conventional technologies, information technologies, and social media, in volunteer data collection activities. From this exploration, we identified two perceived challenges that contributed to the underutilization of mobile technology: questioning the credibility of public participation, and mobile interaction interfering with the field experience. Then, we discussed the potentials of leveraging mobile technology to enhance data collection processes and promoting deeper volunteer engagement, focusing on its capabilities to cope with the impediments lingering in the current practices of technology use.

The challenges and opportunities in mobile technology adoption that we identified are not an exhaustive list, and more might emerge as the adoption and actual use of mobile technologies increase. However, we believe that they are critical starting points to consider, since the perceived challenges constitute the initial obstacles to overcome in the first step towards the adoption of mobile technology, and the identified opportunities are fundamental elements for successful volunteer activities. We believe our findings will help empower the organizations to achieve their goals for volunteer activities through the appropriate use of mobile technology.

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