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Permalink

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ISBN

9781450331456

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Publication Date

2015-04-18

DOI

10.1145/2702123.2702378

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Exploring Barriers to the Adoption of Mobile Technologies for Volunteer Data Collection Campaigns

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ABSTRACT

Volunteer campaigns for data collection make it possible for non-profit organizations to extend their ability to monitor and respond to critical environmental and societal issues. Yet mobile data collection technologies that have the potential to lower the costs and increase the accuracy of volunteer-collected data are not commonly used in these campaigns. In this paper we conduct a series of studies that reveal the complex issues affecting technology adoption in this domain. First, we surveyed and interviewed existing volunteering campaigns to map out current technology usage within volunteer campaigns. Next, we provided two organizations with a customizable tool for data collection (Sensr) and studied its use and non-use across six real volunteer-driven campaigns over six months. Our study explored success and failure across the first few phases of the campaign lifecycle (campaign creation, initial deployment, and adoption). Our results highlight the impact of resource constraints, cognitive factors, the depth of volunteer engagement, and stakeholders' perspective on technology as important factors contributing to the adoption and usage of mobile data collection technologies. We use these findings to argue for specific design features to accelerate the adoption and use of such tools in volunteer data collection campaigns.

Author Keywords

Public participation; data collection; mobile technology; nonprofit organizations; citizen science

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

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CHI 2015, April 18 - 23, 2015, Seoul, Republic of Korea
Copyright 2015 ACM 978-1-4503-3145-6/15/04...\$15.00
<http://dx.doi.org/10.1145/2702123.2702378>

INTRODUCTION

Volunteer data collection has the potential to extend the scale and reach of non-profit organizations engaged in monitoring and tracking data in our everyday lives. Yet traditional tools used for volunteer data collection introduces the risks of error and data loss and limits the ability of remote volunteers to participate in data collection [28]. Mobile technology offers an opportunity to improve volunteer data collection campaigns, as it can save effort, reduce risk associated with traditional modalities (e.g., loss of paper forms), and minimize errors during data entry and analysis. Nevertheless, volunteer organizations, many of which are small nonprofits, often do not make use of mobile data entry applications. For example, a 2012 survey of general mobile technology use in nonprofit fieldwork showed an adoption rate of only 14% [16]. An understanding of the reasons behind this could help to support the integration of mobile technology into volunteer data collection campaigns.

The primary contributions of this paper are a survey of existing volunteer campaigns, a 6-month mobile study covering development, deployment, and use of a mobile application within six campaigns *in situ*, and the resulting design implications for mobile data collection tools.

First, we surveyed existing volunteer campaigns and their technology use practices using an online questionnaire and interviews to map out the current technology landscape. Most participating organizations did not use mobile solutions and viewed resources as a primary obstacle to using technology. While this is clearly a barrier that should be addressed, the goal of our second study was to explore what *other* barriers exist, assuming the resources to create or identify appropriate technology are available. Thus, our second study involved a 6-month deployment of Sensr, a system to support creating custom mobile data collection applications without requiring in-house technical expertise, hardware, or additional licensing costs [11]. We worked with two local nonprofit organizations that were beginning or continuing six separate campaigns over the course of the study. Unlike most previous work that observes existing technology-use practices, we investigated the cycle from assessment to creation to appropriation of, or failure to

adopt mobile solutions *in situ*. Our second study revealed two factors that significantly influence mobile technology adoption: the depth of volunteer engagement in a campaign and stakeholders' perspective on technology. Based on these two studies, we make recommendations for the design of future volunteer data collection campaigns and the mobile software that may support them.

In the rest of the paper, we first revisit literature that has explored advanced technology adoption practices in nonprofits. Next, we briefly describe Sensr, the mobile-tool authoring platform. After explaining our study methods, we describe our findings, and conclude by outlining and discussing implications for leveraging mobile technology in volunteer campaigns.

RELATED WORK

Information Technology (IT) use in nonprofit organizations can enhance mission-related outcomes and organizational performance [9]. However, nonprofits lag behind for-profits in investment and adoption of technology [24]. The average technology budget in nonprofits is less than 5% of the total budget, and over 50% of small nonprofits did not plan to adopt any new technology [18]. Potential reasons for the minimal use of technology in nonprofits identified in the literature include financial and technical constraints [23], lack of understanding the social context into which technologies are deployed [29], the organizational cost of creating and preserving the knowledge necessary to make effective use of deployed IT [13], and diversity in organizational structure, scope, and application area [23].

In the case of volunteer data collection activities (we include *citizen science* [26] in this category), resource constraints are particularly salient for non-profit organizations that may survive on fundraising alone, because these activities typically benefit from the development of custom mobile applications that are specific to the data being collected. An ideal solution to this is a tool for rapid creation of custom data collection applications without programming. Recently, several variations on this theme have been created (e.g., [1,10,15,22]), including Sensr, which we used in our second study [11].

