GI_Forum 2016, Vol.1
Page: 117-132
Full Paper
Corresponding Author:
karl.atzmanstorfer@sbg.ac.at
DOI: 10.1553/giscience2016_01_s117

HCI-Evaluation of the GeoCitizen-reporting App for Citizen Participation in Spatial Planning and Community Management among Members of Marginalized Communities in Cali, Colombia

Karl Atzmanstorfer[1], Anton Eitzinger[2], Beatriz Eugenia Marin[3], Andres Parra Arteaga[3], Bryan Gonzalez Quintero[3] and Richard Resl[4]

[1] University of Salzburg, Austria

[2] International Center for Tropical Agriculture, Cali, Colombia

[3] Institución Universitaria Antonio José Camacho, Cali, Colombia

[4] Universidad San Francisco de Quito, Quito, Ecuador

Abstract

Increasingly, geospatial web applications such as www.fixmystreet.com or www.seeclickfix.com are being integrated within citizen participation processes in spatial planning and the provision of communal services. Recently, several of these platforms have been launched in Latin America and other countries of the Global South. This development raises the questions of whether citizens with low ICT-skills can fully access and use these tools, and hence whether they are empowered to participate in related community management processes. The *GeoCitizen* framework (www.geocitizen.org) has been designed specifically to address citizens who tend to be excluded from established planning processes, providing them with accessible and easy-to-use online tools to make their voice heard through the public space of the internet. This paper describes the set-up and results of a Human Computer Interaction (HCI) Evaluation carried out for the *GeoCitizen*-reporting application amongst members of marginalized communities in Cali, Colombia. It investigates whether spatially illiterate users with low ICT-skills can access and use this application to its full extent. It analyses the most common usability issues that were identified by the test user group and gives indications as to how geospatial web applications should be designed in order to meet the challenges that come along with its use.

Keywords:

geospatial-web applications, PPGIS, HCI-evaluation, usability, marginalized communities

1 Geoweb Technologies, Public Participation GIS and the Digital Divide

In recent years, extensive research has shown how *Public Participation GIS* (PPGIS) can empower marginalized communities to participate in decision-making processes related to spatial planning, community management and urban development (Carver et al., 2001; Ghose, 2001; McCall, 2012; Mukherjee, 2015; Ramasubramanian, 2010; Sieber, 2006). Today, the geo(spatial)web, which combines geographical information, internet technology and social networking to produce, use and exchange geo-spatial information (Scharl & Tochterman, 2007), is an intrinsic part of many PPGIS frameworks (Pfeffer et al., 2015). An increasing number of cities provide geospatial web platforms (e.g. www.fixmystreet.com, www.seeclickfix.com or http://www.frankfurt-gestalten.de/) as well as mobile applications (e.g. 'Salzburg:direkt' or www.citysourced.com/) in order to reach out to their citizens and enable them to participate in the provision of communal services, planning of infrastructure projects, and other developments that affect the livelihood of their communities. Recently, similar applications have been launched in Latin America (e.g. www.ciudadanosactivos.com/, www.barriosactivos.com or http://www.colab.re) and other countries of the Global South.

However, the increasing use of geoweb technologies within PPGIS and community management projects has revealed critical issues that must be addressed for a comprehensive assessment of whether or not these technologies lead to inclusion or further exclusion of members of marginalized communities who should be empowered to engage in better management of their living environments (Elwood & Leszczynski, 2013; Haklay, 2013; Mukherjee & Ghose, 2012; Sui et al., 2013). Ethical issues such as the privacy of shared (locational) data and abusive user behaviour (Ashley et al., 2009; Torrens, 2010), the shortcomings of geo-technologies in representing the perspectives of minority and vulnerable groups (Pfeffer et al., 2015), as well as the issue of ownership of (local) knowledge mapped through crowd-sourced data (McCall, 2012) have to be considered when designing geospatial web applications for a PPGIS environment. In general, maps and data created in these applications tend to reflect the reality of the wealthier and more technologically experienced individuals and communities; they do not represent the qualities of a random sample population. Therefore, they tend to perpetuate existing power relations (Caquard, 2013; Elwood, 2008; Fischer, 2012; Ghose, 2007).

The unequal access to and limited use of *Internet and Communication Technologies* (ICT) can therefore be considered major obstacles for successfully introducing geoweb technologies into citizen participation initiatives in urban planning and community management. This is what the term 'Digital Divide' refers to. This phenomenon is defined as a 'gap between people and places with regard to their access to ICT and the use of the internet for a wide variety of activities' (OECD, 2008). Nielsen (2006) provides a broader definition, in three parts: (1) The Economic Divide refers to unaffordable prices for computer hardware or the lack of broadband data transmission to rural and poor urban areas (Geissinger, 2006). With the advent of mobile technology, this also implies having access to GPS- and internet-enabled mobile devices, adequate bandwidth, and data download volume at a reasonable price (Pfeffer et al., 2015). (2) The Usability Divide (or secondary digital divide) refers to how complex technology hinders users with low literacy skills (such as senior citizens or members from deprived socio-economic areas) in fully accessing and using ICT. (3) The Empowerment Divide relates to how only a few people make full use of the opportunities that such technology affords, although they would be literate enough to do so (e.g. when uncritically selecting the first results in search engines such as Google).

