RECRUITMENT, TRAINING, AND SOCIAL DYNAMICS IN GEO-CROWDSOURCING FOR ACCESSIBILITY

by

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Bachelor of Science
George Mason University, 2011

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DEDICATION

I dedicate this thesis to my loving and wonderful husband, Andres, who has been an immense support in my career and my life. Thank you, Andres, for your patience and words of encouragement in the most intense and overwhelming moments of writing this thesis, and for the precious time you spent editing this thesis.

I also want to dedicate this thesis to my beloved parents, Marcial y Corina, who always encouraged me to finish my education, and taught me to persevere and work hard to achieve my goals in life. Also, thank you to my beloved siblings, Carolina, Gabriel, Juan Carlos, y Sandra, who are my favorite team and best friends in life.

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Le dedico esta tesis a mi amado y maravilloso esposo Andrés, quien ha sido un gran apoyo en mi carrera y en mi vida. Gracias, Andrés, por tu paciencia y tus palabras de aliento en los momentos más intensos y abrumadores de esta tesis, y por el preciado tiempo que dedicaste a editarla.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Americans with Disabilities Act	ADA
Ambient Geographic Information	AGI
Compliance, Diversity and Ethics	CDE
Crowdsourced Geographic Data	CGD
Geographic Information Systems	GIS
George Mason University	GMU
Global Positioning System	GPS
Graduate Research Assistant	GRA
Graduate Teaching Assistant	GTA
Office of Disability Services	ODS
Open Street Map	OSM
Rich Site Summary	RSS
User-Generated Content	UGC
U.S. Geological Survey	USGS
The National Map Corps	TNM Corps
Volunteered Geographic Information	VGI
World Wide Web	WWW

ABSTRACT

RECRUITMENT, TRAINING, AND SOCIAL DYNAMICS IN GEO-CROWDSOURCING FOR ACCESSIBILITY

Fabiana Paez, B.S. in Geography

George Mason University, 2014

Thesis Director: Dr. Matthew T. Rice

Transitory obstacles in the built environment of George Mason University present a great inconvenience and hazard to visually- and mobility-impaired individuals. Accessing real-time information provides great benefits by allowing people with disabilities to assess the potential hazard of an obstacle and find alternative routes in a short period of time. As an emerging technique, geo-crowdsourcing allows for the utilization of community members to collect and share valuable geographic information associated with transitory events. A survey has being conducted to examine current applications of crowdsourcing. Furthermore, the training program of various successful applications of geo-crowdsourcing has been reviewed. Finally, a training program has being designed and implemented for recruiting and motivating contributors to participate in an obstacle reporting system.

INTRODUCTION

Geo-crowdsourcing is a recent trend that has the capability of generating massive amount of geospatial information in a short time, and can be facilitated through social media technologies. The traditional methods of geospatial data production used in previous decades have been transformed by end-users participation and involvement in these new technologies and methods. However, geo-crowdsourcing has not yet been widely recognized by official sources due to the questionable validity of the data provided by users. Dr. Matthew Rice, Assistant Professor of the Department of Geography and Geoinformation Science at George Mason University (GMU), started a research effort in 2011 to analyze and assess the value of user-contributed content to be use in coordination with expert and official sources of information. Dr. Rice's collaborative research project, funded by the U.S. Army Corps of Engineers, is structured into four phases, each of one-year duration.

Phase one, conducted in 2012, devised standard methods for identifying sources of crowdsourced geographic information. A report[1] and a peer-reviewed publication[2]

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[1] Matthew T. Rice et al., *Crowdsourced Geospatial Data: A Report on the Emerging Phenomena of Crowdsourced and User-generated Geospatial Data*, Annual (Fairfax, VA: George Mason University, November 29, 2013), http://www.dtic.mil/dtic/tr/fulltext/u2/a576607.pdf.
[2] Matthew T. Rice et al., "Supporting Accessibility for Blind and Vision-impaired People With a Localized Gazetteer and Open Source Geotechnology," *Transactions in GIS* 16, no. 2 (April 2012): 177–90, doi:10.1111/j.1467-9671.2012.01318.x.

provide a description and discussion of the results obtained in the first phase of the project. Phase two, conducted in 2013, developed methods for quality assessment of geo-crowdsourced data. The methods developed include a preliminary system that allows data contribution, manipulation, sharing, and displaying via geo-crowdsourcing. The system was developed to support navigation for people with disabilities by managing obstacle reports of geo-crowdsourced information in a built environment. The methods and systems developed in this phase are described and discussed in a report[3] prepared for the funding agency and a peer-reviewed[4] publication. Phase three is currently in progress, and it involves the development of ways to combine geo-crowdsourced information with institutional data, and the geovisualization of the contributed data, including quality measures and assessments. Phase four is planned to start in 2015, and propose to develop strategies for incorporating user-contributed data in complex spatiotemporal environments. This thesis developed as a contribution to phases one and two of this larger collaborative research project.

This thesis is based in the premise that the prototype of a reporting and training system will provide a real setting for comprehensive geo-crowdsourcing quality

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[3] Matthew T. Rice et al., *Crowdsourcing to Support Navigation for the Disabled: A Report on the Motivations, Design, Creation and Assessment of a Testbed Environment for Accessibility*, US Army Corps of Engineers, Engineer Research and Development Center, US Army Topographic Engineering Center Technical Report, Data Level Enterprise Tools Workgroup (Fairfax, VA: George Mason University, September 2013), http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA588474.

[4] Matthew T. Rice et al., "Crowdsourcing Techniques for Augmenting Traditional Accessibility Maps with Transitory Obstacle Information," *Cartography and Geographic Information Science* 40, no. 3 (June 2013): 210–19, doi:10.1080/15230406.2013.799737.

assessment. It is expected that the prototype of the training system developed in this thesis will:

- Provide insights on how end-users understand the attributes required for reporting obstacles. This will help research team members improve and redesign the reporting system, making it more intuitive.
- Engage participants to contribute data to the reporting system. Their contributions are essential to gather a significant sample of reports for assessing the quality of VGI.
- Serve as the initial steps for developing an effective training system. Providing supporting resources, such as a training system, have proven to be useful to improve the quality of the information provided via geo-crowdsourcing.

The following section of this thesis provides an overview of the problem and test environment in which the training and reporting system are developed and applied. Next, a review of the current literature on the concept, emergence, and evolution of geo-crowdsourcing is explored. Then, the data and methodology used to accomplish the aforementioned expectations of this thesis are described, followed by the results and discussion. Finally, suggestions for future research are presented.

OVERVIEW

Testbed environment

In 2008, George Mason University (GMU) was positioned first on the list of "Up-and-Coming" colleges in the U.S. News Best Colleges ranking conducted by the U.S. News & World Report. The category ranks colleges "that are making improvements in academics, faculty, students, campus life, diversity and facilities"[5]. Moreover, in April of 2013, Dr. Angel Cabrera, the recently appointed president of GMU, introduced a new vision along with the Mason *idea* in his inaugural speech. Mason *idea* embodies GMU's core institutional characteristics of being innovative, diverse, entrepreneurial, and accessible[6]. President Cabrera envisioned strengthening GMU by reaffirming the commitment to freedom and learning, which is the university's motto [7]. Motivated by all these modern, revolutionary, and progressive changes, every year more students and faculty have been attracted to the GMU community. In five years, the campus population has increased from more than 30,000 to almost 38,000 students, faculty and staff. Over

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[5] Robert Morse, "Up-and-Coming Schools Methodology" (U.S. News, September 9, 2013), http://www.usnews.com/education/best-colleges/articles/2013/09/09/up-and-coming-schools-methodology.

[6] George Mason University, "The Mason IDEA: Our Core Institutional Characteristics," *Mason Idea*, 2014, http://masonidea.gmu.edu/the-mason-idea-our-core-institutional-characteristics/.

[7] George Mason University, "The Mason Vision," Educational, *Mason Vision*, April 29, 2014, http://vision.gmu.edu/the-mason-vision/.

6,000 GMU students live on campus[8]. This positive, upward ascendance has led GMU to rebuild and expand its campuses to accommodate its growing community. Since 2008, twenty-seven new or rebuilt buildings have been opened[9]. Currently, there are seven buildings under construction, and the plans to reconstruct the campus and its surrounding will continue for at least two more years.

The population growth and the on-going campus reconstruction have created a built environment that affects navigation on and around campus. Construction detours, closed sidewalks, larger crowds on sidewalk and traffic during rush hours are some of the consequences during this process of growth. Of all the GMU community members, the individuals with special navigation requirements are the ones who suffer the most in these changing environments. The elderly, and individuals with visual- and mobility-impairment are frequently challenged with detours, construction barricades and obstacles on sidewalks, which, for the non-disabled community might simply be evaded or ignored. Some of the obstacles could pose rerouting inconveniences, while others might pose great hazards to individuals with disabilities. For instance, a blind or visually impaired person might be prone to accidentally falling into a hole created during a construction on a sidewalk. These types of construction activity on sidewalks are extremely common at GMU, and often they last less than a couple of days, so they cannot feasibly be captured by traditional mapping processes, which operate over longer periods of time. Although organizations such as the Office of Disability Services (ODS) and Compliance, Diversity

[8] George Mason University, "Institutional Research & Reporting," Educational, accessed April 16, 2014, http://irr.gmu.edu/.
[9] Ibid.

and Ethics (CDE) offer assistance to the GMU community with disabilities, the transient nature of the obstacles pose an almost impossible task. It is very difficult to alert and help individuals who are facing transient obstacles when navigating around campus. Once a year, GMU produces an accessibility map displaying routes along walkways that are compliant with the Americans with Disabilities Act (ADA), building entrances with ramps and assisted doors, handicapped parking, as well as areas closed for construction. However, this static map is not suitable to represent dynamic events such as transient obstacles and hazards that occur throughout the year in locations outside of the construction areas displayed on the map.

CONCEPTUAL FRAMEWORK

In the last few decades, the rapid evolution of technology has reshaped the ways we communicate and perceive the world. Web technologies and social media have shortened the bridge between citizens and experts in many disciplines. Processes and techniques that used to require high levels of expertise to be implemented are now available and employed by the general public. Map making is a great example of a process that only experts had the instrumentation and ability to engage in, while today even novices can produce maps with geographic information systems (GIS). Nowadays, web technologies offer users the resources to individually or collectively create and share maps, without requiring high investments or technical knowledge. Crampton[10] provides a useful discussion of the way that technology has completely changed map making.

This section introduces the concept of geo-crowdsourcing, as a practice that takes advantage of web technologies to collect geospatially-related information from the public. First, a notion of Web 2.0 technology is introduced, followed by the emergence and evolution of geo-crowdsourcing. Then, two case studies where geo-crowdsourcing was used in disaster relief are examined. Finally, a review of some factors that might motivate users to contribute and participate in geo-crowdsourcing are reviewed.

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[10] Jeremy W. Crampton, *Mapping: a Critical Introduction to Cartography and GIS*, Blackwell Companions to the Ancient World (Malden, Mass: Wiley-Blackwell, 2010).

Web 2.0 and the emergence of geo-crowdsourcing

To understand the great influence that Web 2.0 has had over the emergence of geo-crowdsourcing, first the concept of Web 2.0 needs to be introduced. In 2000, Web 2.0 emerged as a platform characterized by the capabilities of enabling non-expert users to actively and directly interact over the World Wide Web (WWW) by creating and manipulating data from websites[11]. Figure 1 shows a diagram that explains the basic notion of the functionality of Web 2.0, and states the difference between this and the previous Web platform, referred to in the diagram as “Web 1.0”. In the diagram, the “Web 1.0” platform describes the early concept of Web, where only producers or “webmasters” were provided with the technical specifications to produce, manipulate, and share information through the WWW. Likewise, users or “Internet surfers” were provided with a simple unidirectional interface where they could access the information generated by the producers through browsers and hyperlinks[12]. The lower section of Figure 1 shows a diagram stating the interoperability provided by this platform, which has a user-friendly and user-oriented design that blurs the differentiation between users and producers. Web 2.0 platform allows multi-directional communication and interaction through web-based communities, web applications, video-sharing sites, wikis, blogs, and RSS/XML feeds[13].

[11] Michael Batty et al., “Map Mashups, Web 2.0 and the GIS Revolution,” *Annals of GIS* 16, no. 1 (April 22, 2010): 1–13, doi:10.1080/19475681003700831.
[12] Michael F. Goodchild, “Citizens as Sensors: The World of Volunteered Geography,” *GeoJournal* 69, no. 4 (December 2007): 211–21.
[13] Paul Graham, “Web 2.0,” Personal Portfolio, *Paul Graham*, November 2005, http://www.paulgraham.com/web20.html.

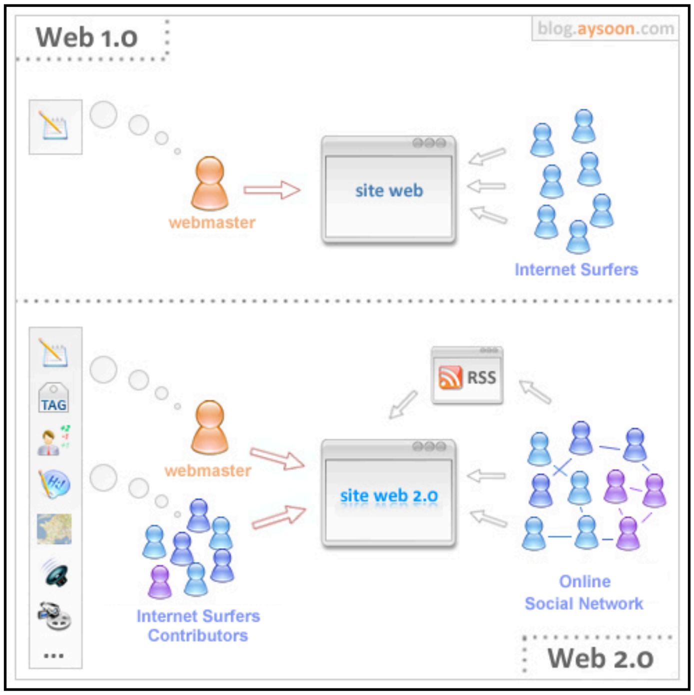

Figure 1. Differences between Web 1.0 and Web 2.0 (Source: blog,aysoon.com)

As might be expected, Web 2.0 revolutionized the ways we communicate and perceive the world. Web 2.0 technologies have entailed to the massive production of information that is mostly freely available. Many disciplines have taken advantage of this new and vast resource for collecting information, and supplement official sources of information.

The emergence of geo-crowdsourced traces back to the 1950s, where a gradual decline in geospatial and geographic information began. The manufacture of maps required extensive and intensive fieldwork to collect data, the use of heavy, technical and sensitive instruments to record and transcribe the information collected, and laborious and often monotonous work to assemble and edit the data[14]. Therefore, these traditional mapping methods used mostly by official mapping agencies became unprofitable leading to a general decline in the manufacture and availability of printed maps[15].