Some examples of projects that have successfully adopted custom mobile applications include eBird [28], and Creek Watch [12]. These projects demonstrate the advantages of technological support for data collection, including scalability, centralization, and a wider variety of sensing capabilities, since people can report on indirect measures such as neighborhood health and community living conditions [5], and urban planning issues [4]. Other examples include COASST¹, MLMP², CoCoRaHS³, etc.

However, very little is known about the success of these tools in campaigns, and even less is known about the reasons why they may have *not* been used. While we know that multi-stakeholder collaborative systems often fail due to complex socio-technical reasons [8,19], the specific socio-technical factors that may affect volunteer data collection campaigns are not well known.

Theoretical framework in IT adoption

A theoretical approach to understanding IT adoption has been an important research agenda in Information Systems research [30]. While resource constraints (i.e. the ability to build technology) may seem like an obvious barrier to IT adoption on the surface, there are several decades of research, starting with Grudin [8], showing that failures in the adoption of technology by organizations cannot be solely explained by technical problems. Among a significant body of research in Information Systems and Human-Computer Interaction to acceptance and usage of new systems, a widely employed model is Structuration Theory, which characterizes technology adoption through a combination of individual acts and social forces [6]. It regards an individual's perceptions of a technology, rather than its capabilities, as a key influencer in technology adoption. For instance, Orlikowski explains that the "appropriation of technology is strongly influenced by users' understandings of the functionalities of a technology, rather than the properties itself" [19]. Further, she said that individual perceptions are shaped through personal experience and social interactions, which shape the way people use technology [20]. In this regard, Leonardi revealed the gap between what a technology is capable of doing and what people interpret a technology as capable of doing [14].

SURVEY TO EXPLORE EXISTING CAMPAIGNS

We first surveyed existing campaigns through an online questionnaire and interviews to map out the current technology landscape in volunteer data collection activities.

Methods

Our recruitment target was nonprofit organizations that collected data from volunteers (described in the invitation as "your organization coordinates a volunteer activity and collects data from volunteers"). We sent out emails to 900 nonprofits listed in a local nonprofit directory⁴ asking them to participate in our online questionnaire. The questionnaire had four parts: Organization's structure and its members; Data collected from volunteers; Volunteer activities and work process; and Technology used in volunteer activities. We also asked if a representative of the organization would be willing to participate in an interview.

Next, we conducted interviews with representatives from organizations that answered the questionnaire and had active volunteer activities at the time of recruitment. One

¹ COASST, <http://depts.washington.edu/coasst/>

² MLMP, <http://www.mlmp.org/>

³ CoCoRaHS, <http://www.cocorahs.org/>

⁴ <http://www.pittsburghcares.org/>

staff member (e.g., executive director, leader or manager) participated in an interview of one to two and a half hours in length. All interviews were audio recorded and transcribed. We analyzed the data using a thematic analysis to reveal patterns across data sets important informed by Grounded Theory [27]. We used open coding to identify concepts that were significant in the data. As a group, we categorized related concepts, created during open coding, into themes that emerged as patterns within the data.

Participants

Forty-six organizations of the 900 we contacted filled out the online questionnaire. Some possible explanations for the low response rate include out-of-date websites, busyness, and the limited scope of this study to organizations with volunteer data collection efforts. A variety of organizations participated in the survey, including animal protection, conservation, education, healthcare, and science. Among the organizations that responded, 77% had 10 or fewer staff members.

Among those forty-six, eleven organizations participated in the interviews. Those organizations fell under one of two topical areas based on their goal: environmental activism organization (EA) and community mobilization organization (CM). We did not recruit organizations based on these two types, but rather the types emerged through the analysis process. While these types might not cover the entire domain of volunteer organizations, these types represent important purposes for which they seek public engagement for data collection.

Table 1 summarizes the participating organizations. 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).

Type	Site ID	Description of site's programs	# of staff	# of volunteers
Environmental Activism	EA1-birds	Bird counting	7	1,000
	EA2-birds	Bird counting	5	1,500
	EA3-dumping	Cleaning illegal dumping	3	2,000
	EA4-water	Water quality monitoring	6	300
	EA5-water	Water quality monitoring	7	500
Community mobilization	CM1-reuse	Waste reclaiming	5	200
	CM2-dev	Community development	9	500
	CM3-bike	Bike-safe community	7	3,000
	CM4-dev	Community development	11	300
	CM5-shale	Protest against Fracking	4f	2,000
	CM6-food	Eliminating hunger	12	14,000

Table 1. A list of interview-participating organizations

Results

To better understand the technology landscape, we began by probing the types of technologies in use in participating organizations for interacting with volunteers (staying in touch, collecting data, etc.). Our focus was on exploring perceived challenges in the adoption of technology for data collection, especially mobile technology.