Usability issues are considered a major parameter in the design process of geospatial web applications for spatial planning and community management initiatives that aim to bridge the digital divide (Adebesin et al., 2010; Haklay et al., 2010). User-friendly tools and frameworks should address users who do not have the necessary skills for handling and processing spatial information adequately. These skills are what scholars such as Bednarz & Kemp (2011) and Goodchild (2010) refer to as Spatial Literacy.

In an attempt to approach the question of whether or not citizens with low ICT skills can fully access and use geospatial web applications for spatial planning and community management, and hence whether they are empowered to participate in related decision-making processes, this research carried out a *Human Computer Interaction* (HCI) evaluation of the *GeoCitizen* reporting application amongst members of marginalized communities in Cali, Colombia, with a specific focus on usability issues. This mobile application is part of the *GeoCitizen* framework (www.geocitizen.org), which aims at engaging citizens, local initiatives and organizations in taking collective action regarding the conservation, management and design of their neighbourhoods and communities. The *GeoCitizen* framework merges geoweb technologies and social media in a comprehensive approach for participatory spatial planning and community management, allowing citizens and communities to collaboratively report observations, to discuss ideas, and to solve and monitor issues in their neighbourhoods through the public space of the internet. This framework is currently being evaluated in a field study in two pilot communities of Quito Sur, Ecuador (http://geobarrio.blogspot.com).

2 HCI and geospatial web applications

The advent of the geospatial web in recent years (Atzmanstorfer & Blaschke, 2013; Mukherjee, 2012; Pfeffer et al., 2015) has not only made geoweb technologies available to a mass public of non-expert users, but has also altered the requirements and parameters of HCI and usability, especially within PPGIS projects and community-engagement activities. Nowadays, geoweb technologies aim at reaching out to the general public by providing basic applications for simple tasks, instead of combining complex functionalities in expert GIS desktop systems (Haklay & Chao Li, 2010; Mittlböck et al., 2012; Skarlatidou et al., 2013). Hence, it is especially important to take into consideration the user context when designing and evaluating these applications. Skarlatidou (2010) lists the following dimensions in determining the user context: (1) the user's characteristics and needs such as age, level of experience with similar applications, and educational background; (2) the user's goals (their expectations with regard to the application) and tasks (or steps to accomplish a goal when using the application); (3) the user's spatial and domain knowledge; (4) the user's mental models of a system (their expectations as to what will happen when a specific action is performed; the vocabulary and metaphors that are used for describing system elements).

Because Human Computer Interaction focuses on the development of interactive software user-interfaces (Shackle, 2009), a key concept of HCI is *User Centered Design* (UCD). This aims at supporting the entire product development process with user-centred activities in order to create applications which are easy to use and fulfil the needs of the intended user groups (Norman & Draper, 1986). Within common UCD approaches, a plethora of HCI techniques are available to developers of geospatial web applications, suited to particular evaluation aims and objectives (Table 1).

Table 1: HCI techniques for evaluating geospatial web applications, according to Marsh & Haklay (2010)

Evaluation frameworks	Evaluation methods	Data collection techniques	Data analysis techniques
Formative evaluation	Usability tests	Questionnaires	Content analysis
Summative evaluation	Field studies	Interviews	Statistical analysis
Rapid prototyping	Cognitive walkthroughs	Focus groups	Performance measures
Case studies	Task analysis	Think aloud protocols	Problem frequency counting
Remote studies	Heuristic or guideline-based evaluations	Diary keeping	Discourse analysis
		Eye-tracking	

Whatever HCI technique is applied in a software-development process or research project, the problem of ecological validity is particularly acute when evaluating software created for mobile devices or web applications (Lindgaard et al., 2005; Marsh & Haklay, 2010). Ecological validity refers to the extent to which conditions simulated in the laboratory reflect real-life conditions (Brunswick, 1955), which is of specific importance when designing applications for PPGIS projects.

Experiences of research and application in Usability Engineering (UE) led to standards that provide a solid base for HCI-evaluation processes in software development. The ISO 9241-210 standard defines usability as 'the effectiveness, efficiency, and satisfaction with which specified users achieve specified goals in particular environments' (ISO, 2010). The ISO/IEC 25010:2011 standard mentions usability as one of the eight characteristics defining the quality of a product (functionality, reliability, efficiency, security, compatibility, maintenance and portability being the other seven; ISO, 2011). Recently, the concept of User Experience (UX) has placed usability in a broader approach that describes the subjective experience people have when using a particular software (Hassenzahl & Roto, 2007; Roto et al., 2011). UX deals with categories such as comfort, sociability, safety, performance, usability, acceptance and identity (Tschigeli, 2013). Usability models for mobile applications have to take into account several parameters that differ from those for desktop and web applications (Budio & Nielsen, 2012; Delikostidis, 2007; Madrigal & McClain, 2010; Zhang & Adipat, 2005): (1) physical restrictions of mobile devices (small screens, keyboards, limited processing and memory capacities, varying display resolutions); (2) limitations on bandwidth, network access and network reliability; (3) limited data entry models, increasing the likelihood of erroneous input and decreasing the rate of data entry; (4) competition between the mobile space and the distracting environment that surrounds the user.