By the early 1990s, a series of developments emerged, which began changing the traditional methods of collecting data for map production. Mechanical stereoplotters were replaced by photogrammetric software, the Internet allowed data storage and processing to be shared over a network, and the creation of accessible geolocation devices such as Global Positioning Systems (GPS) made field data collection much easier[16]. Moreover, in 2007, Goodchild coined the term volunteered geographic information (VGI) to define the emerging, inexpensive and functional methods for collecting geographic data through the active participation of end-users and community members[17]. However, the term "Volunteered" has generated some controversy in the literature[18] in that it does not cover other ways in which geo-crowdsourcing has been applied. Therefore, other terms have emerged to define geo-crowdsourcing. Ambient geographic information (AGI) refers to data that is gathered from observations, and the digital, geographic footprints left by

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[14] Michael F. Goodchild and J. Alan Glennon, "Crowdsourcing Geographic Information for Disaster Response: a Research Frontier," *International Journal of Digital Earth* 3, no. 3 (September 2010): 231–41, doi:10.1080/17538941003759255.
[15] Goodchild, "Citizens as Sensors: The World of Volunteered Geography."
[16] Goodchild and Glennon, "Crowdsourcing Geographic Information for Disaster Response."
[17] Goodchild, "Citizens as Sensors: The World of Volunteered Geography."
[18] Sarah Elwood, Michael F. Goodchild, and Daniel Z. Sui, "Researching Volunteered Geographic Information: Spatial Data, Geographic Research, and New Social Practice," *Annals of the Association of American Geographers* 102, no. 3 (May 2012): 571–90, doi:10.1080/00045608.2011.595657.

social media feeds, such as Facebook, Flickr, and Twitter[19]. The term user-generated content (UGC) is used to describe the data that has been solely contributed by end-users, without the involvement of a centralized authority, such as Wikipedia and Facebook[20]. Crowdsourced geographic data (CGD) does have a relationship with UGC in the sense that it is primarily derived from the participation of end-users in social media and Web 2.0; however, it might include other non-authoritative sources[21]. Also, CGD refers to information that can be associated with geographic and geospatial characteristics [22]. Citizen science is another term used to define UGC but with a specific application in the scientific community, such as the Christmas Bird Count[23]. Finally, Participatory Sensing has been used to expand the notion of citizen science that involves the use of mobile and sensing instrumentation to collect data[24]. Although the terms differ in their purpose and/or application, all of these terms are strongly related in that end-users are the primary source of information, either directly or indirectly. The use of these various terms are just an indication of the evolving interest in studying the potential benefits of the massive

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[19] Anthony Stefanidis et al., "Demarcating New Boundaries: Mapping Virtual Polycentric Communities through Social Media Content," *Cartography and Geographic Information Science* 40, no. 2 (March 2013): 116–29, doi:10.1080/15230406.2013.776211; Anthony Stefanidis, Andrew Crooks, and Jacek Radzikowski, "Harvesting Ambient Geospatial Information from Social Media Feeds," *GeoJournal*, December 4, 2011, doi:10.1007/s10708-011-9438-2; Rice et al., *Crowdsourced Geospatial Data: A Report on the Emerging Phenomena of Crowdsourced and User-generated Geospatial Data*.
[20] Rice et al., *Crowdsourced Geospatial Data: A Report on the Emerging Phenomena of Crowdsourced and User-generated Geospatial Data*.
[21] Ibid.
[22] Ibid.
[23] "Christmas Bird Count," *National Audubon Society Birds*, accessed July 31, 2012, http://birds.audubon.org/christmas-bird-count.
[24] Rice et al., *Crowdsourced Geospatial Data: A Report on the Emerging Phenomena of Crowdsourced and User-generated Geospatial Data*.

information provided by the public through our current technologies, which are leading to transformations in many scientific disciplines, such as atmospheric science[25], astronomy[26] and environmental sciences[27], and traditional authoritative sources.

Geo-crowdsourcing in disaster relief

Geo-crowdsourcing has been widely studied in a variety of applications, some of which occurred unintentionally and by the clear need for sharing information. For instance, geo-crowdsourcing has been demonstrated to be a vital resource supporting emergency management. Between 2007 and 2009 a rapid succession of wildfires severely impacted the area of Santa Barbara in a very unusual manner. The first fire (Zaca Fire) had such a long duration that it allowed authorities to communicate vital information through the regular methods (information kiosks, new releases, and others) to the residents[28]. However, the next three series of fires (Gap Fire, Tea Fire, Jesusita Fire) struck to rapidly that new, more time-effective approaches to communicate the information were required[29]. Consequently, technological resources, such as GPS, digital cameras and maps, and access to the Internet provided a convenient platform for citizens to communicate information in real time[30]. By the time the last fire ignited, the citizens

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[25] "Old Weather - Our Weather's Past, the Climate's Future," accessed April 30, 2012, http://www.oldweather.org/.

[26] "Galaxy Zoo: Classify Galaxies," accessed April 11, 2012, http://www.galaxyzoo.org/classify; "Zooniverse - Real Science Online," accessed June 20, 2012, https://www.zooniverse.org/.

[27] USA National Phenology Network, "USA National Phenology Network - About Us," *USA NPN*, accessed April 28, 2014, https://www.usanpn.org/about.

[28] Goodchild and Glennon, "Crowdsourcing Geographic Information for Disaster Response."

[29] Ibid.

[30] Ibid.

immediately organized themselves to create online map sites produced by volunteers that included both VGI and authoritative information[31]. Another example of geo-crowdsourcing in disaster relief occurred in January 2010, when Ushahidi and OpenStreetMap helped focus the efforts of thousands of people from around the world via the WWW asking for help to create a map of Haiti after the magnitude 7.0 earthquake struck the country. As one of the poorest countries in the Western Hemisphere[32], Haiti has lacked the resources to create official maps of their region. Therefore, after the earthquake hit Haiti, emergency responders did not have the resources to assess the damaged areas and send rescuers to save lives. Similar to the response in the Santa Barbara wildfires, mapping agencies and citizens organized themselves to create reliable maps and collect geographical information to support the disaster relief effort[33]. These two examples highlight the high value and crucial role that citizens can have by contributing geographic information in time-critical situations. Accessibility issues, although based in a different context and conditions than the one presented above, might also consist of real time-critical hazards for those people with physical limitations. These issues are addressed and articulated by Rice et al.[34].

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[31] Ibid.

[32] Central Intelligence Agency (CIA), "The World Factbook," *Central Intelligence Agency*, April 11, 2014, https://www.cia.gov/library/publications/the-world-factbook/geos/ha.html.

[33] Matthew Zook et al., "Volunteered Geographic Information and Crowdsourcing Disaster Relief: A Case Study of the Haitian Earthquake," *World Medical & Health Policy* 2, no. 2 (July 21, 2010): 6–32, doi:10.2202/1948-4682.1069.

[34] Rice et al., "Supporting Accessibility for Blind and Vision-impaired People With a Localized Gazetteer and Open Source Geotechnology"; Rice et al., *Crowdsourced Geospatial Data: A Report on the Emerging Phenomena of Crowdsourced and User-generated Geospatial Data*; Rice et al., "Crowdsourcing Techniques for Augmenting

Although geo-crowdsourcing has been shown to be useful in supporting emergency relief efforts and provide real-time data, there is some controversy when considering its use as a substitute or complement for authoritative sources of information. During emergencies, the information might be prone to errors and cause problems in differentiating official from unofficial reports, which might lead to other crucial problems and confusion[35]. Also, geo-crowdsourcing might have significant social, political, and disciplinary implications, and might reinforce social inequalities, devalue expertise, and threaten people's privacy[36]. Finally, the most controversial and frequently discussed issues are the quality, accuracy, completeness and validity of the data provided. Rice et al.[37] provide a comprehensive review and useful summary of quality assessment and geo-crowdsourcing.

Addressing the last concern in geo-crowdsourcing of quality and validity, one of the common sense solutions has been the selective recruitment and training of those volunteers that will be providing the data, using a premise that a well-trained contributor that understands the context of the data collection might be able to provide higher quality observations. To explore this idea, two popular applications will be studied and examined in the next section: Waze, and OpenStreetMap (OSM). Both applications have

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Traditional Accessibility Maps with Transitory Obstacle Information"; Rice et al., *Crowdsourcing to Support Navigation for the Disabled: A Report on the Motivations, Design, Creation and Assessment of a Testbed Environment for Accessibility*.

35 Zook et al., "Volunteered Geographic Information and Crowdsourcing Disaster Relief."

36 Sarah Elwood, "Geographic Information Science: Emerging Research on the Societal Implications of the Geospatial Web," *Progress in Human Geography* 34, no. 3 (2010): 349–57.

37 Rice et al., *Crowdsourced Geospatial Data: A Report on the Emerging Phenomena of Crowdsourced and User-generated Geospatial Data*.

proven to be successful in keeping volunteers motivated to participate, and both applications provide moderate to high quality data.

Motivational factors in geo-crowdsourcing

A successful geo-crowdsourcing project needs the active participation of users providing data, and consequently, needs to target heir motivation to contribute information. The motivations that led people to contribute geographic information might vary according to the context of the geo-crowdsourcing activity, as well as by the personality of the individuals. In a TEDTalk and in his book, Clay Shirky argues that geo-crowdsourcing in disaster relief, such as the Ushahidi platform is a "design for generosity." He argues that the intrinsic motivations can be enough motivation for people to collaborate and contribute geo-crowdsourced information[38]. Although this might be true for certain groups of people and in certain cultures, there are other factors that might lead to different motivations. Coleman et al. [39] provide a list of motivations, which were drawn from lessons learned in previous applications of crowdsourcing. These motivations are differentiated between those that aim to produce constructive contributions, and those that attempt to produce malicious contributions. To summarize their findings, Coleman et al. suggest that constructive contributions might be motivated by altruistic reasons, professional or personal interest, intellectual stimulation, protection or enhancement of a

[38] Clay Shirky, "Clay Shirky: How Cognitive Surplus Will Change the World | Talk Video | TED.com," *TEDTalk*, June 2010, https://www.ted.com/talks/clay_shirky_how_cognitive_surplus_will_change_the_world#t-176018; Clay Shirky, *Cognitive Surplus: Creativity and Generosity in a Connected Age* (Penguin Press HC, The, 2010).

[39] David J. Coleman, Yola Georgiadou, and Jeff Labonte, "Volunteered Geographic Information: The Nature and Motivation of Produsers," *International Journal of Spatial Data Infrastructures Research* 4, no. 2009 (2009): 332–58.

personal investment, social reward, enhanced personal reputation, providing an outlet for creative and independent expression, and pride of place[40]. Malicious contributions might be motivated by mischief, agenda, and/ or malice and/or criminal intent[41]. Motivating user-contributors to not only provide information to a geo-crowdsourcing project once, but to become a permanent contributor can be difficult to achieve. Different techniques are used in different projects, such as rating and reward system (i.e. Waze and GasBuddy), educational gain (i.e. Christmas Bird Count), and resources to connect with other participants in the community. However, additional research is needed in techniques and approaches for keeping users motivated in geo-crowdsourcing projects.

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[40] Ibid.
[41] Ibid.

DATA AND METHODOLOGY

One of the goals of Dr. Rice's collaborative research work is to create a tool to support navigation for people with disabilities. Although the work is presently funded, in the future these tools will be implemented and maintained with very low or no financial support. Implementing geo-crowdsourcing seems to be a feasible solution considering the large potential contributors that navigate every semester around GMU Fairfax campus, our test environment. Considering the community's local knowledge and the evolution and accessibility of Web 2.0 technologies, Dr. Rice's team of researchers have been developing obstacle-reporting tools for desktop and mobile environments. The reporting tools are envisioned to be interactive, intuitive, and visually appealing. Additionally, features that keep user-contributors motivated to continue reporting and using the tool are intended to be included in the reporting system. In this thesis, I developed a training system that has been applied parallel to the development of the reporting system. This training was developed to recruit participants to contribute information in the reporting system, familiarize participants with the reporting tools and system, and examine the participant's perspectives about the reporting and training systems.

The methodology used to develop an effective training system consisted of three steps. First, a characterization of the current state of geo-crowdsourcing was conducted. This characterization provided insights about the techniques, projects and applications that are using some geo-crowdsourced information to collect, manipulate and share data. Second, some geo-crowdsourcing applications and projects characterized in the previous step were selected to conduct a deeper examination of the training methods and techniques that were used to collect quality information and maintain user-contributors motivation and participation. Finally, considering the previous successful experiences in geo-crowdsourcing applications and training techniques examined in the previous two steps, the training methods for this research were developed. Below, each step is described in greater detail.

Characterization of the current state of geo-crowdsourcing

In this section, a survey was conducted to review, and characterize current online applications that use crowdsourcing to collect and share information. This characterization allows for a comparison of relevant aspects of geo-crowdsourcing applied in a variety of applications. The survey helped my research team gain additional understanding of the practices most commonly applied in geo-crowdsourcing data collection. The review criteria established are mainly focused on supporting the assessment of the data accuracy, completeness, and quality of geo-crowdsourcing. Table 1 describes the elements selected for the review criteria.

Table 1. Review criterion for the characterization of crowdsourcing applications

Review Criteria	Description
Project Name	Refers to the name of the application, project or case study selected for the survey.
Primary Interface	Identifies the type of interface developed for user-contributors for collecting and sharing data. The type of interfaces could be tabular (i.e. check boxes or specific questions), unstructured (i.e. text entries), and/or map-based (i.e. entries done directly on a map interface).
Geo-Coverage	Specifies the scale of the data collected. It could be local, regional, national, or global.
Training	Indicates whether or not a project provides users with instructions or training to contribute data.
Location Input	Details the approach used to allow users to contribute location information. It specifies the type of end-user reference, and if its provided as a point, line and/or polygon.
Content Restrictions	Points out whether or not a project has restrictions to limit and control user contributions.
Methods for Tracking Contributions	Specifies whether or not projects utilize methods for tracking users and their contributions.
Rating System	Indicates whether or not a project provides a system to motivate and encourage users to contribute data.

Examination of training methods of current geo-crowdsourcing applications

This section involves an examination of some of the previously mentioned case studies that have been successful in collecting crowdsourced geospatial information, and that employ significant training materials. For each case study, the training material used to guide user-contributors providing information was described. This section discussed the simplicity of contributing information in the tools provided by each case. Additionally, the accessibility and clarity of training material on each case study is reviewed.

Development and evaluation of training system

After the examination of the successful case studies conducted in the previous section, a prototype of an ad hoc training material was developed to prepare user-contributors to report obstacles through the obstacle-reporting tool developed by Dr. Rice's research team. Considering that the obstacle-reporting tool is also currently a prototype in development, it was expected that the training material would be modified and adapted to reflect the updates made to the tool. Furthermore, an evaluation exercise and feedback section was included as part of the training to assess and evaluate how effective the training was and how participants understood the reporting process. The information obtained from the evaluation and feedback also influenced the decisions for modifying both the training material and some areas of the reporting tool. The training material was designed to be conducted in person, so the researcher conducting the training would be able to observe the behavior of participants and make decisions about changing the format or content of the training material for better communication and understanding of the information.