Staying In Touch

Eight interviewed organizations said that they used social media to post news about upcoming activities, and to communicate with volunteers. However, while social media are powerful for communication, organizations cannot easily manipulate the communication data because it is stored in a third-party's database (e.g., Facebook's server).

Collecting Data and Measuring Its Quality

While the campaigns varied greatly in their goals with respect to what volunteers would gain and how the organization would benefit, the types of data to collect were fairly evenly distributed between qualitative and quantitative data (See Chart 1). However, the interview data revealed a difference in expectations about data collection across different types of organizations. Our interview data also showed that the meaning of *quality* varied across organizations, and was not always synonymous with accuracy. We will return to the complex topic of quality in the discussion section.

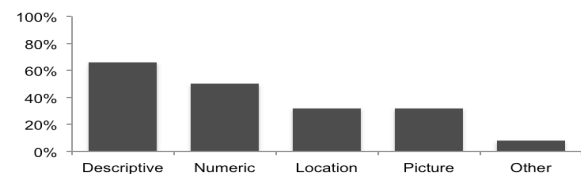


Chart 1. Questionnaire: Data format in campaigns (multiple-choice questions)

Interview participants from *Community Monitoring* organizations collected subjective information about community conditions and neighborhood issues (e.g., feedback on new community facilities). This information helps to shape the focus of campaigns, such as highlighting problems that the organization should address. Therefore, contextual details such as location and demographics were valuable additions to such data because they helped to organize the data. Many organizations used free-form media, such as email and online bulletin boards, although such tools are not well suited to collecting structured data. For these organizations, data is most meaningful and representative when the quantity becomes large enough to identify a trend. Therefore, the *volume* of data submission is regarded as a barometer of data quality.

Conversely, participants from *Environmental Activism* organizations primarily reported seeking factual, standardized, and numeric data (e.g., numeric water quality data). Volunteers were required to follow carefully defined protocols when collecting data. This typically involved a combination of pen-and-paper for manual data capture and IT for digital sharing: people write down their observations out in the field, and then email their findings to a program coordinator. For these organizations, the *accuracy* of data is the barometer of data quality. However, with such protocols in place, volunteer-collected data was sometimes not entirely trusted among our participants, even though prior work has shown that the quality of novice-collected data is as valid and credible as professional-collected data [3].

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

This tendency was particularly conspicuous among EM organizations. Perhaps for this reason, participants from EM organizations described volunteer data collection campaigns as educational outreach that would increase volunteers' sense of achievement and engagement and train novice volunteers for "real" data collection.

Technologies Used for Data Collection

Conventional communication media were a dominant tool for data submission (e.g., email and web-based submission). Pen and paper were also used, but in that case data retrieval was hard and data needed to be digitized manually. Both processes are time-consuming and prone to human error. In addition, 58% of organizations reported data being submitted in person and 40% by phone (See Chart 2).

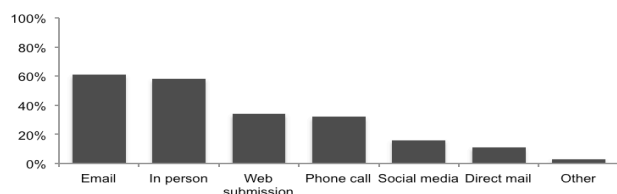


Chart 2. Questionnaire: Technology used for data submission
(multiple-choice questions)

Interviews revealed that technologies with a large temporal distance between capturing and sharing data were more likely to cause data to go missing. One solution that came up is for the coordinator to remind volunteers, something that may not scale well.

"For now, it's manageable to call, because it is small, around twenty [volunteers]. But it's going to grow pretty quickly. If it gets larger, that will become really cumbersome to call everyone and to email everyone" (EA3-dumping)

In contrast, mobile technologies were seen as bridging this gap by allowing data to be reported as they happened.

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

At the same time, some participants concerned that they might diminish authentic field experience, and introduce errors and/or distract.

"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)

Lastly, interview participants could not easily imagine the applications of mobile technology when initially asked. But often once one idea came up, other ideas easily followed.

"If you hover over a section on a map, the device would tell you more about the section." (CM3-bike)

"[If] you can tell yourself like 'I recycled 20 pounds this month'. That would help us with quantifying activities both creativity-wise and recycling-wise." (CM1-reuse)

Summary

Overall, this study highlights both some value and some difficulties that might affect the adoption of mobile technology for data collection. For some organizations, the *quality control process* is crucial, while for others the *quantity of data collected* is more important. Mobile technology can potentially contribute both a process and a just-in-time ability to report information. However, participants also had concerns about its impact on the field experience. Thus, our first study did not give clear answers about the likelihood that mobile data collection technology would be adopted.

