A Study on Citizens' Public Report Application Usage

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Abstract

Background Public reporting with mobile devices is a novel medium for enabling citizen engagement, and its adoption has significantly increased among several nations. Despite its potential, however, this new technology has received minimal practical attention from citizens.

Methods Before conducting the main study, we investigated the problems and user opinions of the existing public reporting applications by analyzing users' application reviews. Then, we conducted a field study to discover difficulties in the actual public reporting process. For the first week, we asked participants to discover problematic situations, document the situations with photos, and submit the evidence via an instant messenger application. For the second week, we asked the participants to use existing public reporting applications to capture and report public issues. Upon completion of the two-week experiment, we interviewed each participant about the details of their reporting situations.

Results Our user study results revealed that the key factors for making reporting decisions were the user's involvement, as well as the seriousness, urgency, and frequency of a problem. At the problem reporting stage, collecting valid evidence made public reporting more challenging. In addition, concern about personal information protection was another factor for citizens' demotivation during the reporting stage. Finally, emotional rewards and explanations of how evidence data would be managed were insufficient at the problem-receiving and problem-solving stages.

Conclusions This paper makes several contributions. First, the results of the field study improve our understanding of what makes citizens reluctant to use the reporting application. Second, it guides the design of future public reporting applications by suggesting design issues and solutions.

Keywords Citizen Engagement, Public Service, Public Reporting Application

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1. Introduction

Citizen participation methodology has recently been actively applied to public decision-making processes. Several countries are trying to design customized services for citizens by engaging citizens in policy design processes rather than limiting them to passive positions. As a representative example, Korean government has been using service design methodology since 2014 to operate the "Government 3.0 Design Group" in which citizens, service designers, and public officials participate in the overall processes of policy formulation and implementation.

In the same vein, to collect various opinions of citizens, a public reporting application has been developed for users to directly report any problems they face in daily life. Typical public reporting applications include the "Report on the inconvenience of life"("Report on the Inconvenience of life," 2017) and "Safety Sin-mun-go" ("Safety Sin-mun-go," 2017) of the Ministry of the Interior and Safety, and "Smart Report" ("Smart Report," 2017) of the National Police Agency. Citizens can use these applications to report on a variety of public services, including safety, transportation, and urban maintenance. Generally, after a citizen recognizes an inconvenient situation, he/she takes a picture or video as an evidence of the report and uploads the data into the application. Next, the appropriate public authority confirms the contents of the citizen's report and notifies them of result. This application is valuable because it enables collection of diverse opinions from citizens in authentic contexts.

As the penetration rate of mobile devices has increased, citizen participation and engagement have become possible without restrictions of time and place. According to the Ministry of the Interior and Safety, complaints of inconvenience through smartphone applications increased 14 times over four years ("Incresed Use of Public Reporting App," n.d.). Despite the rapid increase in citizen's demands for participatory reporting, satisfaction level toward the applications is not high compared to the expectation of existing public reporting applications. According to the Google Play store, the most common public reporting application, "Report of Inconvenience," is rated at 1 star, with 1,316 reviews out of a total of 3,577 reviews (as of September 2017)("Report on the Inconvenience of life," 2017). In addition to functional errors, users point out problems caused by lack of consideration for citizens' user experience, such as complex reporting procedures and lack of feedback on processing results.

How can we improve public reporting applications that encourage civic engagement? In this study, we systematically analyze the use of public reporting applications to determine which problems associated with public reporting applications limit practical and continuous use. Additionally, based on the understanding of current problems, we propose design implications that induce voluntary and continual citizen use.

2. Related Works

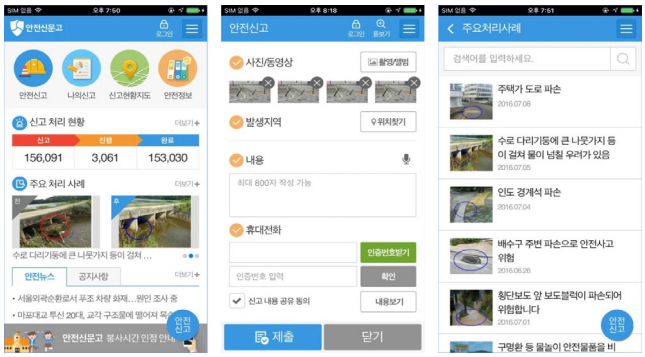

Figure 1 Example of Public Reporting Application (Safety Sin-mun-go)

2. 1. Systems for Civil Engagement in HCI

In the field of design and human-computer interaction, information systems are used to support various forms of civic engagement, such as community policing (Kadar, Te, Rosés Brüngger, & Pletikosa Cvijikj, 2016), urban infrastructure maintenance (Harding, Knowles, Davies, & Rouncefield, 2015; King & Brown, 2007), participatory urban sensing (Aoki et al., 2009), disaster relief (Ludwig, Siebigteroth, & Pipek, 2015), and government budgeting (Kim et al., 2016).

