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Evaluating a Mobile Visualization System for Service Delivery Problems in Developing Countries

Hannah THINYANE[1], Ingrid SIEBORGER[2], Edward REYNELL[2]
[1]*United Nations University on Computing and Society, Casa Silva Mendes, Estrada do Engenheiro, Trigo No 4, Macua SAR, China*
Tel: +853 2871 2930, Email: hannah@unu.edu
[2]*Department of Computer Science, Rhodes University, Prince Alfred Street, Grahamstown, 6139, South Africa*
Tel: +27 46 6038291, Fax: +27 46 6037608, Email: i.sieborger@ru.ac.za

Abstract: MobiSAM is a project aimed to increase citizen participation in local government using mobile devices in order to further the reach and usefulness of the Social Accountability Monitoring (SAM) methodology to ordinary citizens. The project began in 2011 and there have been a number of HCI interventions over the years that have been undertaken to inform the design and subsequent redesign of the system based on the results of a number of evaluations. This paper begins by discussing the interaction design lifecycle model, illustrating how the different interventions were undertaken as part of the cycles that have been involved to date. It then provides details on two such interventions: an evaluation of the navigation and visualization aspects of the MobiSAM client application; and the evaluation of a streamlined app aimed to simplify the process of reporting problems with service.

Keywords: user study, mobile phone, citizen participation, evaluation

1. Introduction

In South Africa, protests and campaigns about a lack of service delivery appear to be on the rise [1]. While South Africa possesses a progressive legislative framework for service delivery, when it comes to implementation at the local level the reality is different [2]. Especially disconcerting is the lack of services in poor rural and informal settlements of the country [3], stemming from the legacy of Apartheid era. As such, while some progress has been made, a need still exists to address service delivery challenges being experienced in predominantly poor communities, rural areas, and informal settlements of South Africa. Since the abolishment of the Apartheid era, the South African government, being aware of this challenge, has taken a pro-poor stance, to ensure service distribution [4]. Therefore, to achieve their goals and objectives, it is incumbent on government to engage with citizens in seeking optimal ways of addressing the problem.

Particularly pertinent to service delivery in South Africa, is the need to institute effective and efficient channels of information and communication flows between multi-stakeholder groups involved and affected by service provision processes. Stakeholders include municipal employees, citizens and service providers (private and public), to name a few. For example, in water service delivery, data flows between stakeholders consist of supply chain logistics, transparency exhibition, feedback from water users on service quality, billing transactions, subsidy considerations and water demand management aspects, amongst others [2], [5].

When we consider the use of mobile devices to increase citizen participation in government, we see that the new platforms are opening up new possibilities and spaces "for different forms of political discourses and networking" [6]. Within Africa, there has been a dramatic rise in the use of mobile phones in the past 20 years. This rise has been shown to stem from a number of different sources. South Africans are now using mobile phones more than any other modern and traditional ICT, including computers, televisions, and radios [7]. As well as access to mobile devices, South Africa has also been ranked as fifth in the world for mobile data usage [7], ahead of countries such as the United States of America, which ranks seventh.

MobiSAM is a system that allows individuals (citizens) to use their mobile phones to voice their opinion or provide information in any number of polls, from identifying or ranking their most pressing needs to reporting on service delivery problems or on the quality of delivery. The initial motivation for the application came from realising that the high penetration rate of mobile phones in developing countries could contribute to empowering citizens to participate in democratic governance processes, primarily by allowing individuals' views and opinions to be heard. By including location information (whether collected through user profiles, cell phone triangulation using cell phone tower locations, or GPS location), results of polls would be able to be collated and visualised by geographical region. MobiSAM can be used for: reporting service delivery problems; collating and visualising reported problems; monitoring reports; and supporting two-way communication between citizens and local government. First, citizens can use MobiSAM to report cases of service delivery problems to their local government. Also important, however, is the support for communication from the municipality back to citizens. MobiSAM supports this by allowing the municipality to send SMS to citizens to update them on the progress of their reports, or provide information to them regarding planned and unplanned outages. This paper describes a series of interventions undertaken to inform the design and evaluation of MobiSAM, a system aimed to increase citizen participation in local government using a mobile phone, around the area of service delivery.

2. Methodology

This research was undertaken using the interaction design life-cycle model. The life-cycle model encourages iteration and user focus. As such, the life-cycle model was iterated through three times, generating alternative designs and thereby shaping and refining the resulting applications. The importance of this process is highlighted by Rogers et al. who argue that "generating alternatives is a key principle in most design disciplines, and one that should be encouraged in interaction design" [8, p. 166]. The four activities are: identifying needs as establishing requirements; develop alternate designs that meet these requirements; build interactive versions of the designs so that they can be communicated and assessed; and evaluate what is being built throughout the process.