DEPLOYMENT TO EXPLORE A CAMPAIGN LIFECYCLE

To more deeply understand the adoption of mobile technology in volunteer data collection campaigns, we investigated the first few phases of the campaign lifecycle through a six-month deployment of Sensr [11], a mobile tool for rapidly creating and deploying custom data collection applications. In this section, we first briefly describe Sensr, and then explain the study methods and participating organizations with their campaigns.

Sensr: a mobile-tool authoring platform

While the entire description of Sensr can be found in [11], here we briefly describe the key features. Sensr consists of



Figure 1. Left two: Screenshots of Sensr web & mobile. Data entered in the fields on the left appears on a replica iPhone screen (left). Drag and drop widgets from a predefined set onto replica iPhone screen to design a mobile tool (right). Right: From left to right, a list of projects a user added, a page to find a project, a project main page, and a data-reporting form

two parts: a website where an author creates and manages a mobile tool for a campaign, and a mobile application where volunteers explore and participate in the campaign.

To create a mobile campaign, an author (typically a staff member in an organization) lays out a data collection interface by dragging and dropping widgets from a predefined palette onto a replica iPhone screen (See Figure 1 left). We provide widgets for a photo, radio buttons (two or three options), and a freeform text entry field. The author can rearrange the order of widgets, delete a widget, and edit labels. Additionally, the system automatically captures sensor data such as a timestamp and location. The final interface is automatically converted into a mobile application.

To participate in a campaign, volunteers download the Sensr app to a smartphone (See Figure 1 right). Volunteers search for campaigns that are interesting, and subscribe to the campaigns that they want to contribute data to.

Method

We recruited two organizations that expressed needs for mobile technology use but were struggling with its adoption. For anonymity, we refer to them as CleanUp and AirQuality. We worked with each organization to investigate the use of mobile technology in six campaigns, summarized in Table 2.

We visited each organization every two weeks for six months to conduct semi-structured interviews. The first two visits were to understand existing campaigns and describing Sensr. The remaining visits focused on understanding how organizations determine, evaluate, and use (or decline to use) mobile technology. Protocols for interview questions were centered on the following areas:

- Staff's knowledge and experience in technology use
- Participatory environmental campaigns and volunteers
- The use practices of new mobile tools created via Sensr

We interviewed one staff member at a time, and interviewed one or two staff members per visit. In both organizations, one staff member managed the entire process of one campaign or more independently. Each interview lasted 1.5 hours on average. In total, 13 interviews were conducted with CleanUp and 10 interviews with AirQuality (See Table 2). All interviews were audio-recorded and transcribed.

Participating Organizations

Among those who participated in the interviews and the organizations that we had previously worked with, two local organizations were selected to participate in the deployment study.

CleanUp Organization: Eliminating Illegal Dumping

The CleanUp organization works with community members to eliminate illegal dumping. Its primary campaigns were where volunteers clean up dumping from the sites (*Dumpsite cleanup campaign*), and from the riverbanks

(*Riverbank cleanup campaign*). Before cleanup, sites were assessed to plan an event, and after cleanup, sites were monitored to prevent them from becoming trashed again. While staff assessed most sites, the organization recently launched a campaign to engage the public in a visual assessment of a local watershed (*Watershed assessment campaign*). For monitoring the cleaned sites, they ran a *Stewardship program*. Lastly, they created a new campaign to receive public dumpsite reports, *Dumpsite reporting campaign*. They have three full-time staff (an executive director, a program coordinator, and an outreach coordinator) and two part-time. All had experience with using basic IT tools for tasks such as web browsing, word processing, and email.

AirQuality Organization: Advocating for Clean Air

The AirQuality organization educates the public, raises awareness, and advocates for laws and regulations regarding environmental issues to improve air quality in the region. They operate a few campaigns, including *Bicycle air-monitoring campaign* that asks cyclists to collect urban air quality. In addition, they created a new campaign to allow citizens to report neighborhood air-quality issues, *Air-pollution reporting campaign*. They have four full-time staff (an executive director, two lawyers, and a policy & outreach coordinator) and three part-time staff. The policy & outreach coordinator was experienced in advanced IT tools.