In these systems, individuals can be recruited to act as data sensors to help populate databases regarding local issues. Then, the collected data are visualized and shared within local communities. For example, SALUS (Kadar et al., 2016) visualizes crime-related information (e.g., crime maps and safety tips) and allows users to report crimes in real time. Crowd Safe (Shah, Bao, Lu, & Chen, 2011) recommends safe paths on a map by incorporating crime data into routing algorithms. Brush et al. (Brush, Jung, Mahajan, & Martinez, 2013) proposed the concept of Digital Neighborhood Watch, in which individual, intelligent surveillance cameras installed in homes are networked for a comprehensive neighborhood watch. Comfort Zones (Blom et al., 2010) is a crowd sourced app designed to mitigate fear at night in urban areas by allowing users to capture and share location-based safety or comfort attributes and provide social support and interaction.

Despite potential values of such systems, there is a lack of consideration as to whether citizens want to use such a system in their everyday lives, or if there is a problem from the perspective of user experience or service design.

2. 2. Public Reporting Application for Citizens

With the help of increasingly powerful information systems, government directives are driving a more transparent and collaborative relationship between governmental agencies and citizens. Beyond making public information accessible with the click of a mouse instead of a formal record request, web and mobile technologies are enabling powerful two-way communication between leaders and constituents (Black, 2009). In practice, many cities and counties are taking advantage of mobile technologies by designing publicreporting applications, which enable citizens to take a photo or video of a situation and report its location to the city in real time (Figure 1). When connected to a city's customer relationship

management software, the information automatically populates work orders for city crews and identifies exactly where the problem is.

Generally, according to government agencies, with the use of a public reporting application, a problem is solved through four steps: Problem Recognition Phase, Problem Reporting Phase, Problem Receiving Phase, Processing Phase. The first step is when the complainant finds the problem and feels the need to report it. In the second step, the complainant uses the application to fill out the problem situation. In the third step, the officer in charge confirms the contents of the report and takes action via each appropriate agency. In the final step, the responsible government agency resolves the reported problem.

2. 3. Summary

As described above, pervasive recording with mobile devices has become an essential tool for civic engagement. Previous cases have demonstrated the potential to integrate the collective knowledge of citizens (Harding et al., 2015), empowering users to take an active role in civic decision-making and urban management. However, interest in long-term civic engagement and use—and the perceived value of civic crowdsourcing applications—has remained low, so any vision of civic authorities and citizens acting as partners appears a considerable distance from being realized.

Thus, the purpose of our study is to discover why citizens are not satisfied in the process of reporting public problems by analyzing current reporting applications. In this research, we aim to explore ways to encourage citizen participation in public reporting applications and how to sustain citizen participation in the long term.

3. Preliminary Study

Before conducting main study, we investigated problems and user opinions of the existing public reporting applications by analyzing users' application reviews. Because general users leave critical comments or request improvements of the applications when they face severe challenges, we could discover wide range of problems of the applications in the reviews. The preliminary study helped us to narrow down the focus of the main study that complements the shortcoming of the preliminary study.

3. 1. Preliminary Study Process

We analyzed the reviews of three reporting applications operated by government and public organizations. When selecting the application for this study, we determined whether it was released to the Google Play store for more than three years, whether the download count was 100,000 or more, and whether there were more than 100 registered reviews in the past year. As a result, the selected applications were 'Report on the inconvenience of life' of the Ministry of the Interior and Safety, 'Smart Report' of the National Police Agency and 'Seoul Smart Complaint Report' by Seoul city government.

We finally gathered 458 review comments (focusing on the newest reviews in each application). While collecting reviews, we excluded reviews on functional errors like server error or abrupt application termination and raw reviews that did not reveal a clear reason or

problematic situation. The reviews were classified twice in order to derive a common pattern. In the first classification, the four researchers investigated the main content of the reviews and classified them into common problems through discussion. In the second classification process, the classified reviews were recategorized according to general process of public reporting (Problem Recognition Phase, Problem Reporting Phase, Problem Receiving Phase, Processing Phase)

3. 2. Preliminar Study Result

The analysis of application user reviews revealed diverse problems of reporting applications and complaint processing. The user reviews were mainly concentrated on the 'problem reporting' phase where the user reports problematic situations after recognizing them. Especially regarding this stage, there were many opinions on the usability of the applications (82.5% among the collected reviews). For instance, several reviews showed that the procedure until completing the report was complicated. Other reviews explained that it was difficult to edit and attach the photographs and videos in order to report. About the problem receiving phase, there was an opinion that the responsible organization did not show a positive attitude for citizen's reporting (4.3% among the collected reviews). In the phase of complaint processing, there was the opinion that it was not possible to receive detailed feedback on the entire process after reporting (1.1% among the collected reviews). There are also problems at various stages related to privacy issues.