When talking about the operational framework for evaluating geospatial web applications, especially within research projects with a limited budget and a challenging organizational set-up typical for PPGIS-initiatives, Nielsen (1994a) advocates 'guerrilla usability'. This approach deploys usability tests with a limited number of test users, based on his research showing that most usability issues can be identified by having just five test users. This approach was applied in the HCI-evaluation of the GeoCitizen reporting application presented here.

3 Case Study: HCI-evaluation of the GeoCitizen reporting App

This research relates to the methodology for HCI-evaluation of geospatial web platforms developed by Ferré Grau (2005), which was based on the work of Nielsen (1994b). It proposes a process with three principal stages:

1. Predesign Stage, consisting in (a) identifying and analysing typical platform users, and (b) defining typical tasks that should be performed
2. Prototype Design
3. Prototype Evaluation carried out through either (a) a usability test, or (b) a heuristic or guideline-based evaluation.

This *Predictive or Formative Evaluation Framework*, which allows an empirical evaluation of user interaction, is particularly useful for evaluating geospatial technology tools developed by small research teams (Bowman et al., 2002; Marsh & Haklay, 2010).

User Analysis

As the GeoCitizen framework aims in particular at integrating members from marginalized communities into decision-making processes in their neighbourhoods, the following typical user characteristics were defined for the HCI evaluation. Users should (a) be members of neighbourhoods with low socio-economic indicators[1] (see Burke, 2014), (b) have little experience in using ICT, and (c) show an interest in participating in neighbourhood initiatives. Most of the test users belong to the Afro-Colombian communities of Guachené and Villa Rica located in the rural area of Valle de Cauca Province in the south of Cali. Over recent decades, this area has suffered from on-going security problems, and related social and economic marginalization, caused by armed conflicts between guerrillas, paramilitaries and the Colombian Armed Forces. As a result, access to ICT and education is difficult, while unemployment and racial segregation are widespread in these communities (Marin, 2015).

[1] Colombia divides neighbourhoods into six categories (‘*estratus*’) according to different socio-economic indicators from 1 (poor) to 6 (rich). People living in low-*estratu* neighbourhoods pay fewer taxes and lower prices for public utilities.

Figure 1: Usability test group from Guachené community

In order to analyse socio-demographic characteristics of users, test users had to complete a questionnaire which followed the categories of the official Colombian Census. Most test users attended the continuous education programmes that the University Antonio José Camacho (Institución Universitaria Antonio José Camacho – UNIJAC) offers at graduate level, especially for members of marginalized communities of Cali and its surrounding municipalities. Other test users were employees of UNIJAC with limited ICT-skills, such as the cleaning staff, guards or cafeteria employees. The typical test user had computer and internet access at home and owned a smartphone, or had at least used these technologies in the past six months. Specifically, they were familiar with the use of email, Facebook and WhatsApp. Detailed results are presented in Table 2.

Table 2: Socio-demographic characteristics of the test users

What is your sex?	Female	11
	Male	11
What age group do you belong to?	< 18 years	1
	18 - 29 years	9
	30 - 65 years	11
	> 65 years	1
What ethnic group do you belong to?	Mestizo	11
	White	3
	Afro-Colombian	7
	Indigenous	1
What is your highest level of education?	Primary School	2
	Secondary School	7
	Graduate Level	13
	Postgraduate Level	0
Do you have a computer at home?	Yes	18
	No	4
Have you used a computer in the past six months?	Yes	17
	No	5
Do you have the internet at home?	Yes	17
	No	5
Have you used the internet in the past six months?	Yes	20
	No	2
Do you have a smartphone/iPhone?	Yes	17
	No	5
Have you used a smartphone/iPhone in the past six months?	Yes	18
	No	4
Which applications and social media do you use regularly?	Twitter	5
	Google maps	8
	E-Mail	15
	Facebook	17
	Skype	6
	Whatsapp	17
Which 'estratus' has the neighbourhood where you live?	1 (low)	6
	2	7
	3	9
	4	0
	5	0
	6 (high)	0
Which labour group do you belong to?	Employee	10
	Employer	1
	Independent Worker	3
	Domestic Employee	2
	Others (Retired, Unemployed, etc.)	6

Task Analysis

In order to simulate the most important steps a user would perform when using the GeoCitizen reporting application, six principal (product-defined) tasks were analysed, following Cordes (2001): (1) Register, (2) Log-In, (3) Explore background maps, (4) Report an observation, (5) Consult observations, and (6) Change personal settings. In order to complete each task successfully, the test user had to work his/her way through one or more sub-tasks and give feedback to the evaluators. The sub-tasks were defined as in Table 3.