This section describes the research methodology utilized to guide this work. It starts by providing a description of Makana Municipality, the municipality where a three and a half year research project and pilot study was undertaken to evaluate the use of MobiSAM to increase citizen participation in local government (Section 2.1). It describes the interaction design life-cycle model as it was applied to this research (Section 2.2). Finally it provides an overview of the main interventions undertaken to inform the design of the system (Section 2.3). Sections 3 and 4 follow with a discussion of the evaluations performed of the MobiSAM system.

2.1 Case Study

Makana Municipality is situated in the Eastern Cape Province; one of South Africa's poorest provinces. The area experiences a high unemployment rate (65.52%) and low levels

of formal education (28.52% of residents have received a primary school education or none at all) [9]. As a result, 64.35% of Makana residents live below the poverty line [9] (defined by Statistics South Africa as earning less than R801 per month). Efforts to alleviate poverty are hampered by a sluggish economy and there is an increasing dependency on social grants; 45.5% of the total Makana population received some form of government grant in 2011 (compared with approximately 29% of the national population receiving some form of government grant in 2011 [9], [10]). This places a significant burden on the municipality, particularly in delivering basic services. The municipality is responsible for (amongst other things) municipal health services; municipal roads; sanitation; electricity reticulation; potable water; refuse removal, refuse dumps and solid waste disposal; child care facilities; and local tourism [9]. Despite a R266 million budget in 2009/10 [11], 4.3% of Makana households had no access to potable water (of those who do have access, 10.94% do not have access to water on their property and have to walk to a communal access point) and 25.58% had no access to sanitation (defined as access to a flush toilet) [9]. The National Auditor-General (AG) has repeatedly found the municipality unable to adequately account for the use of public resources. From 2010 – 2014, the AG could not obtain sufficient audit evidence from the municipality to account for its expenditure, resulting in four successive disclaimers of opinion [12]. In years where enough evidence was provided to perform a partial audit, the municipality continually overspent on operating costs (269.2% in 2012, 120.8% in 2014), and underspent in capital budget (34.5% in 2012, and 78.8% in 2015) [12].

The situation in Makana Municipality is comparable to many local municipalities across South Africa, where "local government capacities are in short supply and financial sustainability is frequently in doubt. This hampers total government ability to perform traditional functions such as service delivery and regulation, collecting rates, user charges and fees" [13, p. 337]. However, this is not a problem that is unique to South Africa, but has been demonstrated on numerous occasions and across a number of different contexts. A recent cross-country, empirical evaluation found similar evidence across developing countries around the world [14].

2.2 Interaction Design life cycle model

During the course of the study two MobiSAM applications were developed; MobiSAM and MobiSAM Report. Three iterations of the life-cycle model were completed during development of the MobiSAM client applications; each of the iterations will be discussed briefly in this section.

- **Iteration 1**. The first iteration aimed to develop prototype client applications. Initial requirements were gathered from the MobiSAM project director and Makana Municipality. Two prototype client applications were developed based on the initial requirements; one targeting the Java ME platform and the other the BlackBerry OS. In an attempt to eliminate major usability problems, an informal evaluation of the applications was conducted with two expert users.
- **Iteration 2**. The second iteration incorporated feedback from the evaluation conducted in the first iteration. As a result of the initial evaluation it was decided to leverage a cross-platform mobile framework instead of developing multiple client application natively. A number of frameworks were evaluated, ultimately resulting in the choice of Codename One as the most appropriate cross-platform framework. The two prototype client applications from the first iteration were subsequently redeveloped as a single cross-platform client application, which was assessed via a usability evaluation involving 30 participants.
- **Iteration 3**. The final iteration incorporated feedback from the usability evaluation conducted in iteration 2, the initial baseline study as well as additional requirements

from MBB Consulting Engineers, a firm tasked with water reticulation within Grahamstown. This resulted in alterations being made to the original MobiSAM cross-platform client application, as well as the development of a second, more specialized cross-platform client application: MobiSAM Report. These two applications were then evaluated side-by-side with 10 participants, in an attempt to determine which version participants found most intuitive and appealing.

2.3 Baseline Investigation

This section presents the initial baseline study conducted within Grahamstown, the largest city within the borders of the Makana Municipality. The study attempted to empirically investigate how local residents are currently using mobile technology and participating with local government around the area of service delivery. The results of the study were used to inform the design of the MobiSAM client applications, in an attempt to ensure that user requirements and expectations were satisfactorily met. The complete findings of the baseline study are beyond the scope of this paper, but can be found in [15]. The primary findings of the baseline study that can be applied to this research are summarized below:

- An application that facilitates communication between citizens and the local municipality should be available for Android, iOS, Blackberry, Windows and Java based handsets to cater for 80% of those used within Makana Municipality.
- There should be support for English, isiXhosa and Afrikaans languages to cater for 98.1% of citizens preferred languages.
- While data was highly ranked in terms of importance, only 60% of citizens knew if their phone was capable of 3G or WiFi. As such, SMS support should be available.
- The majority of citizens surveyed earned $US235 per month or less. As such the application should be conservative on data usage to minimize expenses.