Org	Campaign	Coordinator (Interviewee)	# of Interviews
Clean-Up	Watershed assessment	Outreach coordinator (OC)	3
	Stewardship campaign*	Program coordinator (PC)	12
	Dumpsite reporting*	Program coordinator (PC)	6
	River cleanup	Outreach coordinator (OC)	4
Air-Quality	Bicycle air quality monitoring	Policy & outreach coordinator (POC)	4
	Air pollution reporting*	Policy & outreach coordinator (POC)	11

Table 2. Campaigns and coordinators that we interviewed
(The campaigns marked with * created mobile tools using Sensr.)

Campaign Case Studies

We analyzed the data using a case-based method [17]. Because each campaign (and the staff member running it) is unique, this method helps to contextualize the data being presented. Our discussion section draws themes across the cases together for further insight. Note that each campaign had a single primary coordinator, listed in Table 2, who was also the sole interviewee in quotes for that campaign.

CleanUp Campaign: Watershed Assessment

Two months into our study, the CleanUp org launched a campaign to produce assessment maps of a local creek. A group of one expert and several volunteers was formed to walk through a creek to conduct visual assessment. The outreach coordinator (OC) was the coordinator of this campaign and interviewee for this case.

The coordinator planned to use a camera to record pictures, an inventory sheet to write down a description about the spot, and a photo sheet to mark the ID number of the spot where the photo was taken. Locations were marked on a paper map (See Figure 3). Thus, she planned to form a group of four or more volunteers so that each volunteer would conduct one task. After one month, in which over 250 items were recorded over 2 miles of creek, the coordinator determined that the assessment procedure was too slow: their initial plan was to complete assessing the entire 18 miles within three months. Thus, she revised the process to reduce the number of volunteers to two.

"We are mostly expediting the recording process. Because we were filling it out for each thing we saw on the sheet. It's a lot of paper and a lot of actions for information." (OC)

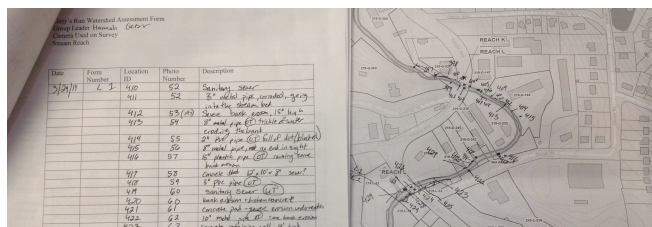


Figure 3. An assessment sheet and a printout map with spots marked used for the watershed assessment project

She explored Sensr for two weeks, and decided not to use it because of the distrust on smartphone's GPS accuracy.

"We will just take pictures and record it on a map for the location, because GPS will not be accurate enough. We are looking at a very fine level accuracy.... We have maps that were made for us in a very small scale." (OC)

In the end, this project did not use any computing technologies except a camera.

CleanUp Campaign: River Cleanup

The outreach coordinator runs a campaign, aiming to clean up the city's rivers and shores twice a month from April to October. The schedule for the entire year is planned out early in the year. Planning includes selecting locations, preparing a boat, and recruiting volunteers.

Selecting locations is a particularly important part of the planning, as it determines where trash is, estimates the amount of trash in the river, and finds the closest riverbank to embark to load/unload the collected trash and volunteers. The existing process was that the boat pilot drove on the river and wrote down a description of spots.

This campaign was originally run by the program coordinator (PC), who was very positive about the potential of GPS to simplify the process.

"[we] try to guess and try to write down the closest from the landmark to estimate." (PC)

However, as with the previous campaign, the outreach coordinator who currently runs the river cleanup campaign did not want to use a mobile tool. She believed that the boat

pilot was skilled enough to determine the location without any technical supports. She trusted human capabilities and believed that pen-and-paper would be more convenient.

CleanUp Campaign: Stewardship Campaign

In the CleanUp stewardship campaign, volunteer stewards monitor cleaned-up sites regularly to prevent them from being trashed again. A steward visits each site once or twice a month walking around and checking whether there is new dumping, and then reports the condition to the program coordinator (PC), who runs this campaign.

Most reports were made through emails by the 25 stewards. But the program coordinator sometimes had to call stewards to gather data, because stewards sometimes forget to report back about their fieldwork after returning home. Thus, she was looking for a systematic channel through which stewards report data. She created a mobile tool to allow stewards to report findings on the go using Sensr with the goal of addressing the time lag in reporting.

"That will be helpful for [stewards] as they go through the busy day, stopping by the place to report things to us. People will not have to wait until they get back and email me." (PC)

The created tool consisted of a photo, three text fields (site name, reporter's name, general comments) and two multiple-choices (litter: minimal or extensive, dumping: yes or no) (See Figure 4).