The recruitment of participants for training considered people who navigate the GMU Fairfax campus with relative frequency. The contributors should be able to observe elements on campus that could obstruct or disrupt the navigation of people with disabilities. The recruitment was focused on people who belong to the close network of Dr. Rice and his team of researchers, which mostly include students and staff from the Department of Geography and Geoinformation Sciences. Some of the people that were invited to participate in the training were professors and instructors, Graduate Teaching Assistants (GTAs), Graduate Research Assistants (GRAs), graduate and undergraduate students, and friends and family who live close to campus. Likewise, instructors of geography courses, particularly GIS courses, were asked to grant time during their classes to provide the training to their students. In these classes, students were offered extra credit for their participation, which might serve as a motivation for contributing reports through the obstacle-reporting tool, and hopefully encourage them to keep contributing in the future.

The recruitment and training was based on the voluntary participation of GMU community members. The contributions in the obstacle-reporting tool and any material collected during the training process were completely anonymous, so no personal, socioeconomic or demographic information was collected in this prototype. Furthermore, project staff working with Dr. Rice have been trained and certified for work with Human Subjects by GMU's Office of Research Integrity and Assurance (ORIA). Hence, the ethical procedures and guidelines that were established by GMU to protect human subjects in research are under compliance[42].

[42] George Mason University, "Human Subjects Policies, Procedures, and Guidelines," *Office of Research Integrity & Assurance*, accessed April 18, 2014, http://oria.gmu.edu/research-with-humans-or-animals/institutional-review-board/human-subjects-policies-procedures-forms-and-instructions/human-subjects-policies-procedures-and-guidelines/.

RESULTS AND DISCUSSION

Characterization of current state of geo-crowdsourcing

The survey was implemented with 167 geo-crowdsourcing projects and activities. Some of the projects were selected from a VGI sites inventory from VGI-net, a collaborative research project that evaluates the content and quality, methods and techniques and social processes of VGI[43]. Other projects included in the survey were found through searches on the Internet, literature review, and projects previously known and used by the team members. Using the review criterion described in Table 1, each project was examined. After conducting the first examination, our team decided to add a new field to the review criteria. A categorization field was included to classify the projects according to their main task or functionality. The classification resulted in twenty-four categories, including mapping, data collection, social media, software, opinion, and meetings. This initial categorization helped the team identify the most common tasks for which geo-crowdsourcing has been used. The twenty-four categories were reduced to twelve, which simplified and described most of the previous categories. The final twelve categories, discussed in Rice et al.[44], are:

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[43] Michael F. Goodchild et al., "About Vgi-net," *Vgi-net*, -, accessed April 23, 2014, http://vgi.spatial.ucsb.edu/about.
[44] Rice et al., *Crowdsourced Geospatial Data: A Report on the Emerging Phenomena of Crowdsourced and User-generated Geospatial Data*.

- **Imaging:** refers to the projects that have used geo-crowdsourcing to build collections of imagery.
- **Geo-referencing**: includes projects where geo-crowdsourcing have been used to rectify maps and imagery.
- **Transcribing**: these are projects that convert text resources to a digital form using geo-crowdsourcing.
- **Digitizing**: refers to the collection of geospatial feature geometry and attributes acquired from maps or imagery via geo-crowdsourcing.
- **Attributing**: descriptive information of known geospatial features or datasets is added using geo-crowdsourcing.
- **Reporting**: refers to projects that collect information related to location, generally by observations or mobile devices.
- **Searching**: user-contributors support projects by searching maps or imagery to identify specific features.
- **Tracking**: these are projects that use geo-crowdsourcing indirectly, where information on paths and traces are collected through the footprint left by people in their GPS-enabled devices.
- **Validating**: refers to projects where people help verify the quality of existing geospatial data.
- **Polling/Surveying**: projects that used polling or surveys to collect geospatial information and opinions from people.
- **Socializing**: refers to the use of social media to contribute geo-referenced information.

- **Sharing**: refers to projects that provide sites for the people to place geospatial content that can be shared, accessed and used in "mashups."

Another element added to the survey, was the type of data that was collected, observed, contributed or shared via crowdsourcing. All of the projects have some geospatial elements in their applications. However, some projects were not directly focused on the collection, sharing, and manipulation of geospatial information. Those projects that include an indirect use of geospatial elements were classified as non-geographic, while those with a very clear geospatial application were classified as geographic.

After completing the characterization, our team selected the most representative projects for each task categorization. We created a ranking system to identify the projects that potentially could represent each task and show the diversity of geo-crowdsourcing projects and applications. Five classes were created to rank the projects from low (rank 1) to high relevance (rank 5). The ranking was useful to assist in the selection of the projects that were later reviewed in detail for gaining additional understanding of the practices in current geo-crowdsourcing projects. We kept only those projects that ranked 4 and 5 for the subsequent review. These were projects that had some level of success and popularity applying crowdsourcing techniques, and were primarily focused in dealing with geospatial data. Figure 2 shows the proportion of the surveyed projects that were ranked in each of the five positions. Twenty-three projects, which represent 14% of the total number of projects, were ranked as 5, and 31 (19%) ranked 4. These top-ranked projects were carefully reviewed again to identify and create a new, smaller selection of projects that provide a more integral representation of each task, and illustrate a variety of applications.

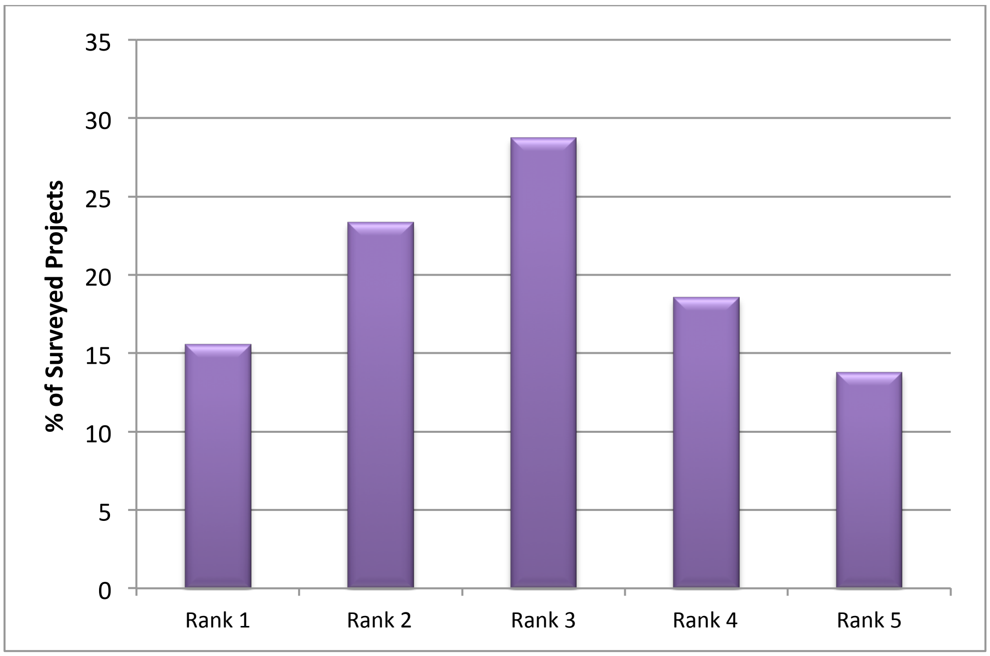

Figure 2. Graph of the proportion of surveyed projects ranked in each position

The following tables present a summary of the final twenty-four projects and applications that resulted from the survey, which were reviewed in detail in Rice et al. [45]. Table 1 shows the survey conducted on projects selected to represent the tasks of imaging, geo-referencing, and digitizing. The projects included Grassroots Mapping[46] for imaging and geo-referencing, NYPL Map Rectifier[47] for geo-referencing, and OSM[48],

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[45] Ibid.
[46] "Grassroots Mapping," March 9, 2012, http://grassrootsmapping.org/.
[47] "NYPL Map Warper: Home," accessed April 16, 2012, http://maps.nypl.org/warper/.

Google MapMaker[49], and Wikipedia[50] for digitizing. Table 3 summarizes the survey conducted for Galaxy Zoo[51] for the attributing task; and Louisiana Bucket Brigade[52], GasBuddy[53], Street Bump[54], SyriaTracker[55], and Wikipedia for the reporting tasks. Table 4 summarizes the survey of the task searching, Field Expedition: Mongolia-Valley of the Khans Projects[56] and DARPA Red Balloon[57] as its representative projects; and tracking, with Waze[58] as its representative. Table 5 shows the surveyed projects that included transcribing, with the example of OldWeather[59]; validating, with the examples of NAVTEQ Maps Reporter[60], Geo-Wiki.org[61], and OSM Inspector[62]; and

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48 "OpenStreetMap," accessed April 28, 2012, http://www.openstreetmap.org/.

49 "Google Map Maker," *Google*, accessed May 1, 2012, http://www.google.com/mapmaker.

50 "Wikipedia.org Site Info," *Alexa*, accessed May 6, 2012, http://www.alexa.com/siteinfo/wikipedia.org.

51 "Galaxy Zoo: Classify Galaxies."

52 Louisiana Bucket Brigade, "Louisiana Bucket Brigade: Clean Air. Justice. Sustainability," accessed April 28, 2014, http://www.labucketbrigade.org/.

53 "GasBuddy.com - Find Low Gas Prices in the USA and Canada," accessed April 26, 2012, http://gasbuddy.com/.

54 "Street Bump," accessed April 16, 2011, http://streetbump.org/.

55 "Syria Tracker," *Syria Tracker: Missing, Killed, Arrested, Eyewitness, Report*, accessed April 16, 2012, https://syriatracker.crowdmap.com/.

56 "Field Expedition: Mongolia," *National Geographic*, 2010, http://exploration.nationalgeographic.com/.

57 DARPA, "DARPA Network Challenge," *DARPA Network Challenge*, 2009, http://archive.darpa.mil/networkchallenge/FAQ.aspx.

58 "Waze - Social Traffic & Navigation App," accessed June 20, 2012, http://www.waze.com/.

59 "Old Weather - Our Weather's Past, the Climate's Future."

60 "NAVTEQ Map Reporter," accessed April 11, 2012, http://mapreporter.navteq.com/.

61 "The Geo-Wiki Project," *Geo-Wiki*, accessed April 11, 2012, http://geo-wiki.org/login.php?ReturnUrl=/index.php.

62 "OSM Inspector," *Geofabrik Tools*, 2011, http://tools.geofabrik.de/osmi/.

polling/surveying, with SurveyMapper[63] as the representative project. Finally, Table 6 summarized the review results for Twitter[64], Flickr[65] and Foursquare[66] as the representative projects of the socializing task; and ArcGIS Online[67], and GeoCommons[68] for the sharing task.

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63 "Welcome to SurveyMapper," *SurveyMapper*, accessed April 16, 2012, http://www.surveymapper.com/.

64 "Welcome to Twitter," *Twitter*, accessed April 11, 2012, https://twitter.com/.

65 "Welcome to Flickr!," *Flickr*, accessed April 30, 2012, http://www.flickr.com/.

66 "Foursquare," *Foursquare*, accessed April 30, 2012, https://foursquare.com/.

67 "ArcGIS Online," *ArcGIS Online*, accessed April 24, 2012, http://www.arcgis.com/home/.

68 "GeoCommons," *Geocommons*, accessed April 24, 2012, http://geocommons.com/.

Table 2. Geo-crowdsourcing applications summary: Imaging, Georeferencing, and Digitizing

Tasks		Imaging & Georeferencing	Georeferencing	Digitizing		
Examples		Grassroots Mapping	NYPL Map Rectifier	OSM	Google Map Maker	Wikimapia
Data Type		Geographic	Geographic	Geographic	Geographic	Geographic
Primary Interface	Tabular				✓	✓
	Unstructured					
	Map-based (Source)	USDA NAIP Imagery	OSM	OSM	Google Map	Google Map
	Alternate view		Google Earth	Cycle Map/ Transport Map/ MapQuest	Satellite	Satellite/ Hybrid/ Terrain/OSM /Panoramio
Geo-Coverage		Local	Local	Global	Global	Global
Training		Online Video	Online Video	Online Resources Available	Online Resources Available	
Location Input	Type of End-user Reference	Direct Location		Direct Location	Direct Location	Direct Location
	Point		✓	✓	✓	
	Line			✓	✓	✓
	Polygon		✓	✓	✓	✓
Placename				✓	✓	✓
Content restrictions					'Appropriate Conduct and Prohibited Actions' policy. Approvation required by Google staff.	
Method for Tracking Contributions		Registration	Registration	Registration	Registration & IP Address	Registration & IP Address
Rating System		No	No	No	No	Yes

Table 3. Geo-crowdsourcing applications summary: Attributing and Reporting

Tasks		Attributing	Reporting				
Examples		Galaxy Zoo	Louisiana Bucket Brigade	GasBuddy	StreetBump	Syria Traker	Wikipedia
Data Type		Geographic	Non-geographic	Geographic	Geographic & non-geographic	Geographic & non-geographic	Non-geographic
Primary Interface	Tabular		✓	✓		✓	
	Unstructured					✓	
	Map-based (Source)	Hubble Telescope imagery			Google Map	Google Map	
	Alternate view			Proprietary	Satellite	Imagery	
Geo-Coverage		Galaxy	Regional	National	Regional	National	Global
Training			Education Provided	None	None	None	None
Location Input	Type of End-user Reference		Data collected from property	Address	Direct Location		
	Point			✓	✓	✓	
	Line				✓		
Placename						✓	
ZIP code				✓			
Content restrictions			Require an air sampling device to participate		Yes		
Method for Tracking Contributions		Registration	Contributors request an air sampling device	IP Address	Required phone application download		
Rating System		No	No	Yes	No	No	No

Table 4. Geospatial crowdsourcing applications summary: Searching and Tracking

Tasks		Searching		Tracking	
Examples		Field Expedition: Mongolia - Valley of the Khans Project	DARPA Red Balloon	MapMyWALK	Waze
Data Type		Geographic	Geographic	Geographic	Geographic
Primary Interface	Tabular		✓	✓	✓
	Unstructured	✓			
	Map-based (Source)	GeoEye Satellite Imagery		Google Map	Proprietary
	Alternate view	None		Satellite/Terrain	
Geo-Coverage		Regional	National		Global
Training		Online video	None	Online instructions available	Instructional videos available
Location	Type of End-user Reference	Direct Location	Direct Location	Direct Location	Direct Location
	Point	✓		✓	✓
	Line			✓	✓
Placename			✓	✓	✓
ZIP code				✓	✓
Content restrictions				None	Terms of Service outline the user submissions limitations. Waze reserves its right to delete any user content they considered inappropriate.
Method for Tracking Contributions		Registration	Registration	Mobile device/Registration	Registration
Rating System		No	Money reward	No	No