3. Learnability and Memorability Evaluation

Two separate evaluations were undertaken of MobiSAM, the first of which aimed to determine the learnability and memorability of the visualization and navigation. The evaluation aimed to: determine how intuitively participants were able to navigate within the client application; understand how effective different visualization techniques were at conveying meaning to participants, as well as the role which interactivity played in helping participants better understand visualized poll results; and identify any usability and functional problems to be addressed during subsequent development iterations.

3.1 Method and analysis

Thirty participants took part in this study from a broad cross section of age groups. Only citizens aged 18 years and older were asked to participate (participants younger than 18 require parental consent and are less likely to participate in local government and service delivery concerns). A stratified sampling technique was employed with opportunity sampling for each age strata.

In total there were four tasks developed for this study that provided different scenarios for reporting service delivery problems. Due to time considerations, participants were only asked to complete two of the four tasks each. All combinations of tasks were investigated, which meant that each combination was performed by five different participants. A pre-intervention questionnaire, post-task questionnaires, and post-intervention questions were used to solicit feedback on: demographics and mobile phone usage habits; immediate responses to each task; and participants' feedback on application navigation and visualisation.

Ethics approval was obtained from Rhodes University (Cs13-12), and researchers began recruiting participants from public spaces across Makana Municipality. A field setting was

employed during the study in an attempt to mirror the variable physical environment in which the first client application (MobiSAM) is likely to be used. Once consent was provided, participants were asked to complete the pre-intervention questionnaire (with English and isiXhosa translations when required). After completing the questionnaire, participants were given a choice between a QWERTY keypad device (Nokia Asha 201) and a touch screen device (Samsung Galaxy Pocket), and were asked to choose the device that best-matched their own phones. Once the device was selected, participants were given two minutes to explore the MobiSAM application. No help was provided to the participants during this stage. When the two minutes were complete, participants were presented with the task questionnaire containing the pair of tasks they were to complete. At the end of the two tasks, the post-intervention questionnaire was provided. For each task the following measures were recorded: completion rate (1 for completed successfully, 0 for not completed); time on task; number of button presses; and subject satisfaction. For each task and each device, the error-free values for button presses were first recorded by the researcher in order to obtain a baseline to compare participant's behaviour against.

Data triangulation was included by incorporating data from the three questionnaires as well as recording observations made by the researcher for each participant, such as problems that were encountered when attempting to complete tasks.

3.2 Results

A complete discussion of the results of this evaluation is beyond the scope (and space) of this paper. Instead, a summary of the pertinent results is provided below, categorized as navigation or visualization findings.

Figure 1: (a) MobiSAM and (b) MobiSAM report interfaces

Navigation: The first and most interesting finding was that participants found it difficult to navigate around the MobiSAM application to find the place to report service delivery problems. When responding to the Likert-scale question "Finding the correct poll was confusing", 6.67% responded 'Strongly Agree', and 46.67% responded 'Agree'. When asked to explain their response, six participants cited confusion with the wording on the interface. Once a poll was found, participants suggested that completing the report was straightforward (94.67% strongly agree or agree).

Visualization: As illustrated in Figure 1 (a), results were automatically collated and visualized in bar and pie charts. 92.85% of participants responded to the following statement positively: "The charts were easy to understand". Participants showed a preference for pie charts (46.67%) compared to bar charts (20%). This is interesting as related work has shown that human perception is less accurately able to judge differences in area, compared to differences in height [16]. The final visualization finding was regarding the interactivity of visualizations. When segments of charts were selected, extra information was presented. Part of the study aimed to determine whether this interactivity encouraged participants to explore the results. In this evaluation 75% of participants did not use the chart interactivity, and three participants commented that they were unaware of the features, despite the screen title that stated "tap chart for more details".

4. MobiSAM and MobiSAM Report Evaluation

One of the key findings of the first evaluation was that participants struggled to identify the method of reporting service delivery problems. This was considered to be a critical issue, so along with feedback from water service providers and the municipality, a second streamlined version of the MobiSAM application was developed, referred to as MobiSAM Report. This application favoured an efficient reporting of service delivery problems at the expense of some of the visualizations and other features that were available on the initial MobiSAM app.

The second evaluation compared the two client applications, assessing them against three of Nielson's five quality components of usability: learnability, memorability, and satisfaction [17]. The first component was chosen as client applications need to be easily learnt, with minimal training. The second aims to ensure that citizens are able to quickly re-establish their proficiency, as there are likely to be long spells where the client applications are not used. While the third component was chosen in an attempt to ensure that citizens find the UI pleasant and engaging to use, therefore increasing the likelihood that they continue using the application, as opposed to seeking alternative avenues of complaint.