4. Study: Evaluation on Usage of Public Reporting Applications

Although we could find many problems in public reporting through our preliminary study, there were limitations to investigate the problems in the actual citizen's reporting process. First of all, we could not figure out why citizens hesitate to use the reporting application. Because the reviews were mainly about the application itself, it was necessary for us to understand what kind of elements users consider during the problem recognition phase before actual reporting. Second, socio-cultural and environmental context in actual reporting situation was rarely revealed. Although we found problems in terms of usability and functional errors, it was not found how contextual elemenets interrupts citizens' reporting.
Thus, we designed a field study to examine the user experience of public reporting applications. In this study, we tried to discover problems at each reporting process that were not found in the previous study.

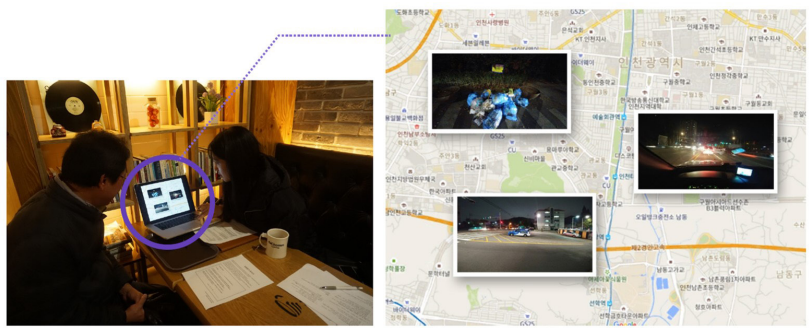

Figure 2 Interview Setup during Main Study

4. 1. Participants and Study Process

We recruited 6 participants who use their own mobile devices (4 males and 2 females, age = 31.0, SD = 13.2). Because there were several opinions on driving context among application reviews, we included 2 participants who regularly drive their own car.

Our experiment was conducted for a total of 2 weeks. To use the reporting application, it was expected that the user would need to be fully aware of what he/she wanted to report. Therefore, we used the first week to allow participants to engage with their surroundings and to motivate self-reporting. During this week, we asked participants to use photos to record problematic situations in everyday life related to urban maintenance, inconvenience, safety, and crime, and send the evidence data through an instant messenger application. When recording data, we asked users to take pictures with the GPS data to collect information about the reported place. In addition, they were asked to describe the situation and reason for reporting along with the data.

In the second week, we asked participants to use existing reporting applications to capture and report on the same situation as the first week. We selected two applications that had been analyzed in the preliminary study; 'Report on the inconvenience of life' of the Ministry of the Interior and Safety and 'Smart Report' of the National Police Agency. Among diverse applications, these were the most actively used one.

To study why citizens sometimes have difficulties in reporting, we asked participants to send personal messages via the instant messenger when they wished to report a situation but were not able to do so. In this way, users were able to explain the circumstances and context of the report, along with a description of the reason why they could not formally report it.

After the experiment was completed for 2 weeks, we collected all the photographs and videos users took to elicit detailed representations of participants. Then, we interviewed each participant on the details of the reporting situation, problems, and what they expected (Figure 2). During the interview, we tried to identify the various contextual information that they experienced by showing the participants the location of the photographs and photographs on the map. We used the 'We Album' application ("We Album," 2017) to check the location of the photos taken by the participants during the experiment and to help participants explain detailed report situations.

4. 2. Data Analysis

To analyze the participants' application usage experience, we used an inductive, qualitative analysis approach to the interview data. All interviews (a total of 10 hours) were audio recorded and transcribed. Then, we performed a qualitative analysis to iteratively develop a classification scheme. In the early stage of analysis, we classified the data according to general process of public reporting (Problem Recognition Phase, Problem Reporting Phase, Problem Receiving Phase, Processing Phase). After this step, we reclustered the findings to gain meaningful insights at each phase.

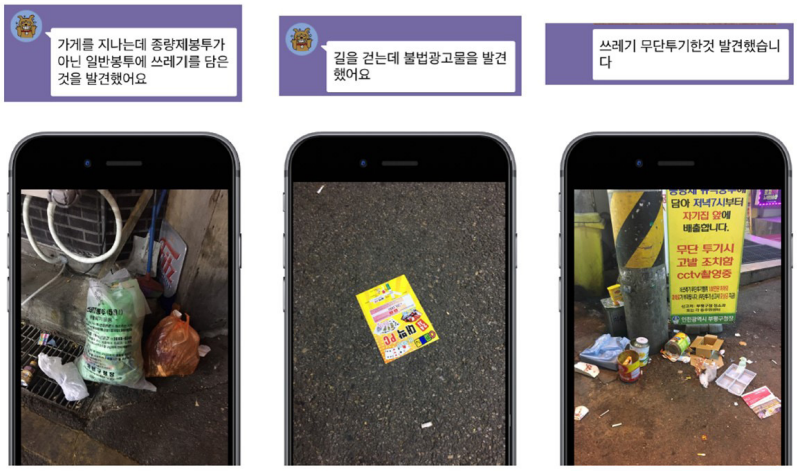

Figure 3 Reported Data by P1 in During 1st Week

5. Findings

Overall, participants were receptive to the idea of using mobile devices for public reporting during the first week. The reporting results from the participants in the first week are shown in figure 3. Participants recorded the situation they wanted to report 4.17 times (SD = 0.90) and sent them to the researchers (Figure 3). In common, participants found problematic situations around their home or workplace. For example, P1 sent pictures of garbage on the street. P4 found that some streetlights were out and illegal advertising materials had been posted on them.