Table 3: Detailed description of sub-tasks of the GeoCitizen usability test

(1) Registration Form	(1.1) Select the 'Create Account' button after accessing the application for the first time (1.2) Complete register form for the personal user account
(2) Log-In	(2.1) Enter credentials on the log-in screen (2.2) Select city where the application would be used (through standard menus for different cities where a specific spatial extent is set in order to help the user to localize him/herself on the map screen)
(3) Explore background maps	(3.1) Select a different background map (the application allows integrating ArcGIS Server background layers such as land-zoning plans that are of special interest in participatory decision-making processes (see Figure 2)
(4) Report an observation	(4.1) Localize the site where a user wants to report an observation (supported by the automatic GPS-positioning of the mobile device) (4.2) Start the process to report an observation (4.3) Choose the topic and thematic category of an observation (e.g. Mobility > Public Transport) (4.4) Complete the reporting form (providing a title and description for the observation as mandatory fields, and a suggestion for a temporal solution as well as a URL for adding a website with further information as optional fields; see Figure 3) (4.5) Make an audio recording in order to provide more detailed descriptions for the observation (4.6) Finish the reporting task by taking a picture of the observation and closing the reporting menu
(5) Consult observations	(5.1) Find a reported observation on the map screen and retrieve information
(6) Change personal settings	(6.1) Find the button for changing the personal settings (6.2) Switch language of the user interface (Spanish<>English)

Prototype Design

During the initial design process of the GeoCitizen prototype, expert users from the University San Francisco de Quito (USFQ), Ecuador identified the most severe usability problems that might occur for typical platform users. The preliminary design of the GeoCitizen reporting application was developed using the results of a heuristic or guideline-based (expert) evaluation carried out by a group of software engineering students from

NIAJC in spring 2015[2] (see Hub et al., 2011). This preliminary design was then evaluated in the usability test presented in this paper.

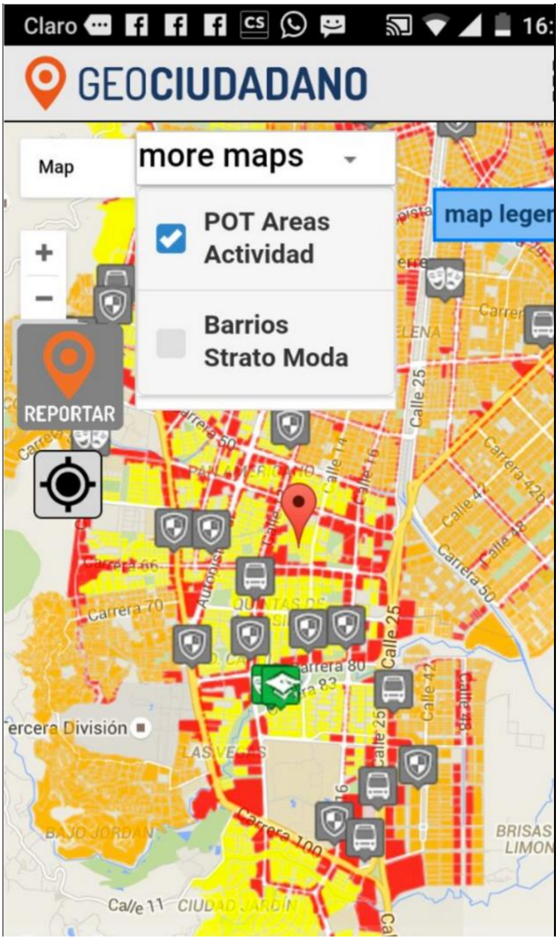

Figure 2: GC reporting App – background layers: land use plan (POT Areas Actividad) and socio-economic stratification map (Barrios Strato Moda) of Cali

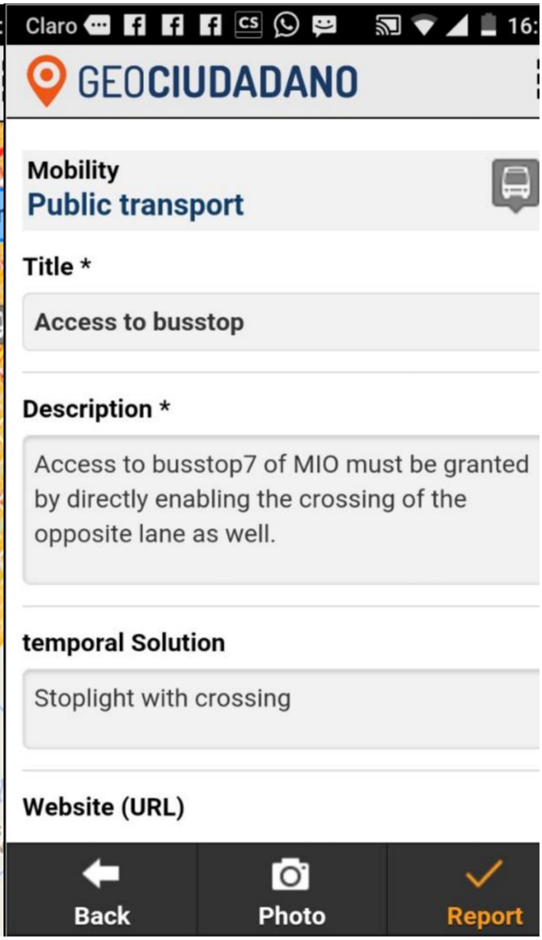

Figure 3: GC reporting App – report form: for an observation in the topic Mobility and category Public Transport

In addition, the research team received constant feedback on usability issues from a non-expert user group taking part in a participatory land-zoning process in Tumbaco-Quito, Ecuador, where the GeoCitizen framework was being tested (Atzmanstorfer et al., 2014). This focus group (Finch & Lewis, 2003) comprised users with similar socio-economic and demographic characteristics and a similar level of spatial literacy. The research team acted as

[2] Specific results are not presented here as this paper focuses on presenting the results of a usability test carried out by non-expert users from marginalized communities.

participating observers, joining people in their activities and giving them access to the application in their everyday environment in order to gain insight into the ecological validity of the usability test subsequently conducted at UNIAJC (in vivo evaluation) (Dunbar & Blanchette, 2001).