Table 5. Geospatial crowdsourcing applications summary: Transcribing, Validating, and Polling/Survey

<table>
<tr><th colspan="2">Tasks</th><th>Transcribing/ Validating</th><th colspan="3">Validating</th><th>Polling/ Surveying</th></tr>
<tr><td colspan="2">Examples</td><td>Old Weather</td><td>NAVTEQ Map Reporter</td><td>Geo-Wiki.org</td><td>OSM Inspector</td><td>SurveyMapper</td></tr>
<tr><td colspan="2">Data Type</td><td>Geographic</td><td>Geographic</td><td>Geographic</td><td>Geographic</td><td>Geographic</td></tr>
<tr><td rowspan="3">Primary</td><td>Tabular</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Map-based (Source)</td><td>Google Map</td><td>✓</td><td>Google Earth</td><td>Geofabrik/Mapnik/Open Cycle Map</td><td>Google Map</td></tr>
<tr><td>Alternate view</td><td></td><td>Satellite/ Hybrid</td><td>Satellite</td><td></td><td>Satellite/ Terrain</td></tr>
<tr><td colspan="2">Geo-Coverage</td><td>Global</td><td>Global</td><td>Global</td><td>Global</td><td>Global</td></tr>
<tr><td colspan="2">Training</td><td>Online Instructional video</td><td></td><td>Online Video Tutorial</td><td></td><td>Online
Instructional Video</td></tr>
<tr><td rowspan="3">Location Input</td><td>Type of End-user Reference</td><td></td><td>Direct Location</td><td>Direct Location</td><td></td><td>Choice of ZIP code, county, or country.</td></tr>
<tr><td>Point</td><td></td><td>✓</td><td></td><td></td><td></td></tr>
<tr><td>Line</td><td></td><td>✓</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Placename</td><td></td><td>✓</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td colspan="2">ZIP code</td><td></td><td></td><td>✓</td><td></td><td>✓</td></tr>
<tr><td colspan="2">Content restrictions</td><td>Based on the assumption that wrong contributions can be identified through other 4 right contributions of the same area.</td><td></td><td></td><td>Geofabrik-internal data processing</td><td></td></tr>
<tr><td colspan="2">Method for Tracking Contributions</td><td>Registration</td><td>IP Address</td><td>Registration</td><td></td><td>Registration & IP Address</td></tr>
<tr><td colspan="2">Rating System</td><td>Yes</td><td>No</td><td>Yes</td><td>No</td><td>No</td></tr>
</table>

Table 6. Geospatial crowdsourcing applications summary: Socializing and Sharing

Tasks		Socializing			Sharing	
Examples		Twitter	Flickr	Foursquare	ArcGIS Online	GeoCommons
Data Type		Non-geographic	Non-geographic	Geographic	Geographic	Geographic
Primary Interface	Tabular			✓		
	Unstructured	✓	✓			
	Map-based (Source)	Google Map	NAVTEQ	✓	Esri/GEBCO/NOAA/CHS/National Geographic/DeLorme/NAVTEQ	
	Alternate view		Satellite/ Hybrid		Aerial/Hybrid/ Streets/Imagery /Terrain/ Topographic	
Geo-Coverage		Global	Global		Global	Global
Training			Online instructions available	None		Videos, blogs, community forum
Location Input	Type of End-user Reference	Direct Location	Direct Location	Direct Location		
	Point		✓	✓	✓	
	Line				✓	
	Polygon				✓	
Placename		✓	✓	✓	✓	
ZIP code			✓		✓	
Content restrictions			Community guidelines and allowance to report abuse			
Method for Tracking Contributions		Registration	Registration	Registration	Registration	Registration

The survey of the 167 geo-crowdsourcing projects showed that more than half of the projects lack some type of data quality control measurements. Figure 3 show that 60% of the projects applied some type of method for tracking contributions, 20% a rating system, fourteen percent content contributions, and 26% percent some form of training method.

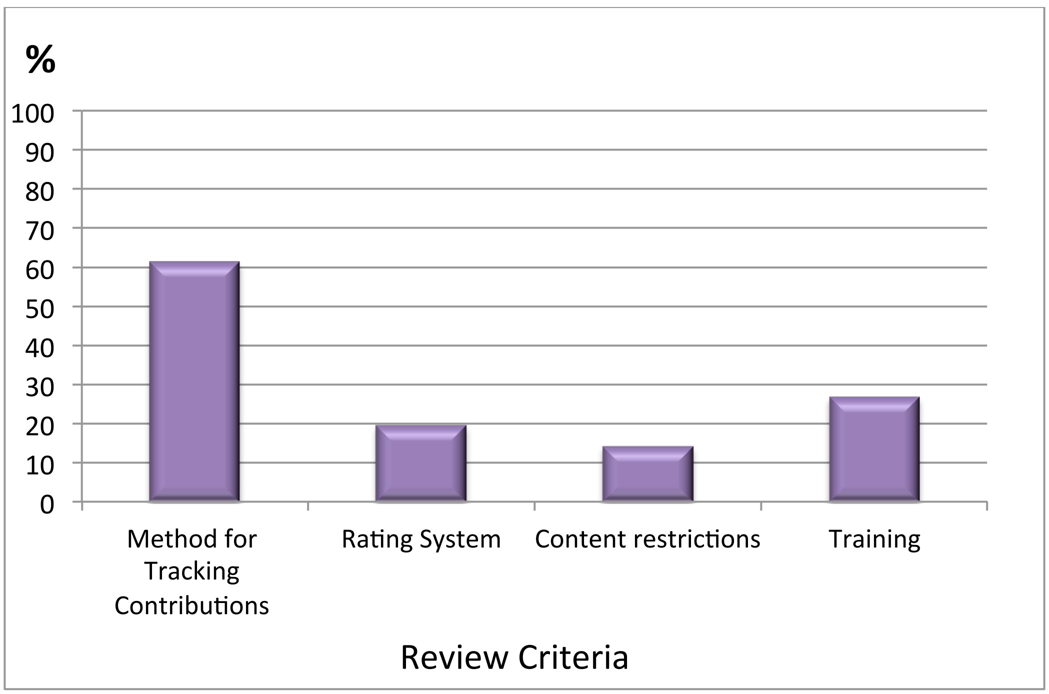

Figure 3. Proportion of the surveyed geo-crowdsourcing applications that have a method for tracking contributions, rating system, content restrictions, and/or training methods

Examination of training methods of current geo-crowdsourcing applications

As the literature review argues, the lack of training is a significant reason that geo-crowdsourcing is considered by some to be unreliable for providing high quality of geospatial data. However, Goodchild[69] argues that geographic expertise is naturally acquired through living and moving through ones own geographic environment, and that this provides a strong argument in favor of geo-crowdsourcing. Goodchild suggests that local geographic expertise has an immense value that can be used in a variety of different ways. Therefore, implementing a good training program that builds on innate local geographic expertise, and assesses any weaknesses in characterizing and contributing geospatial data could greatly improve the data quality generated through geo-crowdsourcing.

Although many applications offer training materials to their user-contributors, very little peer-reviewed literature has been published that studies or characterizes the best practices of training and recruiting in geo-crowdsourcing. Therefore, to support the development of an ad hoc training program (described in the section below), this thesis examines the training methods and resources provided by Waze[70], OpenStreetMap (OSM)[71], the USGS National Map Corps[72], and Google MapMaker[73], which are three successful applications using geo-crowdsourcing to collect data.

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[69] Goodchild, "Citizens as Sensors: The World of Volunteered Geography"; Michael F. Goodchild, "NeoGeography and the Nature of Geographic Expertise," *Journal of Location Based Services* 3, no. 2 (June 2009): 82–96, doi:10.1080/17489720902950374.
[70] "Waze - Social Traffic & Navigation App."
[71] "OpenStreetMap."
[72] "The National Map Corps," *USGS*, August 2, 2011, http://nationalmap.gov/TheNationalMapCorps/.
[73] "Google Map Maker."

Waze

Through short videos, Waze explains the purpose and functionality of the application to their user-contributors graphically and in very simple terms[74]. A few of the videos provided include a guide for creating reports through the mobile interface (which is intuitive and requires little explanation), so many of the videos are focused on explaining how to edit the application's basemap. These optional videos explain each of the features of the Map Editor, which include a rating system, areas that allowed to be edited, and previous map editions. Figure 4 shows a screenshot of the Waze Map Editor interface and the embedded video, which shows users step by step how to edit the basemap. Additionally, Waze provides guidance on creating reports through a wiki-based user manual, where the Waze community writes and edits the content[75]. The information provided through Website and mobile app is intuitive and simple to understand, it uses and explain basic terms, and it is supported with many graphics.

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[74] Waze Gps, "Waze Map Editor Guide Full Clip | Waze," *YouTube*, April 30, 2012, http://www.youtube.com/watch?v=HVksbb1Z4SQ.
[75] "Waze Version 3.5 - User Manual," *Waze*, May 26, 2013, http://www.waze.com/wiki/?title=Waze_Version_3.5.

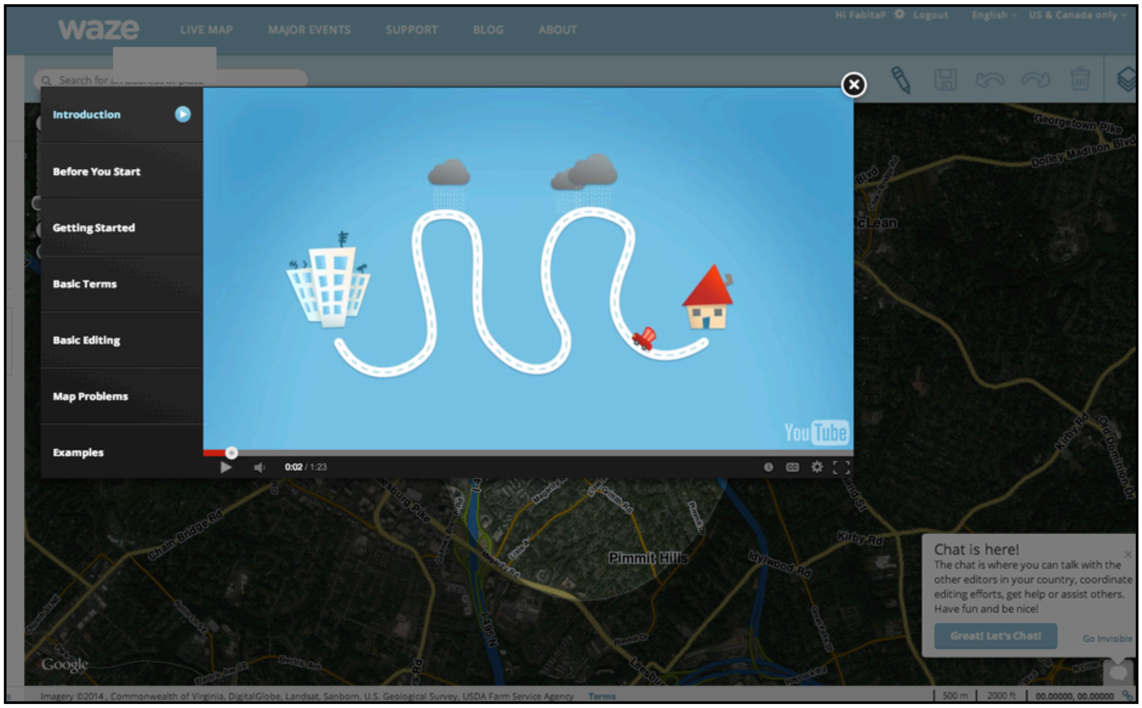

Figure 4. Waze Map Editor training video embedded in website

As noted in the survey and in Table 4, Waze is an example of tracking applications, which suggests its primary purpose is the geo-registering of events in time and space. The majority of the functions associated with Waze are accomplished automatically by the location- and time-aware smart device running the application (typically an Apple iPhone or Android Phone). The user chooses characteristics of the item being tracked by tapping on simple screen icons. The intuitive design of the system requires very little training if the nature of the interaction is simple reporting or tracking. The editing of base data is a more complex and involved task and therefore requires training videos, and in this aspect makes the training for Waze is more like the training for OSM, discussed below.

OpenStreetMap (OSM)

The OSM project has a much larger functional scope, which is more complex than Waze, so its training material is, therefore, more elaborated and detailed. Table 2, from the geo-crowdsourcing application survey, characterizes OSM as a digitizing application, and later in Table 5 describes a related application (OSM Inspector) as a validating application. At its core, OSM is about generating high-quality base maps and data for use in open source applications, and the functionality description from our survey indicates that it is a much more complex application than Waze.

OSM provides a large number of tools and resources for learning how to edit its maps. After creating an account in OSM, users receive an introductory email providing a list of the resources where users can find training material, such as videos[76], a wiki[77], and a questions and answers site[78]. The training methods used in OSM varied in length and complexity according to the many ways to contribute data. This year, OSM improved its training method for editing its map, which is now embedded in Website (Figure 5). The "Walkthrough" link takes the user to an interactive training module, which shows the different features available to edit the maps. As Figure 6 shows, while completing this optional training, a bar at the bottom of the page shows the users the sections that have been explained and the ones that have not been reviewed.

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[76] Steve, "OpenStreetMap," *ShowMeDo*, 2008, http://showmedo.com/videotutorials/series?name=mS2P1ZqS6.
[77] "Beginners' Guide - OpenStreetMap Wiki," July 28, 2013, http://wiki.openstreetmap.org/wiki/Beginners%27_Guide.
[78] "OpenStreetMap Help Forum," accessed August 26, 2013, https://help.openstreetmap.org/.