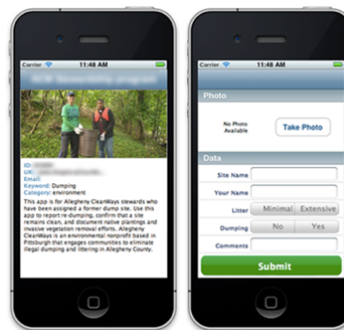


Figure 4. Mobile stewardship project

The program coordinator was extremely positive at the start of the deployment because she felt the mobile tool would help her to manage this campaign more easily. She expected that a mobile tool would provide volunteers with a clear idea of how they are expected to do without much verbal explanation.

"With the app, people clearly know more of what to do. 'I have this app. I am putting my data here.' Otherwise, it's like what am I doing, how am I reporting it to you?"

She also felt that the mobile app made the campaign more official and more in line with social norms.

"With the proliferation of apps for everything, not having an app is a deficit. Someone might say 'you don't have an app for that'? ... It seems more official because we have some technology. I like to be able to say like 'do you want to be a

steward? Now, we do have an app. We do have a way to make it easy if you have a smart phone!” (PC)

This mobile tool was deployed for four months in this study. During the 4-month deployment, 10 reports were made through this tool. One reason for the small number of reports is that reporting is only done monthly or bimonthly. Another reason is that Sensr only supported iOS. Seven stewards who were using Android devices and eleven who were not using smartphones could not participate.

We attempted to support volunteers without iOS devices by creating a web form for data submission, but this interface created additional confusion for users. Most volunteers did not understand how to use it on a mobile platform. In other words, the “mobile app” metaphor did not adequately map across onto web-based interface. After trying to adopt the web data-submission page for two weeks, the program coordinator decided to stop using it.

“People are saying like ‘I don’t know what’s going on’. So it ... discourages people, and they give up.” (PC)

Consequently, she had to keep the conventional ways of emailing and calling for non-iOS device users. Despite this, the program coordinator felt that it still reduced her work in the ways she had predicted.

“It has decreased the number of emails and reminders that I have to send out. It’s more convenient for me because I am not being bombarded with separate requests and updates in my email. Also, it is nice not to have to worry as much about the data coming in, because it’s all right there at one place. Especially for pictures it’s really helpful, because I have a whole record right there, picture, picture, picture. It is great to have all of them in one place, rather than in an email and downloading them.” (PC)

CleanUp Campaign: Dumpsite Reporting

Satisfied with a mobile tool for the Stewardship campaign, the same coordinator decided to launch another mobile tool, one to enable the public to report newly discovered dumpsites. The CleanUp org was already receiving occasional reports from the public about new dumpsites through emails or phone calls. The program coordinator wanted a mobile tool that could function as an alternative channel for people to report new dumpsites on the go. So, she created a mobile tool using Sensr. It consisted of a photo, four fields (city, neighborhood, nearest road, comments, email) and one multiple-choice question (tire: yes or no) (See Figure 5).

The program coordinator announced this mobile campaign via email, social media, and its homepage to volunteers. The tool was deployed for two months. During the deployment, 21 volunteers registered to the campaign, and 6 reports were made through this tool. These reports primarily came from stewards who were already using a mobile tool for the stewardship campaign. We learned that the majority of dumpsite reporters are one-time reporters, for whom installing and learning a mobile tool was too much overhead.

“For the person that comes to me and says one dumpsite behind his house, it doesn’t make much sense for that person to download it and go through the whole process. So, it looks like not as convenient for the regular people.” (PC)

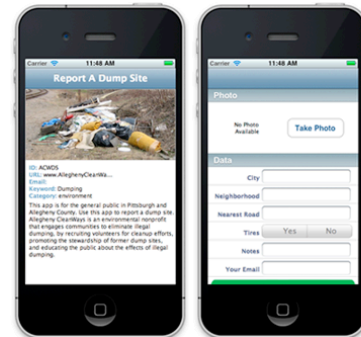


Figure 5. Mobile stewardship project

Hence, the program coordinator did not expect this tool to be widely used by the public. Interestingly, she intended to keep operating it, not only because it was useful to ongoing volunteers, but also for the perceived value of a campaign having its own custom technology.

“Whenever someone does the dumpsite reporting to us, I will say like ‘hey in the future you can use this app that helps you doing it easily.’” (PC)

AirQuality Campaign: Bike Air Quality Monitoring

The bicycle air-quality monitoring program collects air quality data in the region from cyclists. This campaign already made use of custom technology, an air quality sensor to attach on the recruited cyclists’ bikes. With the data, the AirQuality org aimed to present a sampling of the region’s air quality to illustrate where the problem areas are. A part-time staff member operated this campaign, and the policy & outreach coordinator (POC) managed the data and was the primary interviewee.

The POC was a technology expert. He managed technical tasks in the organization, including updating a webpage, posting news on social media, and maintaining computing facilities. The policy & outreach coordinator and the part-time staff used a third party system (not Sensr) to allow cyclists to report air pollution while riding a bike.