Usability Test

The usability test was carried out in October 2015 amongst a group of 22 test users on the UNIAJC-campus in Cali, Colombia. The participants had to work their way through the six principal tasks (see 3.1.2 above) on smartphones and tablets provided by the evaluation team, which consisted of students and teaching staff from UNIJAC. They were asked to express their immediate thoughts and feelings as they went through the different tasks, helping the evaluators to create 'think-aloud protocols' (Verbal Protocol Analysis – VPA) as additional feedback for identifying usability issues (Haniff & Baber, 2003; Marsh & Haklay, 2010; Nielsen, 1994b). Furthermore, test users were asked to give general feedback on the opportunities and limitations of the GeoCitizen reporting application as a tool to empower them to better participate in decision-making processes in their communities.

4 Results and Discussion

From the sample of 22 questionnaires, the following results are considered the most significant for identifying and then interpreting usability issues associated with the use of the GeoCitizen reporting application. Results are organized according to the six principal tasks identified in section 3.1.2 (Task Analysis):

1. Register: This task achieved one of the highest performance levels, with 72% of the users completing the task independently. This is related to their proficiency in using applications with a similar functionality for registering users, such as Facebook.
2. Log-In: 63% of the participants managed to complete the application without help. However, the arrangement of the log-in buttons and the colours assigned did not help them to quickly recognize the logical sequence of the log-in process, which is a serious limitation for novice users in adopting the application.
3. Explore background maps: This task obtained the lowest completion percentage of all tasks, with only 27% of the test users completing it on their own. In particular, they had problems interpreting the map and/or understanding the map legend, as well as when the application did not respond (Figure 4).

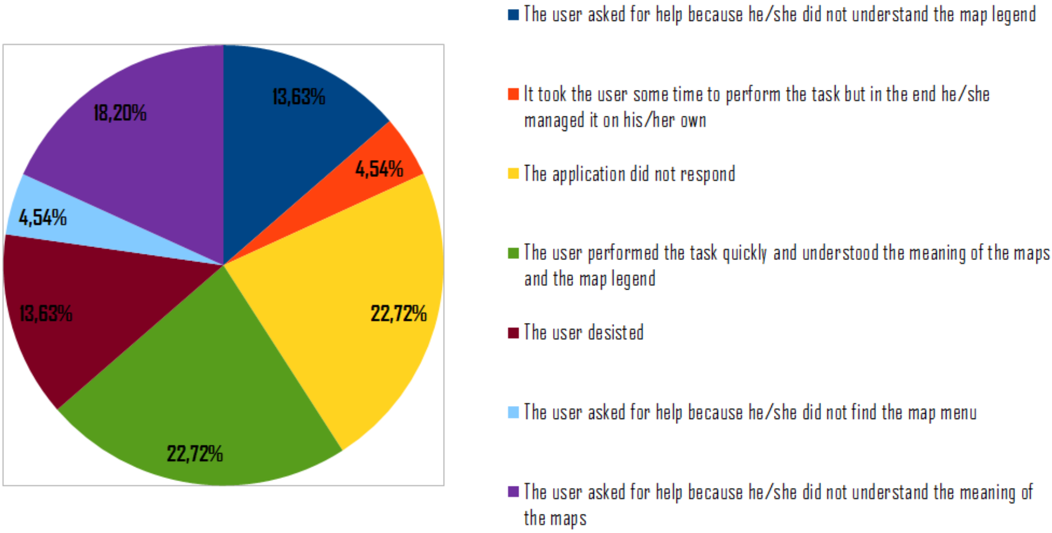

Figure 4: Task performance rates – Explore background maps

4. Report an observation: 50% of the test users managed to complete this task independently; an additional 27% asked for help. The main inconvenience faced was recording the audio testimony and using the mobile device's camera to take a picture when concluding the reporting process, as these *GeoCitizen* functions were different from those of common social media applications such as Facebook and WhatsApp. In addition, some users reported that they would not take pictures in their neighbourhoods as they were afraid of compromising their personal integrity and safety.
5. Consult observations: Half of the participants performed this task without asking for help and managed to recognize icons and their meaning (e.g. the pin-point that marks an observation on the map). This might be related to the fact that those users were already familiar with using Google Map, as the application uses its APIs.
6. Changing personal settings: With a success rate of 73%, this was the task with the highest percentage of independent completion. The general proficiency of the participants in using mobile devices helped them to quickly recognize the configuration menu and to explore its content.

In conclusion, the usability test showed that where functionalities and the interface design of the GeoCitizen reporting application corresponded to the design of familiar mobile applications – notably Facebook and WhatsApp – test users tended to have fewer problems handling the application. This is not a surprising observation, as the majority of the participants were familiar with using smartphones and the internet, although they belong to marginalized and mostly rural communities. This observation coincides with official statistics, which showed 210 million Facebook users and an internet penetration rate of 61% for South America (59% for Colombia) in 2015 (InternetWorldStats, 2015). In 2015, Latin America accounted for 781 million mobile phone connections, which corresponds to a penetration rate of 126% [sic] compared to the overall population (STATISTA, 2015).