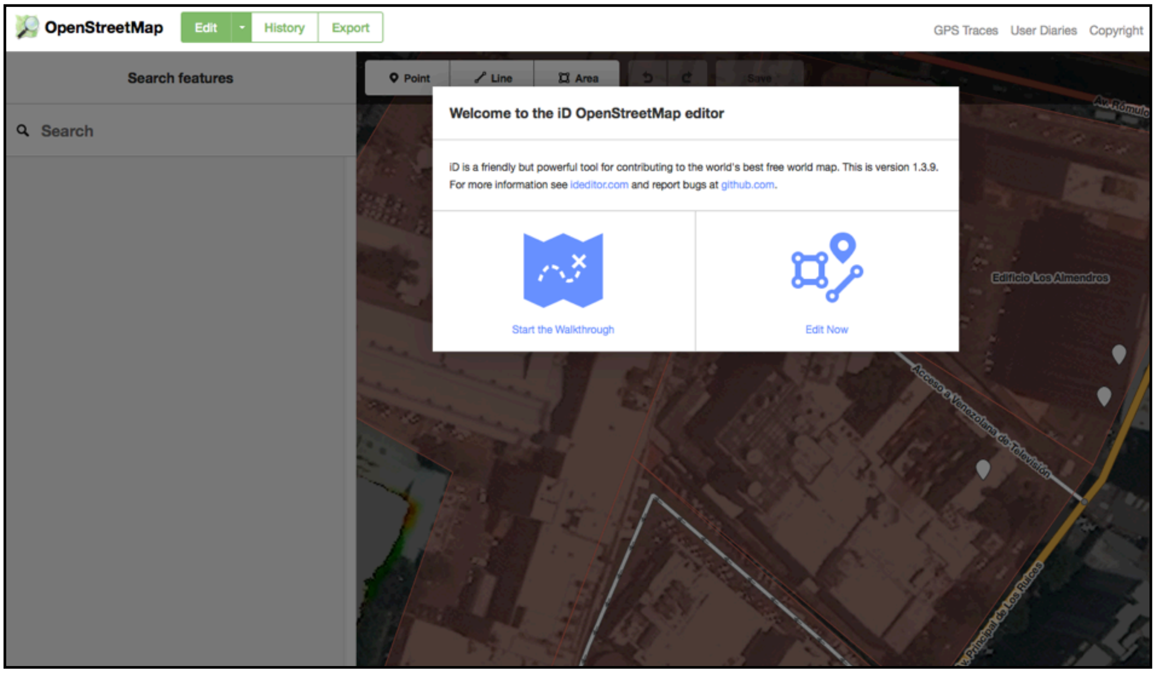

Figure 5. OSM edit tool with embedded training

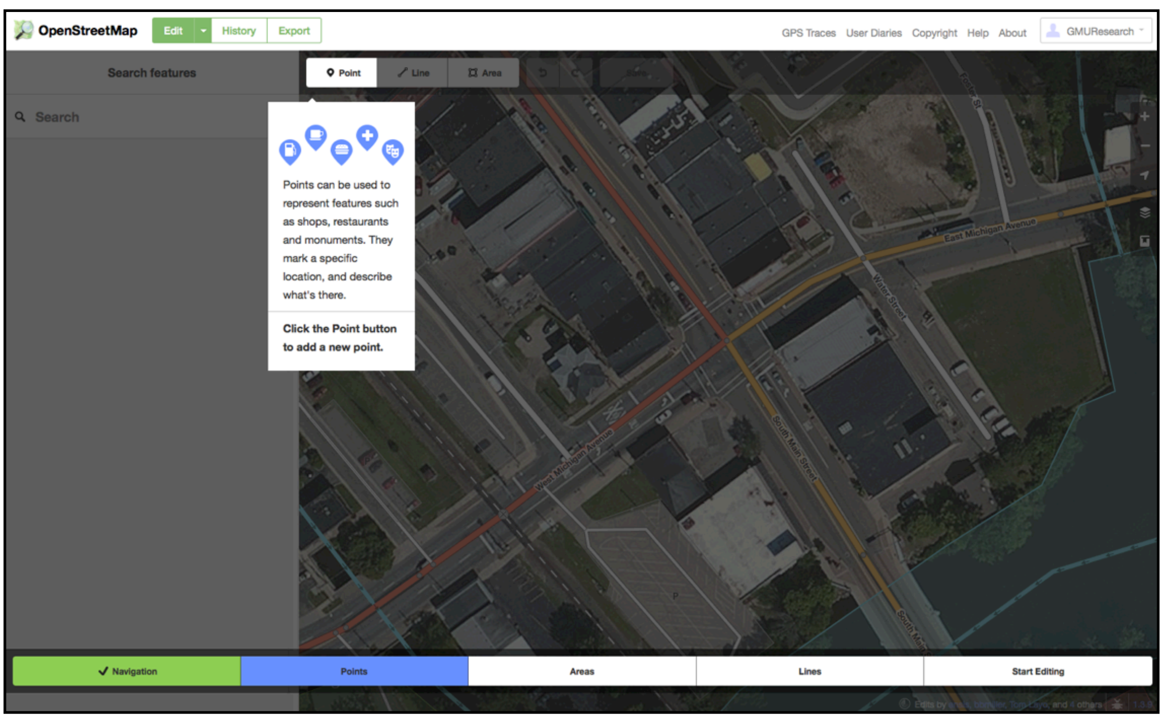

Figure 6. OSM edit tool training material with bar showing the progress of the training

The USGS National Map Corps (TNM Corps)

The USGS National Map Corps was not profiled in the survey described earlier and could probably not be characterized as a geo-crowdsourcing application in the same vein as the others due to its size, history, and complexity. It was, however, discussed in detail in our comprehensive report from 2012[79] and is an important point-of-reference in looking at how an authoritative government geospatial data producer (USGS) has incorporated crowdsourcing techniques into its map production process. The USGS and the differences between traditional and crowdsourced geospatial data production paradigms are discussed in Chapter 2 of our report. This earlier characterization of crowdsourcing at USGS was supplemented by internship experience I had in an important USGS citizen science program involving crowdsourcing and again during the work on this Masters Thesis.

The training developed by the TNM Corps to guide contributors on how to edit its mapping tool is less interactive and dynamic than the ones provided by Waze and OSM. However, TNM Corps training material provides step-by-step, detailed instructions using simple terminology, concise information, and graphics of the map editor's interface. Figure 7 shows some sections of the TNM Corps training material, which describes some of the features in the map editor interface through static arrows and text.

[79] Rice et al., *Crowdsourced Geospatial Data: A Report on the Emerging Phenomena of Crowdsourced and User-generated Geospatial Data*.

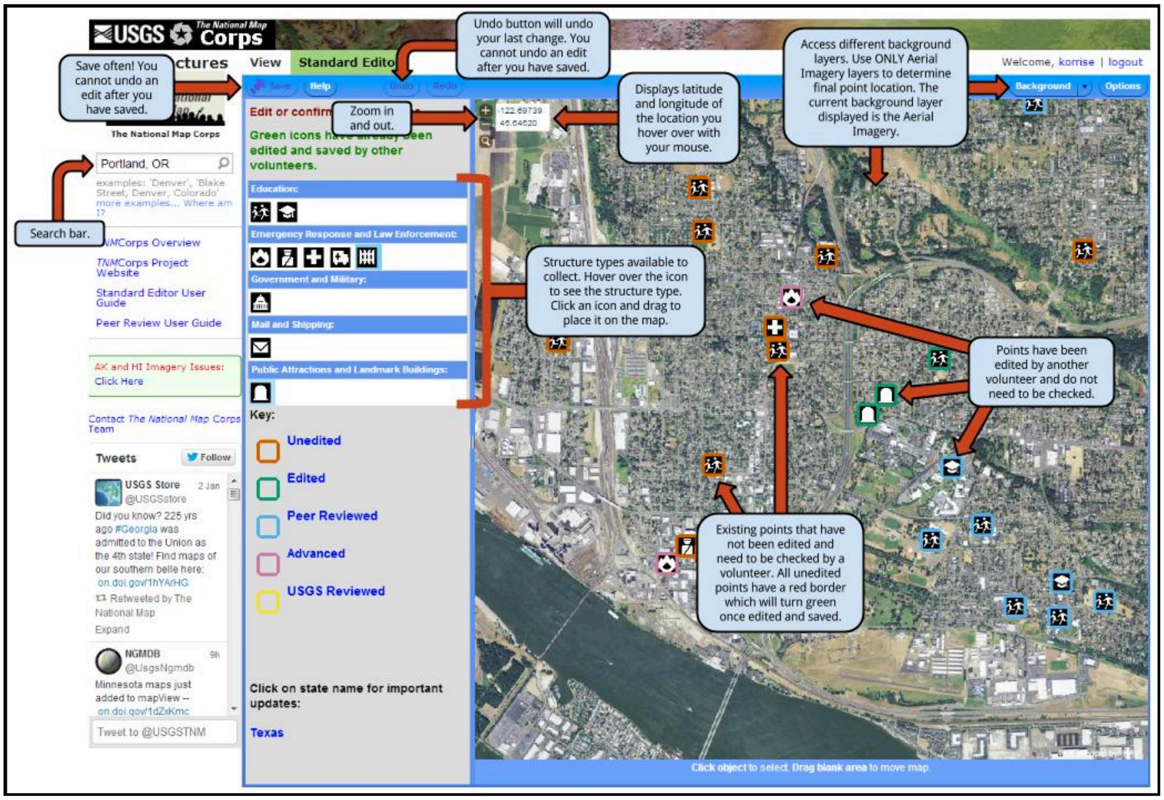

Figure 7. TNM Corps training material

Google MapMaker

Google MapMaker, profiled in our survey (Table 2) as a digitizing application in the same category as OSM and Wikimapia, which suggests that a primary focus of the application is the generation of map features. Its training combines some functionality from Waze and OSM. The training is embedded in the map interface, and it is partially interactive, showing videos exemplifying how to use each feature the editor tool, as well as an option to use the feature selected with a step-by-step instruction (Figure 8). Google MapMaker also provides a Help Center, which explains in more detail the entire project, and provides additional information such as videos and tutorials, community resources, and help troubleshooting issues (Figure 9).

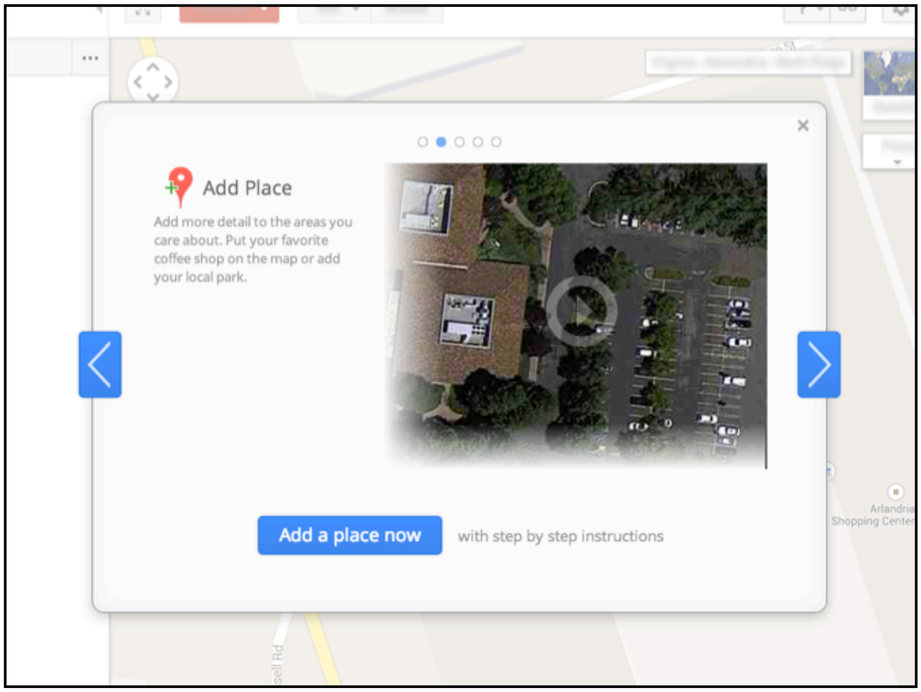

Figure 8. Google MapMaker embedded training material

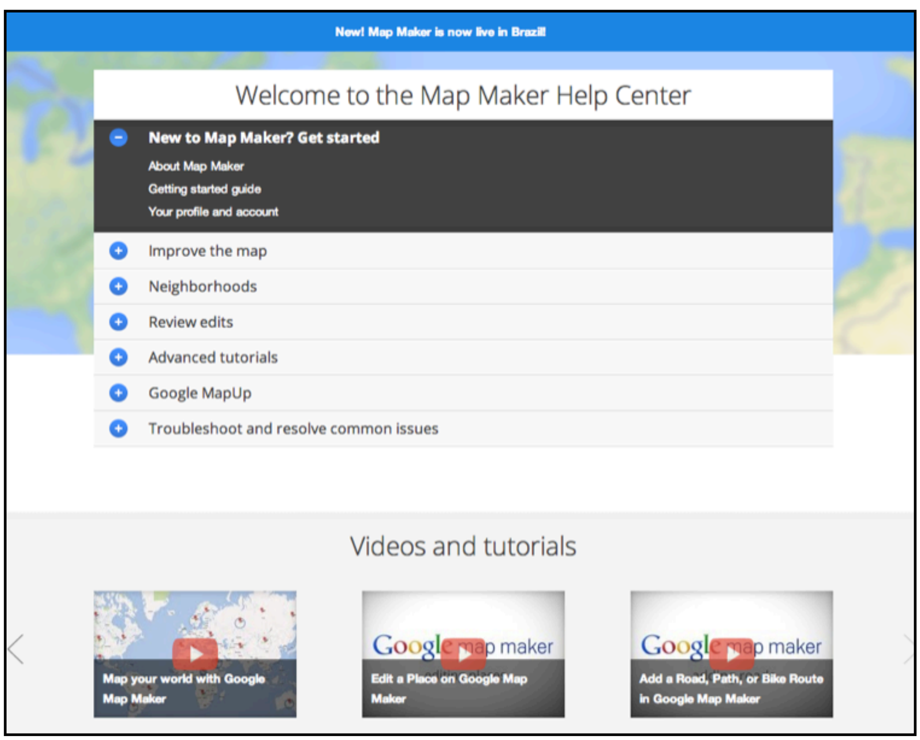

Figure 9. Google MapMaker additional information and training material

Each of the training materials described in this section have unique features, but the structure of the information is similar. First, they provide general information about the purpose of the application. Then, the functionality of the application is explained in detail using videos and/or graphics, as well as the user interface. In projects that are financially limited, which cannot invest in the technology and expertise required to create embedded, customized training material, TNM Corps provides a good example of a simple, and informative, yet static training program. The fact that this training material is static and perhaps more traditional, and also comes from a federal agency is not a coincidence.

Development and evaluation of training program

Design and development of training program

The training material developed for this thesis and for training contributors to our obstacle-reporting application consisted of an in-person presentation, which was also adapted for an online training. For both types of presentations, Microsoft PowerPoint[80] was used as the principal tool to display and structure the information presented to the participants. To create the online presentation, Adobe Presenter[81] was used as an additional tool to embed narration and speaker notes into the presentation, providing a dynamic oral presentation in an accessible format.

The training material was designed and structured to provide participants with enough information about the research and the tool in approximately 20 minutes. The

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[80] Microsoft Office, "Microsoft PowerPoint – Slide Presentation Software," *Office*, accessed August 24, 2013, http://office.microsoft.com/en-us/powerpoint/.

[81] Adobe, "Adobe Presenter 9," *Adobe*, August 8, 2013, http://www.adobe.com/products/presenter.html.

information included in the training material included an introduction, a description of the obstacle-reporting tool functionalities, and a categorization exercise.