In the second week, participants recorded a similar number of problematic situations. On average, participants recorded 4 issues (SD = 1.53) in the second week. However, we could confirm that the record of the problem situation did not lead to all the reports. The difference between the number of recordings and the number of valid reports was found as shown in the Figure 4. Among 4 recorded situations, participants actually reported 2.67 problems (SD = 1.25) to governmental agencies through the applications. So, what interrupted some of the participants' reports, or what caused them to not file a report at all? In the following sections, we analyze general user experiences and problems that occurred while using the actual reporting application, according to the application usage phase.

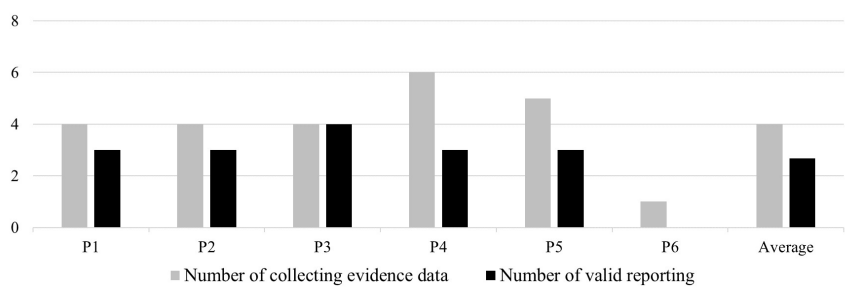

Figure 4 Public Reporting Activities During 2nd Week

5. 1. User Experience at the Problem Recognition Stage

The first step of the report begins with recognizing the discomfort surrounding citizens themselves. Most of the participants stated that they had encountered inconveniences in their surroundings, and they mentioned that they had wanted to improve the problems even before the experiment began.

However, they mentioned that they did not know of any public reporting applications or how to report problems to public agencies: *"I have not heard about the reporting process and I did not know where and how to do it because I did not know that the application could be used for public reporting"- P4*. When we introduced the existing reporting applications and their purpose through the experiment process, participants gave the opinion that they would value applications that encourage citizen participation.

While we expected that participants would file reports immediately after finding a problem, in most cases they tried to remember some problems encountered in their life that they wanted to report later on. As such, we found that participants were considering various factors from finding a problem to reporting it through an application. In the interview, we asked, "Why did you decide to capture and report the events?" From the responses, we identified several dimensions of deciding to report using affinity diagramming. The primary factors were *involvement, seriousness, frequency*, and *responsibility* of a problem.

• Involvement: Participants considered whether a problem was closely related to themselves or their surroundings. Most of the participants said that they had been interested in urban maintenance of their towns because they had experienced real problems: *"I have been living for many years in this town. I have been under the impression that there are too many illegal advertisements and road management is not working well. I was hoping this town would be improved, but now I have a chance to report it" - P3*. Taking into account the relevance to oneself, participants noted that even if they encountered some problems, they were hesitant to report them if there was not enough information about the area: *"If I find a problem in a place I do not know well, it is difficult to [determine if] the problem is severe or not" - P1*. In this way, participants could immediately determine the need to report when they had a problem at a familiar place in which they are closed related.

• Seriousness of a problem: If a problem seemed serious considering economic, environmental, or physical damage, participants tried to report it more actively. For example, P2 mentioned that the problem during car driving would always be considered serious because it might lead to an accident, while street garbage was not as serious: *"Things like road infrastructure damage are very dangerous when you drive. Such problems should be handled right away, and I am sorry that this has not been done for a long time" - P2*. Likewise, participants considered whether a problem needs to be addressed immediately or if it is acceptable for it to be handled more slowly. However, because the seriousness depends on personal evaluation, some participants had difficulties making this decision as well. For example, P3 responded that sometimes he worried that it would be annoying to report a problem that could be considered minor to others.

• Frequency of a problem: How often does the problem occur? How long has it been since the problem first occurred? In the case of P2 and P5, they stated that it would be necessary to report on a problem that has not been solved for a long time in the area: *"In fact, if people on this street often violate the traffic laws, I'll report the matter. Not only I, but also others may be harmed"- P5*, *"One day the trash was just up on the bus stop, and it was left for about*

a month. So, I decided to report it after observing it for several weeks" - P2. Apart from the scale of the damage from the problem, the frequent occurrence led the participants to predict that a governmental agency did not treat the problem properly because they did not figure out the situation at all. Thus, considering frequency and duration of a problematic situation, participants decided to report it.

On the other hand, in the case of P1, she said that if a problem occurred frequently and had not been solved for a long time, he would not report it because he thought that complaints would be neglected again by public authorities: *"Especially in the case of garbage dumping, it is so frequent that it will not be solved even if many citizens complain similar problems again and again" - P1*.