Although initiatives such as the One Laptop Per Child programme (OLPC) (Graham, 2011) and the increasing availability of telecommunication connections and (social) media in the countries of the Global South seem to be helping to close the Digital Divide (Aker & Mbiti, 2010; Evans-Cowley, 2010; Höffken & Streich, 2013; Martin & Corbett, 2011), the research team still observed limitations regarding mobile device performance (poor GIS signals, and limited bandwidth that impeded reporting observations). In addition, several participants could not afford the costly mobile data download packages that are necessary to use mobile applications to their full extent.

As expected, the task that proved the most problematic was exploring background maps, such as the land-use map (POT), which should help GeoCitizen-users to better understand patterns and relationships of spatial parameters influencing decision-making in planning processes. One third of all test users could not understand or interpret the maps presented or their legends; another 13% gave up in the course of working on the task. Improving map-reading skills and spatial literacy in general would require long-term and costly educational initiatives at K12-level (Fu, 2011). In the short term, a comprehensive explanation of integrated map-functionalities, and implementing standard design guidelines and elements such as the Google material design (icons) or Font Awesome icons can provide novice users with a more familiar interface for geospatial web applications (Marin, 2015).

Especially amongst marginalized user groups, geoweb technologies must resort to the social and cultural realities of the citizens and communities addressed (Haklay, 2010; Resl, 2006). Hence, adequate design must consider contextual factors, such as the translation of materials into local languages (Garside, 2009; Gould, 1994), and should provide an interface that uses local cultural and social conventions and symbols (Haklay, 2010; Mark et al., 2005). A specific challenge within PPGIS projects that use geospatial web applications is the integration into the participation process of senior citizens, who tend to have less experience in using ICT. Several scholars (Haklay, 2010; Muktar et al., 2015; Ramasubramanian, 2010) suggest embedding young people into community management projects to serve as 'information brokers' who will familiarize and educate other users in the use of geospatial technology. This approach is being tested in an ongoing field study in marginalized communities of Quito Sur, Ecuador, where pupils teach their relatives and neighbours how to use the GeoCitizen reporting application, helping to build up trust and skills.

In general, the test users in this usability study were very positive about the idea of introducing ICT into participatory initiatives that aim at improving livelihoods in their neighbourhoods. Although members of marginalized communities, they tend to have access to computers, the internet and smartphones. However, they had problems handling the GeoCitizen reporting application where the design and functionalities differed from common social media applications. With these lessons learnt, the GeoCitizen reporting application will be subject to an iterative process of usability-testing and improvement in order to provide an easy-to-use and efficient tool that empowers citizens to make their voice heard in spatial planning processes and community management.

Acknowledgement

This work was supported by the Austrian Science Fund (FWF) and the Doctoral College – GIScience, University of Salzburg.

References

Adebesin, F., Kotzé, P., & Gelderblom, H. (2010). *Impact of usability on efforts to bridge the digital divide.* Paper presented at the 4th International Development Informatics Association Conference, Cape Town, South Africa.

Aker, J. C., & Mbiti, I. M. (2010). Mobile Phones and Economic Development in Africa. *Journal of Economic Perspectives, 24*(3), 207-232.

Ashley, H., Corbett, J., Jones, D., Garside, B., & Rambaldi, G. (2009). Change at hand: Web 2.0 for Development. In A. Holly, N. Kenton & A. Milligan (Eds.), *Participatory learning and action*. London, UK: The International Institute for Environment and Development (IIED).

Atzmanstorfer, K., & Blaschke, T. (2013). Geospatial web: A tool to support the empowerment of citizens through e-participation? In C. Nunes Silva (Ed.), *Handbook of Research on E-Planning: ICTs for Urban Development and Monitoring*. Hershey, PA: IGI Global

Atzmanstorfer, K., Resl, R., Eitzinger, A., & Izurieta, X. (2014). The GeoCitizen-approach: Community-based Spatial Planning. An Ecuadorian Case Study. *Cartography and Geographic Information Science CaGIS, 41*(3), 248-259.

Bednarz, S. W., & Kemp, K. (2011). *Understanding and nurturing spatial literacy.* Paper presented at the Spatial Thinking and Geographic Information Sciences Conference, Tokyo, Japan.

Bowman, D., Gabbard, J., & Hix, D. A. (2002). A Survey of Usability Evaluation in Virtual Environments: Classification and Comparison of Methods. *Classification and Comparison of Methods. Presence: Teleoperators and Virtual Environments, 11*(4), 404-424.

Brunswick, E. (1955). Representative design and probabilistic theory. *Psychological Review, 62*, 193-217.

Budio, R., & Nielsen, J. (2012). *Mobile Usability* Berkeley, CA: New Riders Press.

Burke, C. (2014). Trying to make sense of Colombia's "Strata" economic system. Retrieved 13.01., 2016, from http://www.occasionalplanet.org/2014/09/09/trying-to-make-sense-of-colombias-strata-economic-system/

Caquard, S. (2013). Cartography II: collective cartographies in the social media era. *Progress in Human Geography, 38*(1), 141-150.

Carver, S., Evans, A., Kingston, R., & Turton, I. (2001). Public Participation, GIS, and cyberdemocracy: Evaluating on-line spatial decision support systems. *Environment and Planning. B, Planning and Design, 28*, 907-921.