First, the introduction of the training material was designed to engage participants in the research and the obstacle-reporting tool. The introduction to the training provided general information about the goals of the research project. It stated the importance of creating a reporting system for providing obstacles information in real time, and summarizing the system's usefulness for people with accessibility needs. Next, the participants were introduced to the definition and benefits of using crowdsourced geographic information for data collection. This section provided a list of current examples of projects that use crowdsourcing for collecting different type of information. Besides providing general information about the research, the information included in the introduction attempts to awaken the humanitarian and altruistic motives of the participants by explaining not only the navigation needs of some of their peers but also a feasible solution in which they can partake. In other words, the participants might feel motivated to contribute obstacles in the reporting tool for reasons such as altruism or getting the satisfaction that they are helping their own GMU community and society. Figure 10 and Figure 11 show the PowerPoint slides created for the introduction in the training material. It includes a description of the problem and purpose of the research (Figure 10), and a brief description of crowdsourcing as a methodology to collect information (Figure 11).

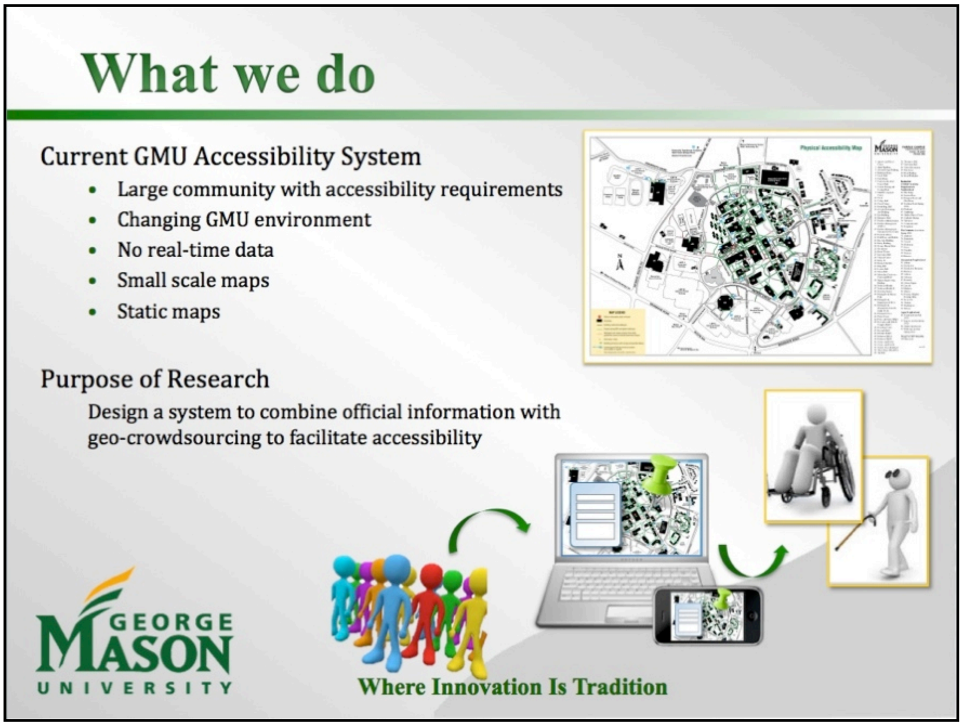

Figure 10. Training material - Introduction to the research problem and purpose

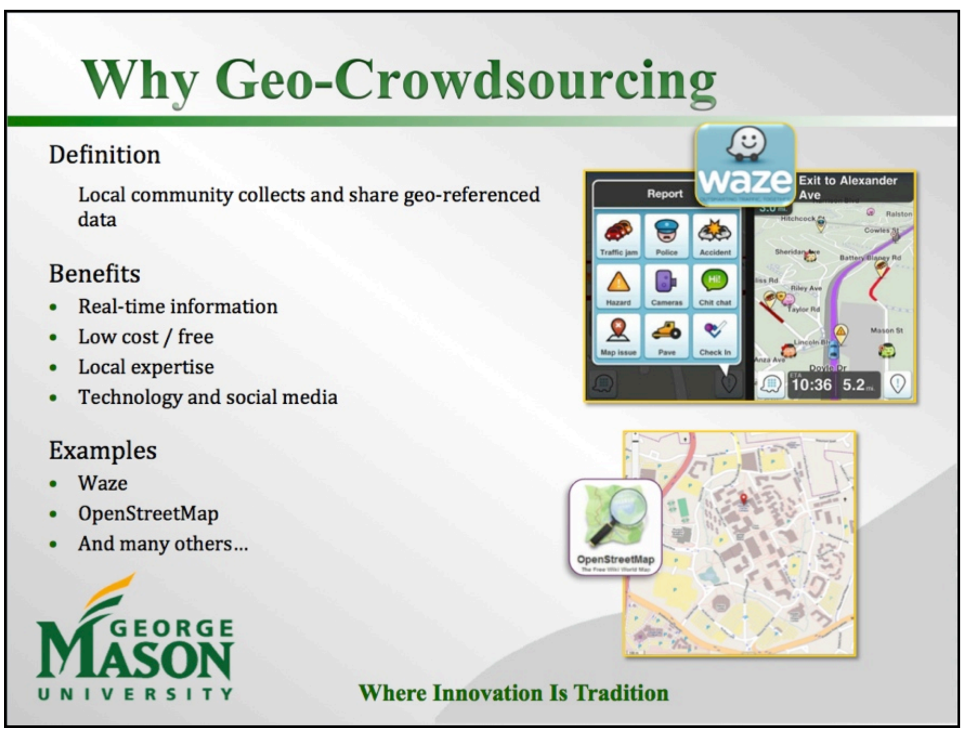

Figure 11. Training material - Introduction to research framework

Next, the reporting system functionality and the obstacle-reporting tool interface were described in detail. A functional diagram of the reporting system procedure, shown in Figure 12, was explained to describe the process of reporting obstacles. The diagram indicates a process that starts with the participants navigating around campus as they normally do, it continues with the observation and identification of an obstruction in walking areas, and it concludes with the completion of the online form from the obstacle-reporting tool. The diagram attempts to show the simplicity of the process of reporting obstacles, where the process to report obstacle would be effortless, relatively fast, and even enjoyable.

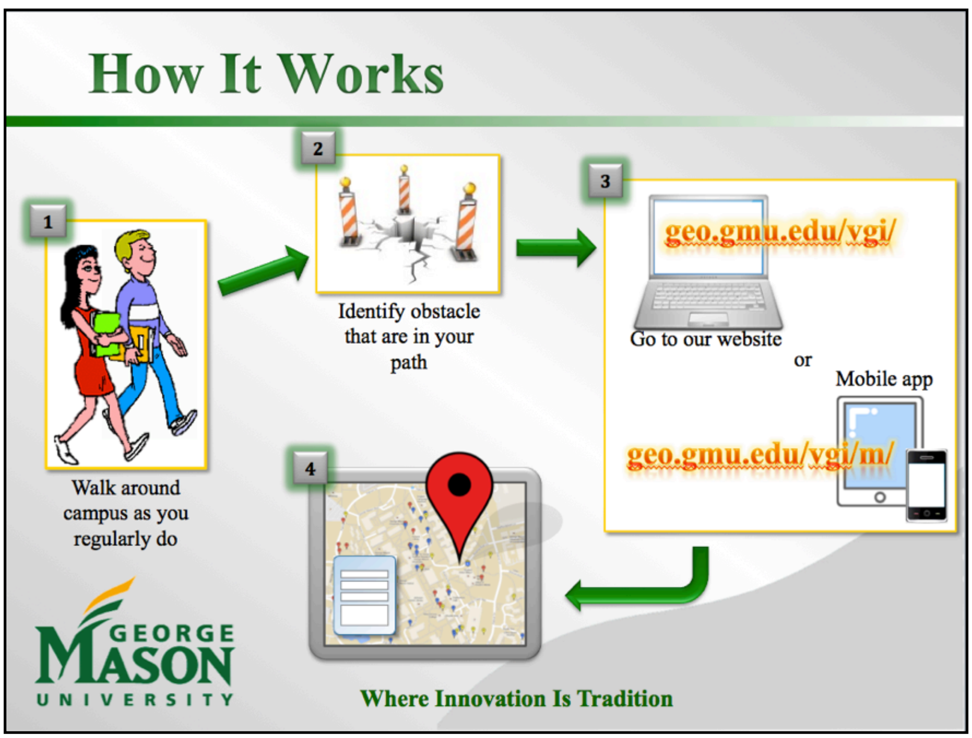

Figure 12. Training material - Obstacle reporting process

Successively, each of the steps necessary to complete the obstacle's attributes in the reporting form was explained in detail. Although the main structure of the form remained similar throughout the development of this thesis, the interface of the obstacle reporting tool was modified several times. Therefore, this section of the training was subject to changes to reflect the modifications made to the obstacle-reporting tool. Each of the steps in the online form is verbally described in detail and supported by the PowerPoint slides, which were created using color, graphics, and limited text to help maintaining the audience engagement in the presentation. Figure 13 shows an example of the slides created to describe the fields that a user-contributor will be required to complete when reporting an obstacle. A screenshot of the real, current reporting form was used in the slides to familiarize participants with the interface and structure of the obstacle reporting system.

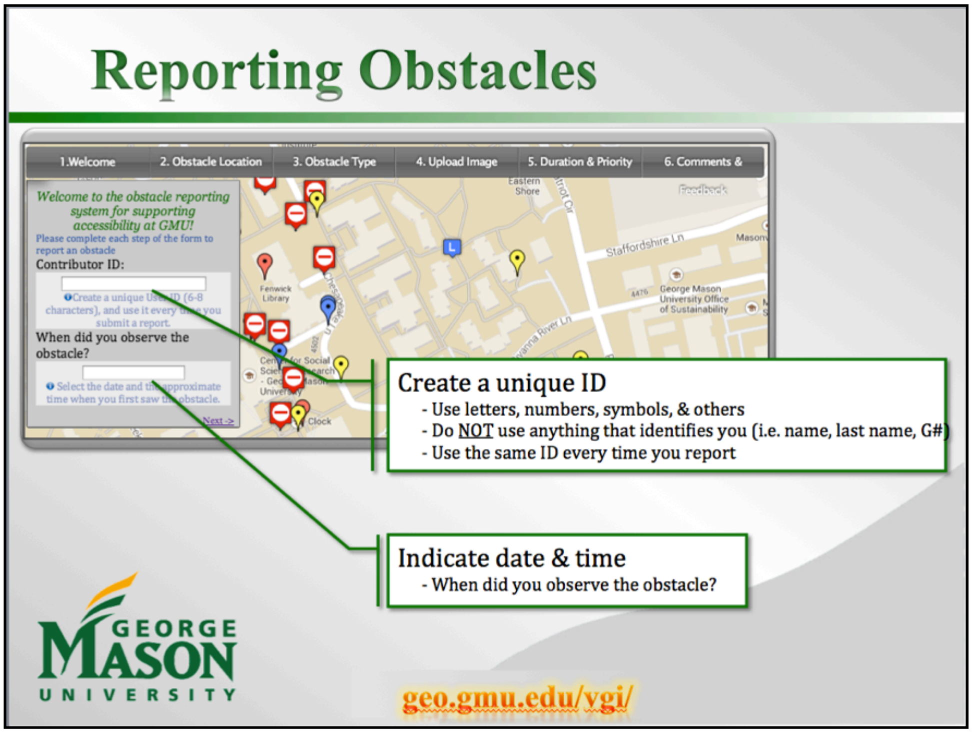

Figure 13. Training material – Obstacle-reporting online form

The final section of the training provides more detail of the obstacle reporting process. This section provides representative examples of each of major obstacle types in our system. These representative examples take the form of images selected through the consensus of project staff to be most representative of each object type (Figure 14). The participants learn to characterize obstacles by viewing these representative images and the associated type of obstacle, the duration estimate and the urgency or priority estimate. Figure 14 shows a slide of one of the five examples given during the training. The image shows a cracked sidewalk, representing the category of poor surface conditions, and which might pose a high inconvenience to a person with mobility impairment of medium urgency. The duration category refers to the time that the hazard will be in place, and this type of work might require more than seven days to be fixed, so it is considered of long duration.

Figure 14. Training material - Examples and assessment of obstacles (picture sources: www.sanantonio.gov and www.leaderbasementsystems.com)

After explaining how to assess each type of obstacle, a categorization exercise was provided to participants. The categorization exercise intended to evaluate the quality of the training, and how well the participants understood both the training and the obstacle attributes they had to report. The participants were told that the exercise was not a test and there was no a right or wrong answer. In that way, the pressure to answer correctly was reduced, so more honest answers were expected. The categorization exercise consisted in assessing 15 obstacles, with pictures displayed for 20 to 30 seconds to complete the assessment (some examples are shown in Figure 15). The pictures of the obstacles were taken within GMU Fairfax campus and the surrounding neighborhoods, in order to make the assessment realistic and reflective of the types of obstacles likely to be encountered during future report contributions.

Figure 15. Categorization exercise - Sample of the pictures of obstacles

Additionally, participants were provided with an answer sheet to record their obstacle assessments. The categorization answer sheet was design using simple-choice answers in the categories of obstacle type, duration, and urgency, which were the same categories explained in the previous section of the training. The design of the answer sheet went through various changes to improve the user experience. One of the early designs of the categorization answer sheet is shown in Figure 16, where a three-step general instruction is specified at the beginning of the form, and two pictures could be assessed per page. One of the problems with this design frequently observed during the training was that it took them a few more seconds to turn the page, leaving them with not enough time to assess the next picture. It was noticed that some participants rushed to fill out the information, which could have influenced their ability to provide a thoughtful answer. Additionally, in the training where this version of the answer sheet was provided, there were cases where answers were missing. Therefore, the answer sheet was redesigned attempting to reduce some of the problems observed.

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Department of Geography and GeoInformation Science

OBSTACLE CATEGORIZATION EXERCISE

INSTRUCTION:

1. Mark with an X the category or categories you think that better describe each picture
2. Give us your feedback in the spaces provided to you at the end of the document
3. Send this documents with your answers to Fabiana Paez (fpaez@masonlive.gmu.edu) - Please type in the subject: "Obstacle Categorization Exercise"

PICTURE 1	PICTURE 2
Obstacle Type *(Mark one or two options)*	Obstacle Type *(Mark one or two options)*
☐ Sidewalk Obstruction	☐ Sidewalk Obstruction
☐ Construction	☐ Construction
☐ Poor Surface Condition	☐ Poor Surface Condition
☐ Entrance/Exit Problem	☐ Entrance/Exit Problem
☐ Crowd/Event	☐ Crowd/Event
Duration *(Mark one option + periodical optional)*	Duration *(Mark one option + periodical optional)*
☐ Short (< 1 day)	☐ Short (< 1 day)
☐ Medium (1 – 7 days)	☐ Medium (1 – 7 days)
☐ Long (> 7 days)	☐ Long (> 7 days)
---	---
☐ Periodic. Explain ________________	☐ Periodic. Explain ________________
Urgency *(Mark one option)*	Urgency *(Mark one option)*
☐ Low	☐ Low
☐ Medium	☐ Medium
☐ High	☐ High

Figure 16. Categorization exercise - Initial versions

The next version of the answer sheet, shown in Figure 17, included a one-page introduction, as well as additional information about the obstacle-reporting system website that participants take out with them. This new version of the answer sheet was designed to help participants familiarize themselves with the answer sheet before starting the exercise, and simplify the process of choosing an answer during the assessment. At the end of the categorization exercise a survey asking for feedback was included. The early versions of the answer sheet included one open question asking for comments and suggestions, while the latest versions included more specific questions addressing both the understanding of the training and the obstacle categorization options. Figure 18 shows the last page of the latest design of the answer sheet showing an entire page dedicated for a survey, with questions addressing the perceived quality of the training and the clarity of the obstacle categorization options. Many participants provided feedback on obstacle attribute categories, particularly duration and urgency. Additionally, some participants provided meaningful suggestions for the improvement of the obstacle-reporting tool, which were carefully considered and many of them implemented.