• Cause & responsibility: We found that participants also considered who caused the problem. In the case of driving situations or violent events, the fault of a certain person is relatively obvious. In such cases when a cause of a problem is clear, participants worried that their personal information would be disclosed to the suspects in the process of reporting, and the suspect who was accused might retaliate against them: *"When I should shoot someone else's car license plate as evidence, I thought it might be better not to report it, because I might have another problem later with the car owner" - P4*. *"I was afraid that I would have an uncomfortable relationship with someone else if I reported public discomforts by someone" – P6*. If a responsibility of a problematic situation was unclear, participants were less worried the accompanying problems. Instead, some of participants said they felt sorry for the public authorities who had to deal with the problems.

5. 2. User Experience at the Problem Reporting Stage

The report stage includes activities of collecting evidence and inserting information about the discovered problem through applications.

5. 2. 1. Difficulties in Reporting

In the course of this study, we heard about incidents when participants did not complete reports due to problems during application operation, even if they decided to report the specific situation.

• Insufficient guidance: Despite the relatively simple procedure of using the application, a guidance for reporting stages was insufficient for first-time users: *"I think it would be a little difficult if I had to complete the report by myself without any explanation. In my case, I think it was easy to use the application because of the researcher's explanation" - P1*. P3 responded that it was difficult to select a category for the problem situation: *"It was inconvenient to select a proper category where the reported situation belongs to at first."*

• Gathering valid evidence: A more serious difficulty was that it was uneasy and time-consuming to collect evidence data sufficient for the report to have legal effect. Although participants recognized problematic situations to be corrected and collected necessary evidence, they sometimes did not have practical effect and did not proceed to the problem receiving and solving stage. While some information, like location, is automatically recorded in some applications, participants still needed to prepare additional materials, like pictures, or provide details about the problem.

Several participants mentioned that it was not easy for them to collect, edit, and prepare the

evidence so that the data could be effective: *"In the case of illegal parking, I have to record a one-minute-long video or take two photos with a one-minute gap in the application. I thought it would be difficult to take that footage because I have to stay on the road" - P1*. According to governmental policy, if a citizen wants to report a problem regarding illegal car driving, it is necessary to attach a photograph showing clearly a car's license plate. However, problems arising during driving are often difficult to capture because the problematic situation often occurs in a short time and disappears: *"Driving-related problems are often found while I drive my car. It's hard to turn on an application and take clear pictures because the car is moving" - P5*.

In addition, participants noted that reporting during driving was even dangerous in practice. It was uncomfortable for participants to make a report because it might threaten the safety of the drivers on the road. Because the use of smartphones during driving is illegal according to the Domestic Traffic Act in Korea, participants hesitated under this contradictory situation: *"One of the reasons I did not report was not to crash a car. When I tried to shoot the car number clearly in the car, I was so anxious about car accidents. I will not use the app again while driving" - P6*.

In public reporting applications, it is possible to use evidence data captured from other devices, like a dash cam. Still, some participants felt burdensome in using other devices because they require effort to copy the data and edit them into the necessary format: *"To report it, users have to download the images stored in the dash cam in the car to their computers, which involves lots of boring steps. Who would do that annoying thing?" - P6*.

5. 2. 2. Reasons for Not Reporting Captured Events

There were several cases where, even after gathering the valid data for reports, participants did not proceed to the actual reports. Only 16 cases among 24 recorded cases proceeded to the final report in the second week of our study. From the interviews, we confirmed that there were other factors besides practical usability of public reporting applications, including issues of privacy and security.

Participants in this experiment expressed fear of privacy and anxiety about keeping anonymity in actual reporting situations. In particular, concerns about personal information protection were more pronounced when reported data included other persons or their information, like the case of parking violations: *"I cannot trust that my personal information in the reported content is not exposed to other people. Of course, it is a common sense that the personal information of the person reporting is not shown to others, but there is a question about whether it is 100% guaranteed" - P6*. P1 also responded that she was concerned about the leakage of personal information because of the fear of retaliation that might occur in the future.

Participants said that other people's negative perceptions about the report was an important factor of their hesitation in reporting: *"I want to take a picture and report with it. But since many people do not know about these reporting methods in general, they seemed to think my actions were strange" - P4*.

5. 3. User Experience at the Problem Receiving and Solving Stages

This step is the process of governmental agencies' accepting the contents reported by the

citizens through the application, confirming the contents of the application, reflecting it in the actual policy, or solving the problem. Originally, the problem receiving stage and problem solving stage were separately distinguished. However, because the two stages were not significant in terms of our participants' user experience, the results in the two stages were summarized together.

5. 3. 1. Feedback on Problem Solving

In the problem receiving and solving stages, many participants responded that they were positively surprised by rapid feedback from the governmental agencies. According to P2, P3, and P4's explanations, some agencies (e.g. district officers) called them to confirm the participants' information and to obtain more detailed information about the problems after receiving reports on the system. In addition, P4 said that government agencies sent an SMS after handling the problem: *"I expected that the notification about the processing would be a little bit late. But, right after my first report, I visited the same place the next day and I found that it was already processed" - P4*.