Cordes, R. E. (2001). Task-selection bias: a case for user-defined tasks. *International Journal of Human Computer Interaction, 13*(4), 411-419.

Delikostidis, I. (2007). *Methods and techniques for field-based usability testing of mobile geo-applications.* (MSc), Internatoinal Institute for Geoinformation Science and Earth Observation (ITC), Enschede, The Netherlands.

Dunbar, K., & Blanchette, I. (2001). The invivo/invitro approach to cognition: the case of analogy. *Trends in Cognitive Sciences*, 5334-5339.

Elwood, S. (2008). Volunteered geographic information: future research directions motivated by critical, participatory, and feminist GIS. *Geojournal, 72*(173-180).

Elwood, S., & Leszczynski, A. (2013). New spatial media, new knowledge politics. Transactions of the Institute of British Geographers. *38*, 544–559.

Evans-Cowley, J. S. (2010). Planning in the Age of Facebook: the role of social networking in planning processes *Geojournal, 75*(407-420).

Ferré Grau, X. (2005). *Principios Básicos de Usabilidad para Ingenieros Software.* (PhD), Universidad Politécnica de Madrid, Madrid, Espana.

Finch, H., & Lewis, J. (2003). Focus groups. In J. Richie & J. Lewis (Eds.), *Qualitative Research Practice: A Guide for Social Science Students and Researchers.* (pp. 170-198). London, UK: Sage.

Fischer, F. (2012). *Geotagging and the City: Understanding the Use of Social Location Applications in Urban Space.* (PhD), University of Salzburg, Salzburg, Austria.

Fu, W. H. (2011). Why Spatial Literacy? Retrieved 28.01., 2016, from https://apps.carleton.edu/collab/spatial_analysis/SpatialLiteracy/

Garside, B. (2009). Village voice: towards inclusive information technologies. Retrieved 22.11., 2014, from http://tinyurl.com/IIED-ICTbriefing

Geissinger, S. (2006). Governor: It's high time we all go digital. *Oakland Tribune*.

Ghose, R. (2001). Use of information technology for community empowerment: Transforming geographic information systems into community information systems. *Transactions in GIS, 5*(2), 141-163.

Ghose, R. (2007). Politics of scale and networks of association in public participation GIS. *Environment and Planning A, 39*, 1961–1980.

Goodchild, M. F. (2010). Twenty years of progress: GIScience in 2010. *Journal of Spatial Information Science, 1*, 3-20.

Gould, M. D. (1994). *Map Use, Spatial Decisions, and Spatial Language in English and Spanish (Puerto Rico).* (PhD), State University of New York, Buffalo, NY.

Graham, M. (2011). Time machines and virtual portals: the spatialities of the digital divide. *Progress in Development Studies, 11*(3), 211-227.

Haklay, M. (2010). Computer-Mediated Communication. In M. Haklay (Ed.), *Interacting with Geospatial Technologies*. Chichester, UK: John Wiley & Sons, Ltd.

Haklay, M. (2013). Neogeography and the delusion of democratisation. . *Environment and Planning A, 45*(1), 55-69.

Haklay, M., & Chao Li, L. (2010). Single user environments: desktop to mobile. In M. Haklay (Ed.), *Interacting with Geospatial Technology*. Chichester, UK: John Wiley & Sons, Ltd.

Haklay, M., Skarlatidou, A., & Tobón, C. (2010). Usability engineering. In M. Haklay (Ed.), *Interacting with Geospatial Technology*. Chichester, UK: John Wiley & Sons, Ltd.

Haniff, D. J., & Baber, C. (2003). *User evaluation of augmented reality systems.* Paper presented at the Seventh International Conference on Information Visualization, London, UK.

Hassenzahl, M., & Roto, V. (2007). Being and doing. A perspective on User Experience and its measurement. *Interfaces, 72*, 10-12.

Höffken, S., & Streich, B. (2013). Mobile Participation: Citizen Engagement in Urban Planning via Smartphones. In C. Nunes Silva (Ed.), *Citizen E-Participation in Urban Governance: Crowdsourcing and Collaborative Creativity*. Hershey, PA: IGI Global.

Hub, M., Visek, O., & Sedlak, P. (2011). *Heuristic evaluation of Geoweb: case study.* Paper presented at the World Scientific and Engineering Academy and Society (WSEAS) Stevens Point, Wisconsin.

InternetWorldStats. (2015). Usage and Population Statistics. Retrieved 24.01., 2016, from http://www.internetworldstats.com/stats2.htm#

ISO (2010). ISO 9241-201:2010 - Ergonomics of Human-System Interaction - part 210: Human-centered design for interactive systems. Retrieved 16.01., 2016, from http://www.iso.org/iso/catalogue_detail.htm?csnumber=52075

ISO (2011). ISO/IEC 25010:2011 - Systems and Software Engineering/Systems and Software Quality Requirements and Evaluation (SQuaRE)/System and Software Quality Models. Retrieved 15.01., 2016, from http://www.iso.org/iso/catalogue_detail.htm?csnumber=35733

Lindgaard, G., Tsuji, B., & Khan, S. (2005). *Ecological validity and behavioural measures in the usability testing of new applications: A workshop in reality testing.* Paper presented at the HCI 2005, Napier University, Edinburgh, Scotland.