George Mason University
Department of Geography and GeoInformation Science

Date: ____/_____/ 2014

OBSTACLE CATEGORIZATION EXERCISE

Instruction:

1. Mark with an X the category or categories you think that better describe each picture.
2. Please, give us your feedback in the space provided at the end of the document.

PICTURE #

Which of the provided categories best describe the obstacle?

Obstacle Type *(Mark 1 or 2 options)*

- ☐ Sidewalk Obstruction
- ☐ Construction
- ☐ Poor Surface Condition
- ☐ Entrance/Exit Problem
- ☐ Crowd/Event

How long do you estimate the obstacle will remain in place?

Duration *(Mark 1 option)*

- O Short (< 1 day)
- O Medium (1 – 7 days)
- O Long (> 7 days)

What is the risk that the obstacle might have for people with accessibility requirements?

Urgency *(Mark 1 option)*

- O Low ← Informative, small inconvenience
- O Medium ← Detour required, highly inconvenient, small hazard
- O High ← Threat to safety, significant hazard

✂ -

Go to our website and start reporting obstacles: geo.gmu.edu/vgi/

Contact us:
Fabiana Paez (fpaez@masonlive.gmu.edu)
Matt Rice (mrice@gmu.edu)

Figure 17. Categorization exercise - Latest versions

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FEEDBACK

a) Did you find the training useful to understand how to complete the exercise?

☐ Yes ☐ No

b) Did you find any difficulties completing the exercise?

☐ Yes ☐ No If yes, please explain: ______________________________

____

____

c) Please, select the option that best describe how interested are you in reporting obstacles through our online reporting systems this week?

☐ 5) Highly interested – As soon as I leave class I will start reporting obstacles
☐ 4) Somewhat interested –I will try to make at least one report
☐ 3) Neutral
☐ 4) Little interested – I will report just for the incentive offered (e.g. extra credits in a course)
☐ 5) Not interested – As soon as I leave class I will forget about this

Other comments, questions, or suggestions:

____

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____

____

____

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Thank you for your participation! ☺

5/5

Figure 18. Categorization exercise - Feedback

Training program quality assessment

The implementation of the prototype of this training was organized in ten sessions, where a total of 149 people were trained. The courses selected to recruit and train student were three undergraduate level courses and one graduate level course related to GIS. Also, 14 GRA and GTA students, and 3 local residents participated in the training. Since both the obstacle-reporting tool and the training are still a prototype and they are designed to be ad hoc to this research, it is important to acknowledge that the majority of the participants might fall within the WEIRD category, which refers to the people from western, educated, industrialized, rich and democratic societies[82]. However, this thesis does not look for behavioral or psychological analyses, which would require a more representative population sample that includes diversity. Figure 19 shows a graphic of the number of participants trained in each session, as well as the version of the categorization exercise's answer sheet used in each one. Recognizing that five different versions of the answer sheet were used is important because it might provide some insights about the different answers provided by participants.

[82] Joseph Henrich, Steven J. Heine, and Ara Norenzayan, "Most People Are Not WEIRD," *Nature*, July 2010, http://www.facstaff.bucknell.edu/jvt002/BrainMind/Readings/Henrich_2010.pdf.

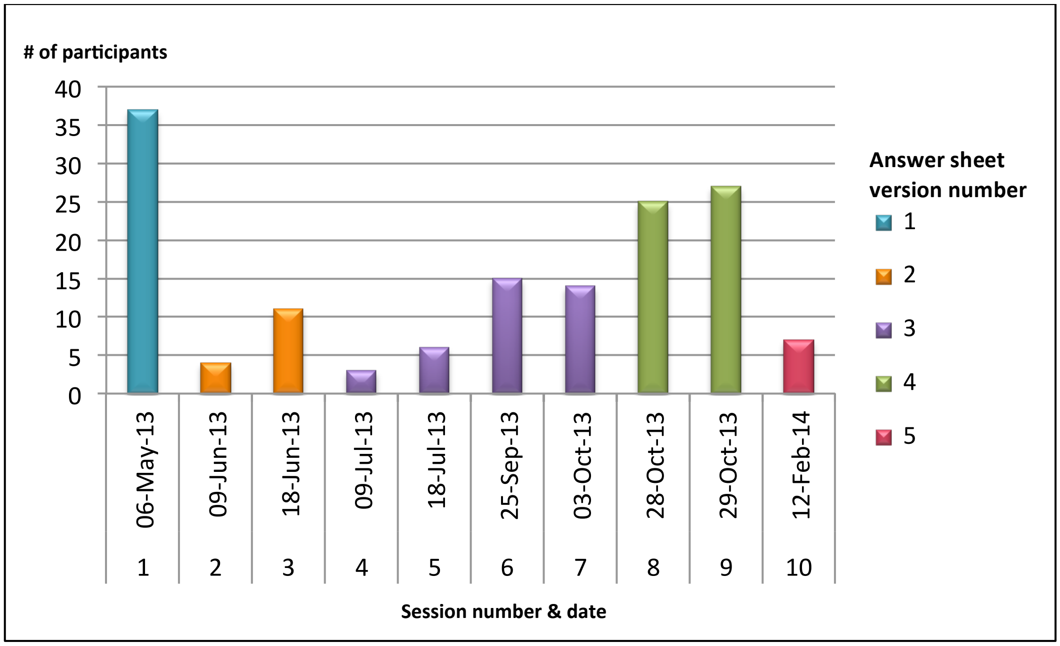

Figure 19. Graph of the number of participants trained per session, and the answer sheet version used.

Another change implemented in some training sessions was the various pictures of obstacles used for the categorization. The results of the first training indicated that some of the pictures were difficult to assess even by the team of researchers. For instance, Figure 20 shows one of the pictures that resulted in a great variety of answers from participants on the first training (answers are shown in Figure 21). The picture shows an area that is frequently congested during rush hours of classes. It also shows benches that were positioned over the sidewalk while the construction of one of the local buildings was taking place. It is understandable that a variety of answers were collected from participants. However, it was difficult to evaluate which obstacle the participant was assessing and comparing them with other answers. Therefore, the research team decided to select new pictures that substitute those that created a great variety of answers and confusion such as the one described above. Additionally, the team discussed how some obstacle types might overlap when assessing a particular obstacle. For example, construction cone and barriers in the middle of a sidewalk could be categorized as construction detour and sidewalk obstruction. This situation led the team of researchers to reevaluate the naming of the obstacle type categories, and consider asking for professional advise in the topic of categorization for accessibility. The team also decided to allow users to select up to two obstacle types when completing the obstacle report.

Figure 20. Picture showing a variety of sidewalk obstacles, GMU, Fairfax, VA (Source: author)

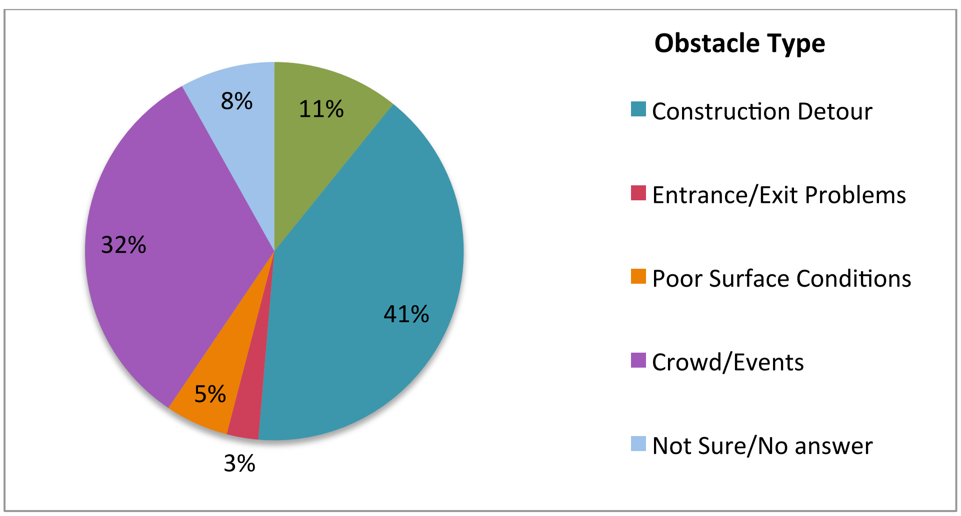

Figure 21. Graph of the proportion of categories selected by participants in training 1 for the picture shown in Figure 20 during the categorization exercise

Figure 23 shows an alternative example, where the selected categorization for the picture shown in Figure 22was almost homogenous in all participants across all trainings.

Figure 22. Picture used in categorization exercise. It shows a group of people standing in the middle of a sidewalk obstructing the navigation of other pedestrians. GMU, Fairfax, VA. (Source: author)

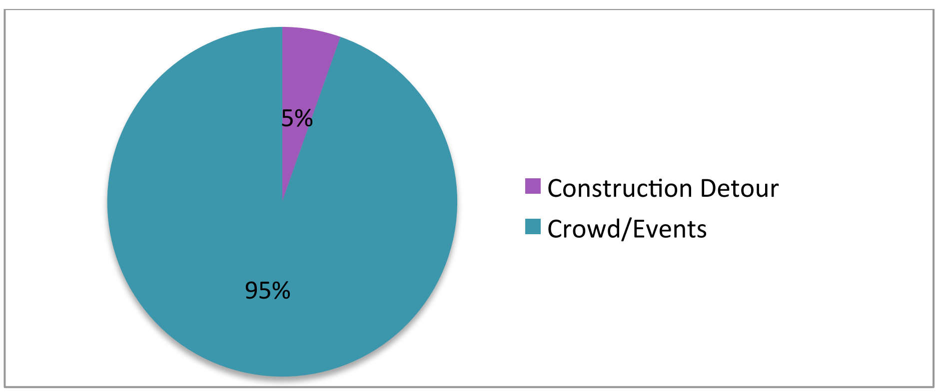

Figure 23. Graph showing the proportion of categories selected by participants across all trainings for the picture shown in Figure 22 during the categorization exercise

Discussion

As this thesis is part of a larger research that studied the quality and value of geo-crowdsourcing, the results generated in this thesis served as a major contribution to the development of phase one and two of our collaborative research project. The survey and characterization was conducted between Brandon Shore, a former member of the team, and myself. The survey helped the research team to select the most representative geo-crowdsourcing applications and projects for each of the task described in step one. Then, we reviewed the selected applications in more detailed to assess their data quality measures and results, as well as to draw the lessons learned from them. The product of this survey, categorization, analysis and evaluation of current geo-crowdsourcing applications are published in a report[83] and a peer-reviewed paper[84]. The training system is being used to recruit and prepare participants to contribute in the prototype of the obstacle-reporting tool. During and after the completion of this thesis, the training has been implemented with new groups of participants. Furthermore, the quality of the training will be studied and reviewed by Patricia Pease and the research team in the upcoming months. For her Master thesis, Patricia will extend this thesis by conducting a comparative study that evaluates the differences of the contributions generated by trained versus untrained subjects. The subjects will be test in their abilities to locate reports on a map and provide accurate attributes to obstacles on campus. Conducting this comparative

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[83] Rice et al., *Crowdsourced Geospatial Data: A Report on the Emerging Phenomena of Crowdsourced and User-generated Geospatial Data*.

[84] Rice et al., "Supporting Accessibility for Blind and Vision-impaired People With a Localized Gazetteer and Open Source Geotechnology."

test will provide a formal way of assessing the quality of the training developed in this thesis, and the usefulness and benefits of training participants for geo-crowdsourcing.

During the development of this thesis and the training material, the categorization exercise served as an informal method for assessing the quality of the training. Initially, the categorization exercise was designed to explore how participants understood the obstacle types that the team was developing to enclose the potential hazards on campus. For the second training, the research team decided to include in the categorization exercise a more detailed assessment of the obstacles presented in pictures that included not only obstacle type, but also duration and urgency. Since the categorization exercise became more complex, the team agreed to provide examples of obstacles outside campus. Consequently, I included in the training a section to provide a more detailed assessment of pictures representing each type of obstacle, and the rationale behind the selection of attributes. Additionally, a feedback section was included in the categorization answer sheet, to gather information about the participants experience during the training and the categorization exercise. In this way, the categorization exercise became a way to assess the quality of both the reporting and the training systems. The initial feedback included in the training comprises a small section at the end of the categorization answer sheet, which asked people for general suggestions or comments. As the research progressed, the feedback section became more complex. I included more specific questions that helped the research team to gain more insight on the weaknesses and strength of the reporting systems, as well as the quality of the training. For instance, we received feedback from most participants expressing the difficulties they encounter when assessing the priority and duration of obstacles. This generated various discussions on the team, which led to change of the word priority to urgency to better describe the potential risk than an obstacle might pose to a person with disabilities. Additionally, the training was modified to provide a more detailed description and explanation of these two attributes. Other participants provided feedback about the reporting tools and system. Initially, the reporting process consisted of recording the obstacle attributes and location in a paper form, and then transcribing the information to the online reporting tool. Many participants expressed a desire for the development of a mobile app to allow contributions directly from the field. Although the team planned to develop a mobile app in the future, the feedback helps to prioritize this option. A similar situation occurred with feedback related to the practicality of allowing contributors to upload obstacle images. Both the mobile app and the obstacle images upload are currently available to contributors. Most of the feedback gathered in the training system I developed in this thesis has allow our research team to improve the reporting and training system by incorporating the user-contributors' needs, perspectives, and ideas into the system. The consistency in the answers provided for the categorization exercise in the lasts training sessions provides evidence that the training has become more efficient as more feedback is received. Currently, our research project has generated 250 reports contributed to the reporting system in the course of twelve months time. Most, if not all, contributions were generated after the recruitment and training conducted in this thesis, evidencing the effectiveness of this training to engage participant to contribute in our tools. Furthermore, the survey conducted and the training system developed in this thesis have helped Dr. Rice's collaborative research project achieve and extend the original research funding.

In summary, this thesis was successful accomplishing all the hypotheses proposed in the introduction. The training developed provided insights on how end-users understand the attributes required for reporting obstacles, helping the research team to improve and make a more intuitive reporting system. It helped recruiting and engaging participants to contribute data on the reporting system. Finally, an effective training system was developed for improving the quality of the information provided via geo-crowdsourcing.