Data provided by this sensor was seen as supplementary evidence for effective communication with other stakeholders, rather than to be used in-house for assessing air quality. He trusted the accuracy of the sensed data but did not expect that the data would provide new information.

“I personally don’t need monitors to see the data. I know it without a monitor. But other people like political leaders and businessmen won’t believe me unless I show them a nice fancy map.” (POC)

Whereas Sensr was not needed for this campaign, the POC decided to create a campaign, described next, through which the public could report issues related to air pollution.

AirQuality Org Campaign: Reporting Air Pollution

The AirQuality org created a mobile campaign through which the public can report air pollution. While the campaign itself was new, the idea was not new, as they were already receiving reports about air pollution from the public through an email or phone call occasionally. The mobile tool was designed as an alternative way to collect reports. Because they were receiving reports via emails and phone calls, they sought a systematic channel through which they could manage reports.

The policy & outreach coordinator created the mobile tool using Sensr and announced it via mailing list, social media, and the organization homepage to their volunteers. The tool consisted of a photo, two multiple-choice questions (Pollution type: mobile or stationary, email from us: yes or no) and one field (email) (See Figure 6).

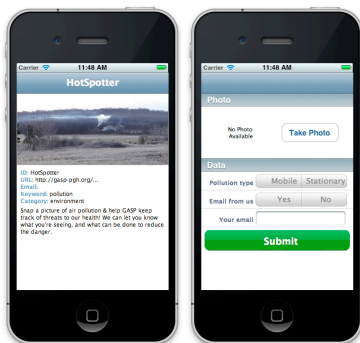


Figure 6. Air pollution source reporting campaign

During the three-month deployment, 27 volunteers registered to this campaign, but only 7 reports were made through this tool. We had several discussions with the coordinator to explore possible reasons why it was not used much. Similar to the Dumpsite Reporting campaign, it seemed this campaign consisted mostly of one-time reports, for which volunteers preferred email or phone:

“They are usually people we never heard of. People don't think about air pollution until it affects them. Then, they freak out, research, find us, and email or call us... we give them some answer, and usually we never hear again from them.” (POC)

Additionally, POC said that volunteers were dissatisfied with short yes-no questions. He also said that the descriptive information is less useful for the organization, but powerful and persuasive to share within community members to promote collective action.

“People don't want to share a small piece of data, but want to share a whole experience about what happened and their thoughts. In this way, people feel that their actions are more meaningful than submitting a line of short sentences.” (POC)

The AirQuality org had volunteers who were regular participants in monitoring air pollution. However, unlike the volunteers for the CleanUp org, the active volunteers in the AirQuality org did not make use of Sensr but kept their own way of reporting data.

“They have their own ways to make a report, because they have been doing this for years. So, I think the people that would have been very excited to use this are already set [in their ways].” (POC)

Similar to the OC for CleanUp, volunteers' beliefs and attitudes about technology as well as their relationship to the campaign itself strongly affected their use of Sensr.

DISCUSSION AND DESIGN IMPLICATIONS

Our two studies, taken together, reveal a landscape of participation that matches our expectations about the impact of individual perception and attitude on technology use. In total, our studies included over fifty interviews, deep explorations of the potential value of Sensr across six separate campaigns, and the construction and deployment of four separate data collection applications. Our results help to tease apart a range of specific issues and ground our understanding of how technology adoption plays out in resource-constrained, small non-profit campaigns.

Our findings touch on some of the key issues that may need to be considered in designing mobile data collection tools for small non-profit organizations. At a high level, it is critical to bring the viewpoints of multiple stakeholders into the design process (e.g., using participatory design [2,25] or Value-sensitive design – an approach to account for human value throughout the design process [7]).

Specifically, our data revealed four factors that could directly influence design.

1. Quality Control, Trust, and Authenticity are an issue for any data collection task. However, our data highlight how notions of *data quality* can vary widely based on the perceptions of individuals involved, the goals of the organization, and the structure of a campaign. For example, quality was expressed across our studies in terms of specificity, quantity, novelty, ability to appeal to funders, accuracy, and trust (in technology and/or volunteer participants). In addition, even when quality was raised as the primary issue, underlying issues were often visible, such as lack of familiarity with the capabilities of technology or a concern about losing control of tasks when using technology. *Thus, it is critical to figure out what “quality” means before designing for it.*