Madrigal, D., & McClain, B. (2010). Usability for Mobile Devices. Retrieved 20.01., 2016, from http://www.uxmatters.com/mt/archives/2010/09/usability-for-mobile-devices.php

Marin, B. E. (2015, 10.10.2015). [Interwiew on the socio-economic situation in Guachene, Valle de Cauca, Colombia].

Mark, D. M., Smith, B., Egenhofer, M. J., & Hirtle, S. J. (2005). *Ontological foundations for geographic information science*. Research Agenda for Geographic Information Science.

Marsh, S. L., & Haklay, M. (2010). Evaluation and deployment. In H. M. (Ed.), *Interacting with Geospatial Technologies*. Chichester, UK: John Wiley & Sons, Ltd.

Martin, M., & Corbett, J. M. (2011). *Creating the new 'new': Facilitating the growth of neo-geographers in the Global South using emergent Internet technologies.* . Paper presented at the Geoinformatik 2011 – Geochange, Münster, Germany.

McCall, M.K. & Dunn, C.E. (2012). Geo-information tools for participatory spatial planning: Fulfilling the criteria for 'good' governance? *Geoforum, 43*, 81-94.

Mittlböck, M., Morper-Busch, L., Atzl, C., & Klug, H. (2012). *Task-orientierte Web-Maps zur kompakten Visualisierung kartographischer Inhalte.* Paper presented at the AGIT 2012, Salzburg, Austria.

Mukherjee, F. (2015). Public Participatory GIS. *Geography Compas, 9*, 384-394.

Mukherjee, F., & Ghose, R. (2012). Exploring the Complexities of Community Engaged GIS. *International Journal of Applied Geospatial Research (IJAGR), 3*(4), 87-102.

Muktar, B. G., Muktar, U., & Ahungwa, G. T. (2015). Harvesting Youth for Agro-entrepreneurship: Stimulus role of Social Media in Nigeria. . *International Journal of Applied Research on Technology, 4*, 94-100.

Nielsen, J. (1994a). Guerrilla HCI: Using Discount Usability Engineering to Penetrate the Intimidation Barrier. Retrieved 16.01., 2016, from https://www.nngroup.com/articles/guerrilla-hci/

Nielsen, J. (1994b). Heuristic Evaluation. In J. Nielsen & R. L. Mack (Eds.), *Usability Inspection Methods*. New York, NY: John Wiley & Sons, Ltd.

Nielsen, J. (2006). Digital Divide: The 3 Stages. Retrieved 10.01., 2016, from https://www.nngroup.com/articles/digital-divide-the-three-stages/

Norman, D. A., & Draper, S. W. (Eds.). (1986). *User-Centered System Design: New Perspectives on Human-Computer Interaction*. Hillsdale, NJ: Lawrence Erlbaum Associates.

OECD. (2008). Digital Divide. Retrieved 03.01., 2016, from http://stats.oecd.org/glossary/detail.asp?ID=4719

Pfeffer, K., Martinez, J., O'Sullivan, D., & Scott, D. (2015). Geo-Technologies for Spatial Knowlegde: Challanges for Inclusive and Sustainable Urban Development. In J. Gupta, K. Pfeffer, H. Verrest & M. Ros-Tonen (Eds.), *Geographies of Urban Governance*.

Ramasubramanian, L. (2010). *Geographic Information Science and Public Participation*. Berlin, Heidelberg, Germany: Springer Press.

Resl, R. (2006). *GI for Development - Can GIS challenge existing power structures? Working experiences from Ecuador.* Paper presented at the Geoinformation for Development - Bridging the divide through partnerships, Salzburg, Austria.

Roto, V., Law, E., Vermeeren, A., & Hoonhout, J. (2011). *User Experience White Paper.*

Scharl, A., & Tochterman, K. (2007). *The geospatial web: how geobrowsers, social software and the web 2.0 are shaping the network society*. London, UK: Springer.

Shackle, B. (2009). Human-Computer Interaction - Whence and whither? *Interacting with Computers, 21*, 353-366.

Sieber, R. (2006). Public participation gegraphic information systems: A literature review and framework. *Annals of the Association of American Geographers., 96*(3), 491-507.

Skarlatidou, A. (2010). Web-mapping applications and HCI considerations for their design. In M. Haklay (Ed.), *Interacting with Geospatial Technologies*. Chichester, UK: John Wiley & Sons, Ltd.

Skarlatidou, A., Cheng, T., & Haklay, M. (2013). Guidelines for trust interface design for public engagement Web GIS. *International Journal of Geographical Information Science, 27*(8), 1668-1687.

STATISTA. (2015). Mobile penetration rate in Latin America from 2007 to 2015 Retrieved 13.01., 2016, from http://www.statista.com/statistics/218141/mobile-penetration-rate-in-latin-america-since-2007/

Sui, D., Elwood, S., & Goodchild, M. (2013). *Crowdsourcing Geographic Knowledge*. New York, NY: Springer Press.

Torrens, P. M. (2010). Geography and computational social science. *Geojournal, 75*, 133-148.

Tschigeli, M. (2013). *Details Matter: Human Computer Interaction for Special Contexts*.

Zhang, D., & Adipat, B. (2005). Challenges, Methodologies, and Issues in the Usability Testing of Mobile Applications. *International Journal of Human-Computer Interaction, 18*(3), 293-308.