CONCLUSION AND FUTURE RESEARCH

In this thesis, a review and characterization of current geo-crowdsourcing projects was conducted. As the literature has shown, the emergence of geo-crowdsourcing was spontaneous and in response to a variety of necessities, particularly the need for new methods of data collection. Many disciplines have learned about geo-crowdsourcing and incorporated some practices. There are no definitive established parameters that have been determined for best practices with respect to geo-crowdsourcing, though some lessons learned and significant practices are discussed in Rice et al.[85]. However, previous experiences have demonstrated the potential usefulness and benefits of geo-crowdsourcing. Past events, such as the Santa Barbara wildfires and the earthquake in Haiti, have provided a good base for analyzing the social dynamics of geo-crowdsourcing, as well as its capabilities. Many other current geo-crowdsourcing applications, such as the one surveyed in this thesis and reviewed in Rice et al.[86], are taking advantage of the vast amount of information provided by users in real time and without costs. Many research are looking to find ways to improve and test the quality of

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[85] Rice et al., *Crowdsourced Geospatial Data: A Report on the Emerging Phenomena of Crowdsourced and User-generated Geospatial Data*.
[86] Ibid.

the data provided via geo-crowdsourcing to be able to incorporate these data together with data from authoritative and official sources[87].

This thesis and Dr. Rice's collaborative research project are studying geo-crowdsourcing to assess the reliability of crowdsourced geospatial data. The first two phases of our project studied the framework behind geo-crowdsourcing and developing a prototype of an obstacle-reporting system to go beyond the literature and have firsthand observations of the social dynamics that emerged. This thesis developed and tested an initial training process that will help in preparing participants to contribute reliable data through our systems. The next steps will require an evaluation of the efficiency of the training. A possible approach for this evaluation could be to implement a comparative study between trained and untrained contributors. Furthermore, it would be interesting to include additional behavioral analyses to study how people from different cultural and educational backgrounds, and socio-economic status (not just WEIRD[88] contributors) might understand the obstacle-reporting system we developed for data contribution. This will also make possible the extrapolation of this project to other locations and communities. Furthermore, Michael Goodchild suggested in one of his visits to the research team at GMU, that we study the campus geography, which could provide a good insight on the coverage of contributions around campus.

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[87] Ibid.; Rice et al., "Crowdsourcing Techniques for Augmenting Traditional Accessibility Maps with Transitory Obstacle Information"; T. V. Authority, "Geospatial Positioning Accuracy Standards - Part 1: Reporting Methodology" (National Aeronautics and Space Administration, 1998), http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part1; D. Coleman, B. Sabone, and J. Nkhwanana, "Volunteering Geographic Information to Authoritative Databases: Linking Contributor Motivations to Program Characteristics," *Geomatica* 64 (2010): 27–40.
[88] Henrich, Heine, and Norenzayan, "Most People Are Not WEIRD."

Another useful tool that is currently under development in our research, is a website that will allow users to register, find additional information on the research, and communicate with other users via forums. The website is a useful approach to augment the sense of community and community collaboration, which might provide a motivation for people to engage in the system and contribute data. Other motivational approaches, such as ranking and rating systems, can be included in our research to form a group of frequent and reliable data contributors.

REFERENCES

Adobe. "Adobe Presenter 9." *Adobe*, August 8, 2013. http://www.adobe.com/products/presenter.html.

"ArcGIS Online." *ArcGIS Online*. Accessed April 24, 2012. http://www.arcgis.com/home/.

Authority, T. V. "Geospatial Positioning Accuracy Standards - Part 1: Reporting Methodology." National Aeronautics and Space Administration, 1998. http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part1.

Batty, Michael, Andrew Hudson-Smith, Richard Milton, and Andrew Crooks. "Map Mashups, Web 2.0 and the GIS Revolution." *Annals of GIS* 16, no. 1 (April 22, 2010): 1–13. doi:10.1080/19475681003700831.

"Beginners' Guide - OpenStreetMap Wiki," July 28, 2013. http://wiki.openstreetmap.org/wiki/Beginners%27_Guide.

Central Intelligence Agency (CIA). "The World Factbook." *Central Intelligence Agency*, April 11, 2014. https://www.cia.gov/library/publications/the-world-factbook/geos/ha.html.

"Christmas Bird Count." *National Audubon Society Birds*. Accessed July 31, 2012. http://birds.audubon.org/christmas-bird-count.

Clay Shirky. "Clay Shirky: How Cognitive Surplus Will Change the World | Talk Video | TED.com." *TEDTalk*, June 2010. https://www.ted.com/talks/clay_shirky_how_cognitive_surplus_will_change_the_world#t-176018.

Coleman, D., B. Sabone, and J. Nkhwanana. "Volunteering Geographic Information to Authoritative Databases: Linking Contributor Motivations to Program Characteristics." *Geomatica* 64 (2010): 27–40.

Coleman, David J., Yola Georgiadou, and Jeff Labonte. "Volunteered Geographic Information: The Nature and Motivation of Produsers." *International Journal of Spatial Data Infrastructures Research* 4, no. 2009 (2009): 332–58.

Crampton, Jeremy W. *Mapping: a Critical Introduction to Cartography and GIS*. Blackwell Companions to the Ancient World. Malden, Mass: Wiley-Blackwell, 2010.

DARPA. “DARPA Network Challenge.” *DARPA Network Challenge*, 2009. http://archive.darpa.mil/networkchallenge/FAQ.aspx.

Elwood, Sarah. “Geographic Information Science: Emerging Research on the Societal Implications of the Geospatial Web.” *Progress in Human Geography* 34, no. 3 (2010): 349–57.

Elwood, Sarah, Michael F. Goodchild, and Daniel Z. Sui. “Researching Volunteered Geographic Information: Spatial Data, Geographic Research, and New Social Practice.” *Annals of the Association of American Geographers* 102, no. 3 (May 2012): 571–90. doi:10.1080/00045608.2011.595657.

“Field Expedition: Mongolia.” *National Geographic*, 2010. http://exploration.nationalgeographic.com/.

“Foursquare.” *Foursquare*. Accessed April 30, 2012. https://foursquare.com/.

“Galaxy Zoo: Classify Galaxies.” Accessed April 11, 2012. http://www.galaxyzoo.org/classify.

“GasBuddy.com - Find Low Gas Prices in the USA and Canada.” Accessed April 26, 2012. http://gasbuddy.com/.

“GeoCommons.” *Geocommons*. Accessed April 24, 2012. http://geocommons.com/.

George Mason University. “Human Subjects Policies, Procedures, and Guidelines.” *Office of Research Integrity & Assurance*. Accessed April 18, 2014. http://oria.gmu.edu/research-with-humans-or-animals/institutional-review-board/human-subjects-policies-procedures-forms-and-instructions/human-subjects-policies-procedures-and-guidelines/.

———. “Institutional Research & Reporting.” Educational. Accessed April 16, 2014. http://irr.gmu.edu/.

———. “The Mason IDEA: Our Core Institutional Characteristics.” *Mason Idea*, 2014. http://masonidea.gmu.edu/the-mason-idea-our-core-institutional-characteristics/.

———. “The Mason Vision.” Educational. *Mason Vision*, April 29, 2014. http://vision.gmu.edu/the-mason-vision/.

Goodchild, Michael F. “Citizens as Sensors: The World of Volunteered Geography.” *GeoJournal* 69, no. 4 (December 2007): 211–21.

———. “NeoGeography and the Nature of Geographic Expertise.” *Journal of Location Based Services* 3, no. 2 (June 2009): 82–96. doi:10.1080/17489720902950374.

Goodchild, Michael F., and J. Alan Glennon. “Crowdsourcing Geographic Information for Disaster Response: a Research Frontier.” *International Journal of Digital Earth* 3, no. 3 (September 2010): 231–41. doi:10.1080/17538941003759255.

Goodchild, Michael F., Darren Hardy, Daniel Sui, and Sarah Elwood. “About Vgi-net.” *Vgi-net*. Accessed April 23, 2014. http://vgi.spatial.ucsb.edu/about.

“Google Map Maker.” *Google*. Accessed May 1, 2012. http://www.google.com/mapmaker.

Graham, Paul. “Web 2.0.” Personal Portfolio. *Paul Graham*, November 2005. http://www.paulgraham.com/web20.html.

“Grassroots Mapping,” March 9, 2012. http://grassrootsmapping.org/.

Henrich, Joseph, Steven J. Heine, and Ara Norenzayan. “Most People Are Not WEIRD.” *Nature*, July 2010. http://www.facstaff.bucknell.edu/jvt002/BrainMind/Readings/Henrich_2010.pdf.

Louisiana Bucket Brigade. “Louisiana Bucket Brigade: Clean Air. Justice. Sustainability.” Accessed April 28, 2014. http://www.labucketbrigade.org/.

Microsoft Office. “Microsoft PowerPoint – Slide Presentation Software.” *Office*. Accessed August 24, 2013. http://office.microsoft.com/en-us/powerpoint/.

Morse, Robert. “Up-and-Coming Schools Methodology.” U.S. News, September 9, 2013. http://www.usnews.com/education/best-colleges/articles/2013/09/09/up-and-coming-schools-methodology.

“NAVTEQ Map Reporter.” Accessed April 11, 2012. http://mapreporter.navteq.com/.

“NYPL Map Warper: Home.” Accessed April 16, 2012. http://maps.nypl.org/warper/.

“Old Weather - Our Weather’s Past, the Climate’s Future.” Accessed April 30, 2012. http://www.oldweather.org/.

“OpenStreetMap.” Accessed April 28, 2012. http://www.openstreetmap.org/.

“OpenStreetMap Help Forum.” Accessed August 26, 2013. https://help.openstreetmap.org/.

“OSM Inspector.” *Geofabrik Tools*, 2011. http://tools.geofabrik.de/osmi/.

Rice, Matthew T., Ahmad O. Aburizaiza, R. Daniel Jacobson, Brandon M. Shore, and Fabiana I. Paez. "Supporting Accessibility for Blind and Vision-impaired People With a Localized Gazetteer and Open Source Geotechnology." *Transactions in GIS* 16, no. 2 (April 2012): 177–90. doi:10.1111/j.1467-9671.2012.01318.x.

Rice, Matthew T., Kevin M. Curtin, Fabiana I. Paez, Christopher R. Seitz, and Han Qin. *Crowdsourcing to Support Navigation for the Disabled: A Report on the Motivations, Design, Creation and Assessment of a Testbed Environment for Accessibility*. US Army Corps of Engineers, Engineer Research and Development Center, US Army Topographic Engineering Center Technical Report, Data Level Enterprise Tools Workgroup. Fairfax, VA: George Mason University, September 2013. http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA588474.

Rice, Matthew T., R. Daniel Jacobson, Douglas R. Caldwell, Scott D. McDermott, Fabiana I. Paez, Ahmad O. Aburizaiza, Kevin M. Curtin, Anthony Stefanidis, and Han Qin. "Crowdsourcing Techniques for Augmenting Traditional Accessibility Maps with Transitory Obstacle Information." *Cartography and Geographic Information Science* 40, no. 3 (June 2013): 210–19. doi:10.1080/15230406.2013.799737.

Rice, Matthew T., Fabiana I. Paez, Aaron P. Mulhollen, Brandon M. Shore, and Douglas R. Caldwell. *Crowdsourced Geospatial Data: A Report on the Emerging Phenomena of Crowdsourced and User-generated Geospatial Data*. Annual. Fairfax, VA: George Mason University, November 29, 2013. http://www.dtic.mil/dtic/tr/fulltext/u2/a576607.pdf.

Shirky, Clay. *Cognitive Surplus: Creativity and Generosity in a Connected Age*. Penguin Press HC, The, 2010.

Stefanidis, Anthony, Amy Cotnoir, Arie Croitoru, Andrew Crooks, Matthew Rice, and Jacek Radzikowski. "Demarcating New Boundaries: Mapping Virtual Polycentric Communities through Social Media Content." *Cartography and Geographic Information Science* 40, no. 2 (March 2013): 116–29. doi:10.1080/15230406.2013.776211.

Stefanidis, Anthony, Andrew Crooks, and Jacek Radzikowski. "Harvesting Ambient Geospatial Information from Social Media Feeds." *GeoJournal*, December 4, 2011. doi:10.1007/s10708-011-9438-2.

Steve. "OpenStreetMap." *ShowMeDo*, 2008. http://showmedo.com/videotutorials/series?name=mS2P1ZqS6.

"Street Bump." Accessed April 16, 2011. http://streetbump.org/.

“Syria Tracker.” *Syria Tracker: Missing, Killed, Arrested, Eyewitness, Report*. Accessed April 16, 2012. https://syriatracker.crowdmap.com/.

“The Geo-Wiki Project.” *Geo-Wiki*. Accessed April 11, 2012. http://geo-wiki.org/login.php?ReturnUrl=/index.php.

“The National Map Corps.” *USGS*, August 2, 2011. http://nationalmap.gov/TheNationalMapCorps/.

USA National Phenology Network. “USA National Phenology Network - About Us.” *USA NPN*. Accessed April 28, 2014. https://www.usanpn.org/about.

“Waze - Social Traffic & Navigation App.” Accessed June 20, 2012. http://www.waze.com/.

Waze Gps. “Waze Map Editor Guide Full Clip | Waze.” *YouTube*, April 30, 2012. http://www.youtube.com/watch?v=HVksbb1Z4SQ.

“Waze Version 3.5 - User Manual.” *Waze*, May 26, 2013. http://www.waze.com/wiki/?title=Waze_Version_3.5.

“Welcome to Flickr!” *Flickr*. Accessed April 30, 2012. http://www.flickr.com/.

“Welcome to SurveyMapper.” *SurveyMapper*. Accessed April 16, 2012. http://www.surveymapper.com/.

“Welcome to Twitter.” *Twitter*. Accessed April 11, 2012. https://twitter.com/.

“Wikipedia.org Site Info.” *Alexa*. Accessed May 6, 2012. http://www.alexa.com/siteinfo/wikipedia.org.

Zook, Matthew, Mark Graham, Taylor Shelton, and Sean Gorman. “Volunteered Geographic Information and Crowdsourcing Disaster Relief: A Case Study of the Haitian Earthquake.” *World Medical & Health Policy* 2, no. 2 (July 21, 2010): 6–32. doi:10.2202/1948-4682.1069.

“Zooniverse - Real Science Online.” Accessed June 20, 2012. https://www.zooniverse.org/.

BIOGRAPHY

Fabiana Paez, B.S. in Geography graduated from high school and started her Bachelor degree in her home country, Venezuela. After moving to the U.S., she continued her studies in Northern Virginia Community College. Then, she transferred to George Mason University where she received her Bachelor of Science in Geography in 2011. After graduating, she worked for over two years as a graduate research and teaching assistant in George Mason University, while completing her Master of Science in Geographic and Cartographic Sciences. During the summer, she was awarded the Segal AmeriCorps Education Award to do an internship with the U.S. Geological Survey as a research assistant. She is currently working as a Geospatial Analyst Consultant at MITRE Corp., through Protiviti Government Services.