Despite the quick feedback, some participants were skeptical of the completeness of the problem solving because they could not view a detailed explanation of the results: *"Status information appears in the application and shows that my report is in process, but I do not know if the officers have found the cause of reported problem correctly or if they have difficulty in managing it. I was frustrated because I could not know whether I was being ignored or whether these people were solving the problem now" - P2*. *"If the agency finished my complaint, I thought it would be more reliable if they had sent me a picture as a result of my report" -P2*. Participants argued that to judge the result of the treatment, it would be important for governments to respond promptly and to provide concrete feedback on the result of the treatment.

5. 3. 2. Rewards for Civic Engagement

While we interviewed participants about the reporting process, they also gave their opinions about compensation and reward after reports. First, when asked about their opinion on monetary compensation, users suggested that it would be effective in the short term, but would not be a practical long-term possibility: *"I am a little skeptical about the monetary compensation. I think there might be someone who exploits a large amount of compensation. There may be people who just eat and do these five times a day" - P2*.

Participants also showed skeptical attitudes toward honorary compensation, such as providing points to users and upgrading users' levels inside applications. One of the reasons was related to privacy concerns and retaliation: *"I thought anonymity was important in reporting, but it's not a good idea to reward how much I have reported and show it to others" - P1*.

Many participants suggested that psychological satisfaction would be more important than other types of compensation. As individual users report problems they have personally experienced, participants noted that rewards would not be of much importance if initial motives and needs of reporting were strong enough: *"Whether the reported issues are handled quickly is the most important factor in participating in the report. Therefore, I do not think I will report because of the compensation" - P2*. The fact that filing reports might

prevent a participant's family or neighbors from experiencing problems also served as a factor for psychological satisfaction: *"I am pleased that the streets are arranged in aesthetically pleasing manner for my family" - P1. "I think I felt a little bit proud of what I have done for this town" - P3.*

6. Discussion

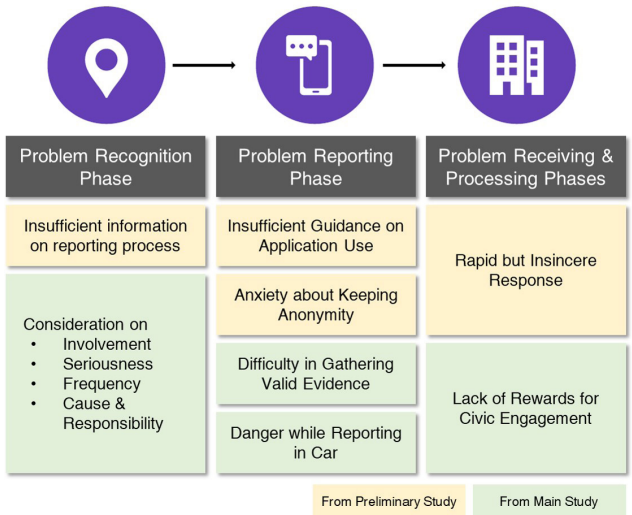

Figure 5 Problems of Public Reporting Applications

We found various problems that users experienced during the reporting process and discovered why they hesitated to use reporting applications (Figure 5). In the problem recognition stage, users decided whether to report or not by considering the involvement, seriousness, urgency, and frequency of a problem. At the problem reporting stage, there was an inconvenience in the process of collecting valid evidence. In addition, we found that there were several cases where users did not file a report even after collecting valid evidence because of concerns about their personal information. In the problem receiving and solving stages, we found that a more detailed explanation of the post-declaration process and emotional reward were insufficient.

So, how can we design a public reporting application that encourages citizen participation and induces long-term engagement? Based on the insights accumulated during the field study, we make the following suggestions on how to guide the design of smartphone application features supporting public report activities. Toward expanding citizen's use of public reporting applications, our main findings have significant implications in separate problem reporting stages.

6. 1. Design for the Problem Recognition Stage

• Explanation and guidance on the entire reporting process: One reason our some of our participants did not report public problems before our study was that they did not know how to file a report using an application or whether such application existed. Additionally,

although some knew public reporting applications, they wondered if the problem they discovered was notifiable. Also, the lack of guidance on how the reported problems might be handled later on made citizens hesitate.

Thus, when designing a public reporting application, it is necessary to include an appropriate explanation of the entire reporting procedure and how reported data will be utilized at the beginning of citizens' actual reporting. This will allow citizens to appreciate the value of the reporting application and gain trust toward the application and governmental agency.

• Share an urgency of a problem within local community: When a particular problem occurs and citizens find the problem, because their judgments are limited to a personal level, they sometimes feel difficulties in judging whether they are doing the right thing. Therefore, it will be necessary to be able to share opinions among other neighbors from the problem recognition stage. For instance, like Facebook's *Like* feature, the application might be designed to show that other people also experience the same problem and they need treatments at the same place. When significant amounts of agreement among citizens are made inside the application, the person who hesitates to report may feel increased confidence in his/her activities.