Instead of conducting the study on a new set of participants it was decided to employ a self-selection sampling technique, enlisting ten participants who had taken part in the initial usability evaluation. While this meant that the sample was not truly representative of the Grahamstown population at large, it allowed the researcher to evaluate the memorability of MobiSAM by gauging how easily participants were able to re-establish their proficiency at using the initial client application.

4.1 Method and Analysis

Four tasks were constructed as part of the usability evaluation, each designed to be representative of the client applications' real world use. A within-groups study design was used whereby the same ten participants were used to test both client applications. Once a participant had performed all four tasks using the MobiSAM application they were asked to repeat the tasks using the newer MobiSAM Report application. The order in which each client application was presented to participants was counter-balanced in an attempt to mitigate learning effects.

A number of performance measures were recorded for each task including completion time, display press count, and a usability rating. In addition, a number of questions were presented to participants at the end of the study in an attempt to collect more qualitative information.

4.2 Results

Results from the study indicated that there was no statistically significant difference ($p < 0:05$) in task completion times between MobiSAM and MobiSAM Report. Participants did, however, make fewer display presses performing Task 2 and 3 using MobiSAM Report, the results of which were statistically significant ($p < 0:05$). Due to the (relatively) small sample size, and the fact that the sample was self selected and therefore not representative of the population, the remainder of the discussion of results will instead focus on qualitative feedback. Qualitative feedback from participants highlighted that MobiSAM provided a more learnable UI when compared to MobiSAM Report. Similarly, participants rated MobiSAM to have a more memorable UI, primarily due to the continual guidance it provides. The process of completing a report on MobiSAM Report requested more information from the user, and this was one of the points that participants looked on less favourably. This is an interesting point, as the 'additional information' included specifics of the problems that they were asked to report on (for example location of water outage).

Two participants indicated that their previous use of MobiSAM in the initial evaluation made them feel more comfortable with this interface.

MobiSAM Report was rated as more pleasing to use as participants showed a preference towards the Home screen's gird layout and large icons. They also mentioned a preference for the use of pictures and graphics on the home screen (Figure 1(b)), representing the different categories of service delivery problems. Another participant described the use of these images as helping them not to make mistakes in their reporting.

In concluding the evaluation, participants were asked to identify components that they preferred across the two apps. They are summarised as: clean and simplistic interface for MobiSAM; "Other" category for MobiSAM to allow users to report service delivery problems that participants could not clearly identify; use of "Update profile" term rather than "Settings" as it seemed more personal; streamlined method of reporting in MobiSAM; Home screen icons for MobiSAM Report; the use of thumbnails to represent captured images in MobiSAM; the plain background of MobiSAM app; the use of multiple steps with breadcrumb trail between steps in MobiSAM as compared to the requirement to scroll (on some phone displays) in MobiSAM report.

5. Discussion and Conclusion

This paper motivated for the use of mobile phones in increasing citizen participation with local government. After presenting the problem area and prosing how the use of mobile phones could help in facilitating meaningful citizen participation we presented the MobiSAM applications and the evaluations that were undertaken in order to assess their quality. The second evaluation saw participants perform four tasks using each client application which aimed to examine a broad range of their functionality. Comparisons between MobiSAM and MobiSAM Report were drawn using three of Nielson's five quality components (learnability, memorability and satisfaction) in an attempt to determine which client application was most preferred by participants. Results from the study indicated that although participants were able to perform the equivalent tasks in slightly less time (and with fewer display presses) when using MobiSAM Report, the improved guidance and assurance offered by MobiSAM highlighted it as the fractionally preferred client application amongst participants. Although no statistically significant difference in preference existed between MobiSAM and MobiSAM Report when compared according to the 'satisfaction' component, it is interesting to note that the grid layout of MobiSAM Report was found pleasing by most. As such, it may be worth combining the different approaches taken by MobiSAM and MobiSAM Report in a future release of the application. For example, by employing the grid layout and icons used by MobiSAM Report while at the same time maintaining the 'guiding' nature of MobiSAM. The findings from these evaluations will be used to design the next version of the MobiSAM client application.

The impact of MobiSAM during phase 1 was significantly hampered as a result of political instability and poor communicative practices within Makana Municipality. Thus, while citizens were making use of the application and reporting service delivery issues, they were being largely ignored by the municipal structures. A second phase of this pilot evaluation is being undertaken in 2016-2017; which aims to *capacitate* municipalities to improve their internal communication first, and then provide tools to communicate externally with citizens in order to hopefully be more effective at positively impacting service delivery and two-way communication between local government and citizens.

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