2. Individual Beliefs and Attitudes towards Technology are sure to have an impact on the use of various technologies. For example, one participant was concerned about a social expectation of there being “an app for that” as a sign of the realness of a campaign. *What was unexpected in our data is the degree to which personal opinions dominated decision-making within the organizations we studied.* Personal propensity and organizational context are known to be strongly associated with the adoption of technological innovations [28]. Perhaps because of their small size, the attitudes of individuals reigned supreme in our data. One explanation is the lack of social interaction (among staff) around the technology – over time in other settings. It has been shown

that workers may improve their interpretations about technology through social interaction [14]. It might be because organizations are operated under a traditional hierarchical structure that made it hard for new technical interventions to merge into the existing structure. Another reason might be because elements of Sensr may have biased towards a more flat organizational structure rather than a hierarchical one. This opens up the opportunity to discuss how such community data collection tools need to support existing organizational structures. *In all, systems need to allow alternative flows of information and improved transparency.*

3. The presence of volunteers requires special consideration. Multiple stakeholders are a given in organizational contexts, and volunteers have a unique relationship to the organizations we studied. They are not accountable in the same way that a staff member may be. In addition, volunteers are often unpaid and in some cases completely transitory. Our data suggests that it is critical to pay attention to whether participation is *recurrent* (as with structured, periodic field events) or *sporadic* (as with one-time reports of air quality or dumping issues).

Data collection tools may serve communities best by designing multiple entry points to participate through dedicated apps like Sensr as well as lightweight social media such as Twitter. Customized tools like Sensr will serve a critical role in providing a richer experience of the data, campaign, and community in recurrent activities, whereas lightweight tools (e.g., Twitter) will serve to lower the barrier to participation and provide a scaffolding mechanism for individuals into data collection systems. *As such, our findings suggest that an application installation and its associated overhead is better suited to recurrent participants, while a lighter-weight interaction may be necessary for sporadic participants.*

4. Need for Narrative was another interesting finding. The recording and reporting of data varied from logging raw values to descriptive stories and contextual narratives. This related to how satisfied participants felt about their recorded data. For example, repeated volunteers facilitated formally structured tools for data submission, whereas transitory volunteers sought a narrative input mechanism to share the entire story of what they experienced. While most existing data collection systems are suited to formal, structured data collection efforts, a richer narrative-based input mechanism should be another design consideration for future digital volunteering systems. For example, perhaps a collection of stories could become the basis of a brochure or feed into an annual report for potential funders. In addition, a flexible mechanism that supports data flow between volunteers and organizers in both directions should be considered. For example, an organization can notify volunteers with a follow-up on data. This mechanism will increase volunteers' feeling of engagement and allow organizations to grasp richer contexts about the issue of concern. *Thus, a tool could help organizations to scaffold participation over*

time by leveraging volunteers' existing proclivities for data entry into new and beneficial types of data.

LIMITATIONS

A limitation of our data is its focus on only two organizations in the second study, and the fact that our studies did not continue to track technology use beyond the initial diffusion of that technology into the volunteer community. Because of the small number of organizations in the study, our discussion and results should be interpreted as a starting point for exploring mobile data collection adoption. In addition, because Sensr did not support every feature/platform organizations may have wanted, it is possible that Sensr itself might have influenced adoption in ways that are difficult to tease out. Lastly, while previous work has studied volunteers (e.g., [21,31]), one of the unique features of our work was to study an underrepresented stakeholder in mobile data collection: the campaign organizing staff. Ideally, this study would be complemented by a volunteer perspective, something not present in our paper.

CONCLUSION

Despite the increased usage of mobile technology across many wide economic and cultural demographics, application specific mobile data collection applications have yet to be widely adopted. There is a clear opportunity here, since mobile technology has the potential to provide information that could be of great value in community based data collection tasks. Photos, GPS location, and other sensors could be easily leveraged to enhance existing data collection tools. However, the technical skills required to effectively develop these custom mobile data collection applications still remain well outside the ability of most non-profit organizations.

Building on prior work which points to the importance of a range of social factors in technology acceptance (e.g., [8,13,14]), our contribution is an analysis of the factors that should be considered in the design of custom mobile technology for data collection in small non-profits. Through a series of survey studies, we first mapped out current technology use in volunteer campaigns. Then, in the six-month deployment study, we removed the issue of technical difficulty to allow other more subtle problems to rise to the surface. Our findings reveal important issues such as personal interpretation about, comprehension of, and propensity to accept technological interventions as barriers. Extending existing theoretical approaches to the design of technology, this work suggests identifying different perspectives, needs, benefits, and skills of multiple stakeholders that constitute volunteer campaigns, incorporating these into the process of designing novel mobile volunteering systems. We are hopeful that our work can motivate future research on mobile technology and digital volunteerism.

ACKNOWLEDGMENTS

We appreciate the valuable input of our anonymous reviewers. We also would like to thank all the study participating organizations. This work was supported by NSF IIS-1211047 and NSF IIS-1217929.

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