6. 2. Design for the Problem Reporting Stage

• Penetration of reporting in everyday life: Existing reporting applications have a limitation in that users must endure long and effortful reporting processes. Unless the motivation for reporting is clear and strong, the users might give up reporting during the application. Thus, there is a need for design that naturally infiltrates the reporting behaviors and procedures in the users' daily lives. For example, rather than developing separate reporting applications, a reporting feature might be added to frequently used applications, like navigation or a map.

• Computational support: Could mobile technology be used to capture the values associated with public inconvenience and urban maintenance and communicate the extent to which these aspects differ between locations? In some situations, participants were in dangerous situations for recording problematic situations with mobile devices. Like the example of taking a photo during driving, it is difficult for users to drive a car and launch an application for reporting the discovered problem.

We expect that computational support in reporting applications will help increase citizens' safe and convenient reporting. First, it would be possible to collect valid evidence data with the help of an application. If a user wants to report a car-related problem, the application could be automatically designed to detect and capture the image of a car plate, which is essential for problem reporting.

In addition, automatic sensing allows some of problematic situations to be tracked without human intervention. For example, tilt sensors could be used to map how streets vary in terms of gradient. Using sensors in a smartphone, applications can capture and detect various conditions (e.g. if the road is even or slippery). It might be impossible to confirm problems correctly only by a single mobile device. However, information may also be collected through crowdsourcing techniques. Ushahidi.com relies on willingness of the general public and the crowd's data to use the mobile phone to report cases of political unrest in various locations("Ushahidi.com," 2008). As in the previous case, synthesizing crowd device data in public reporting applications could increase the accuracy of sensing problems.

• Personal information protection: One of the most important issues in the problem reporting stage was related to protecting the identity of the citizen who requested problem solving. As found in our study, citizens might be afraid that their identity would be exposed to others. Therefore, before a citizen files a problem-solving request and uploads evidence data, the application's public agencies must provide detailed instructions on how the user's requests and evidence data would be processed. This may help reduce fears regarding privacy and anonymity and help form a sense of trust.

Additionally, it is possible to prevent the risk of leakage of personal information by supporting citizens' evidence editing. If the application includes image, video, or audio editing features (e.g. deleting voice in evidence video), citizens might be able to hide private information when uploading evidence data.

6. 3. Design for the Problem Receiving and Solving Stages

Violio et al. (Violi, Shneiderman, Hanson, & Rey, 2011) used Batson et al.'s motive framework (Batson, Ahmad, & Tsang, 2002) and showed that the key motives for participating in online neighborhood watch communities are egoism (for my safety), altruism (for others' safety), collectivism (for our community safety), and principlism (for social justice).

Although one of the biggest rewards for users might be that their request is processed quickly, there is also a need for design that provides psychological rewards for users' effort of voluntary participation.

As also mentioned by participants, emotional rewards can be provided through online community fostering. While information and communication technologies are increasingly used to support community policing efforts, designing web tools that provide information to citizens will not necessarily increase online participation. Our results suggest that web tools to support community policing should be designed to adhere to and support communication that allows residents to engage in collective problem-solving discussions and to informally regulate social norms. Using technology that facilities communication, citizens would be able to share personal experiences and strengthen social ties with other residents while also addressing crime and local concerns (Lewis & Lewis, 2012).

In the current application, individuals can communicate with organizations that deal with the problem to a minimum extent. But what is more important for reporting is communication with other citizens. In particular, it is important to let users know that bonds of sympathy are being developed among citizens and their participation is meaningful to their community even though the reported issue might not be solved. For example, it would be possible to design an application that informs citizens when local problems have been reported and solved.

A community fostering feature in reporting applications might induce activities, such as sharing and discussing issues in the community, through interaction with other individuals in the area. Accordingly, it might further lead to the effect of forming a social consensus.

6. 4. Redesigned Case

Based on the design implications, we designed an application as a proof of concept. It does not include all the design implications, still it shows how design of public reporting can be improved. As shown in Table 1, design implications were considered in this design. We created a concept video that describes main features (https://youtu.be/bMZu7vj2lPQ).

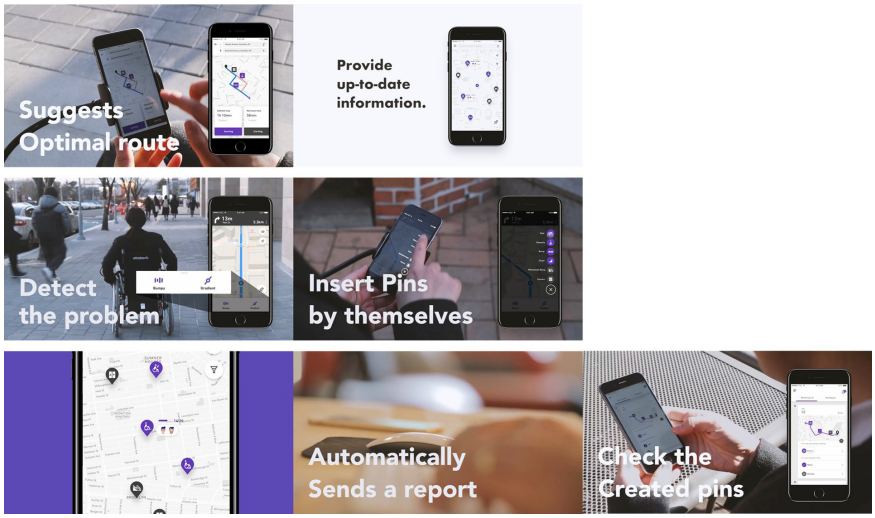

Figure 6 Wheeling: Crowd-based Navigator for Wheelchairs

Table 1 Features of Designed Example (Wheeling)

Step	Problem Recognition Phase	Problem Reporting Phase	Problem Receiving and Processing Phase
Features of Designed Example	• Share an urgency of a problem within local community	• Penetration of reporting in everyday life • Computational support	• Online community fostering

As a design example, we finally designed an application called "Wheeling" that not only includes public reporting feature, but also provides a map and navigation functions. It detects wheeling conditions of large areas with the help of crowdsourcing technology that connects multiple Wheeling users. The application support citizens' wheelchair riding and rapid road condition maintenance.

• Wheeling Route Guidance: To enable the penetration of reporting in everyday life, we designed Wheeling as a navigator rather than just a reporting application. The application suggests an optimal route to travel in a wheelchair. The application guides the user to avoid obstacles, such as stairs or steep slopes and recommends facilities, such as elevators, with easy access for wheelchairs. To find the right path for a wheelchair, the application manually or automatically collects diverse conditions of the Wheeling path and updates the data into the Wheeling map in real time. This feature shows how the design implication of '*sharing an urgency of a problem within local community*' is applied in this system.

• Automatic detection of road conditions: This application supports users with automated problem detection. It detects problems occurring when users are in a wheelchair by using a tilt sensor, a gyro sensor, camera, and GPS inside the mobile devices and adds them into the Wheeling map. For example, when a user passes a road and enters a ramp, the application analyzes the slope through the tilt sensor to determine drivability. In addition, the application judges whether the road surface is even or uneven and reflects it on the map. In case of detecting difficulties in wheeling, the app takes a photo automatically and pins are plugged into the map, so that it can be quickly responded to when other users are guided along the road.

• Manual road condition reporting: In addition to automatic detection, this application allows

users to participate manually in updating wheeling-friendly maps with just a few touches. For example, if they find wheeling-friendly facilities, like a staircase or elevator on the road, users can recommend the place immediately in the Wheeling application while adding GPS data and photos as evidence.

As noted above, automatically and manually recorded wheeling points (Wheeling Pin) are shared with all wheelers. This Wheeling Pin share is used to incrementally refine Wheeling's crowdsource-based map and provide up-to-date best wheeling routes. We expect this map will foster positive use of online community and their gatherings.

• Road condition improvement: To improve the fundamental problems of wheeling conditions, technical support of Wheeling is given to users to easily capture problematic situations, so that valid evidence data can be delivered to local governmental agencies. First, as several Wheeling users go through the same road and enough data about bad wheeling conditions are automatically accumulated, the Wheeling app automatically sends a report to the appropriate local public agency. In addition, users can check the automatically-detected and user-created Wheeling pins in the past Wheeling List and file a request to public agency. Finally, Wheeling users can constantly monitor whether the reported problems are being resolved by public agencies.

6. 5. Limitation

Despite several contributions of this study, there are limitations and issues that should be investigated further. First of all, we could not cover diverse types of public reporting applications in this study. We expect that there might be other problems in the reporting process because of differences in their functions and themes of reporting. Although we have dealt with representative reporting applications, applications for a specific situation such as driving in a car should be studied further. Second, participants in our study were mainly young generations who can access mobile technologies easily. Considering diversities of citizens, it is expected that citizens' user experience will be different depending on their age, technology familiarity or cultures. Especially, the elderly citizens might have difficulties in using mobile application, thus we need further research on how technology, cultural and environmental factors should be considered for public reporting. Third, from the perspective of service design, there are various stakeholders such as citizens, civil servants, and practitioners etc. for a reporting application. While we only focused on one stakeholder (citizens), it is necessary to identify and improve the problems that other stakeholders face as well. Besides, we should study the interactions among various stakeholders and the problems that arise in them.

7. Conclusion

Public reporting with mobile devices is a novel medium for enabling citizen engagement, and its adoption has significantly increased among several nations, such as Korea and the United States. Despite its potential, this new technology has received little attention of citizens in practice. Our goal was to explore difficulties in public reporting applications. Our user

study results revealed that the key factors for making reporting decisions were involvement, seriousness, frequency, and responsibility of a problem. At the problem reporting stage, collecting valid evidence made public reporting more challenging. In addition, concern about personal information protection was another factor for citizens' demotivation during reporting stage. Finally, explanation of how evidence data would be managed and emotional reward were insufficient at the problem receiving and solving stages. Our findings provided several practical design implications, such as penetration of reporting in everyday life, computational support, and community fostering. Also, the designed example will inspire other designers and researchers to develop more citizen-friendly public reporting applications.

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