GEOINQUIRY: A NOVEL METHOD FOR QUALITATIVE SPATIAL RESEARCH IN HEALTH AND PLACE

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GeoInquiry: A Novel Method for Qualitative
Spatial Research in Health and Place

William R Buckingham
Under the supervision of Associate Professor Samuel F Dennis Jr.
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Qualitative data have long been a neglected data type in geospatial analysis and GIS. Over the course of the past decade work in Qualitative GIS and the Geoweb has provided the basis for new methods of combining qualitative data, GIS and the Geoweb. Recently, areas of study like New Media have added a foundation for the construction of a new method called GeoInquiry. GeoInquiry is a research framework for collecting, analyzing and visualizing qualitative spatial data in a lightweight web-framework. The technical framework for GeoInquiry is described before two research tasks are undertaken. Formal user testing of the GeoInquiry software resulted in minor changes to the analysis application. The input applications showed through user acceptance testing that the input application has potential to feed the analysis applications, especially when training and guidance is included with the system. The GeoInquiry system was deployed to three sites in Dane County WI, to attempt to understand the spatial context around a public health study analyzing the decline in black infant mortality in Dane County. Building off of a quantitative Deprivation Index, GeoInquiry demonstrates the need for qualitative context to supplement and enhance a quantitative index. The highest area of deprivation was demonstrated to be significantly different in context than the other study areas. GeoInquiry has a connection to past work by many participatory mapping practitioners, but is especially linked to the work of Bill Bunge in Detroit and builds upon his early participatory mappings through a novel qualitative mapping framework.

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Abstract

Qualitative data have long been a neglected data type in geospatial analysis and GIS. Over the course of the past decade work in Qualitative GIS and the Geoweb has provided the basis for new methods of combining qualitative data, GIS and the Geoweb. Recently, areas of study like New Media have added a foundation for the construction of a new method called GeoInquiry. GeoInquiry is a research framework for collecting, analyzing and visualizing qualitative spatial data in a lightweight web-framework. The technical framework for GeoInquiry is described before two research tasks are undertaken. Formal user testing of the GeoInquiry software resulted in minor changes to the analysis application. The input applications showed through user acceptance testing that the input application has potential to feed the analysis applications, especially when training and guidance is included with the system. The GeoInquiry system was deployed to three sites in Dane County WI, to attempt to understand the spatial context around a public health study analyzing the decline in black infant mortality in Dane County. Building off of a quantitative Deprivation Index, GeoInquiry demonstrates the need for qualitative context to supplement and enhance a quantitative index. The highest area of deprivation was demonstrated to be significantly different in context than the other study areas. GeoInquiry has a connection to past work by many participatory mapping practitioners, but is especially linked to the work of Bill Bunge in Detroit and builds upon his early participatory mappings through a novel qualitative mapping framework.

Chapter 1—Introduction

> *"The greatest value of a picture is when it forces us to notice what we never expected to see." (Tukey 1977)*

Qualitative data have long been a neglected data type in geospatial analysis and GIS. Combining qualitative analysis with geospatial information is a challenge that has been met through either re-engineering the GIS with coding plug-ins to accommodate qualitative analysis or abandoning technology completely (Elwood 2006; Jung 2009; Jung and Elwood 2010; Knigge and Cope 2006; Kwan 2000; Kwan and Ding 2008; Kwan and Knigge 2006; Van Wart, Tsai and Parikh 2010). The research reported here focuses on creating a new approach to capturing, analyzing and visualizing qualitative spatial data by harnessing the ubiquity of the Internet and embedding methods for qualitative data analysis and visualization within a web-based framework. While considerable effort has gone into understanding the nature and technologies making up the Geoweb (the integration of maps and geographic information on the Internet), there have been to date no attempts to extend these efforts into constructing an analytical method that can link the Geoweb to qualitative spatial data analysis.

The study of both the Geoweb and qualitative spatial data analysis have taken non-intersecting paths. Both areas of inquiry have been productive in pushing understandings of multiple domains: (1) producer-consumer interactions (in terms of spatial knowledge on the Internet), (2) the shifting nature of geographic information from desktop and quantitative to web-based and qualitative, (3) database methods for facilitating collection of narrative and (4) incorporation of multiple forms of knowledge into a GIS. This research extends the ideas of New Spatial Media[1] and the Geoweb to provide a direct link to the collection and analysis of spatial qualitative data, pushing the consumer-producer dichotomy[2] to extend beyond the common binary relationship to

1 another term for the Geoweb, focusing on the relationship between the geospatial web and new media - interactive media

2 The consumer-producer dichotomy is the split between those who disseminate media and those who consume those media. In old media, this dichotomy is best represented by television, a medium where the recipient does not create content but watches, passively.

include the analyst in the framework.

Looking at geospatial tools, both available and ideas in development, it is possible to use them to capture, analyze and visualize qualitative spatial data. These can include narratives, photographs and videos. While these data have been accessible in a GIS for years, there is a need to provide a strong analytical framework that is more inclusive, one requiring less technological prowess to access and analyze than is currently necessary. The research reported here focuses on the framework and construction of one example of a new idea I call GeoInquiry. This research offers not only the methodology and its technical implementation, but also illustrates its potential by focusing a limited case study on characterizing and understanding the conditions surrounding areal deprivation in the context of a larger health conundrum.

1.1 Opportunity: Combine Qualitative Data Analysis with Current Geoweb Concepts and Technologies

While GIS has been applied to issues of deprivation in the past, it has been without the necessary context required to understand the nuanced nature of the findings. Its use has been limited to combining multiple variables for index creation or characterizing an area through quantitative spatial measures for small geographical units (Krieger 2009; Krieger et al. 2003; McLafferty 2008; Messer et al. 2006). The complexity that underpins the quantitative spatial regime, from the census area to an aggregated index like a deprivation score, makes it difficult to completely understand the results of these quantitative findings as I will show in Chapter 7 through the use of Messer's Index of Deprivation in Dane County, WI. Extending qualitative spatial inquiry to include a web-based framework will encourage wider adoption of qualitative spatial methods and make it easier for both researcher and practitioner to efficiently analyze and understand the contextual factors of the area where any research question is situated. Further, the collection of the qualitative data will be enhanced through the analysis and visualization of these data, enriching both the data set's value and the understanding of the researcher performing the analysis.

The potential exists for a combining of the power of the Geoweb with the contextual understandings possible from Qualitative GIS. This is true for these four reasons: (1) the ubiquitous availability of technology to capture the qualitative lived experience of the population, (2) the need to understand and to consume these qualitative spatial data, (3) the wide adoption of Geoweb technologies like Google Maps, and (4) the potential to use this familiarity with web-based spatial data to offer qualitative analytical capacity in the cloud.[3] There are many efforts underway to characterize and define both the Geoweb (or New Spatial Media, or Open Geography) and the tools and concepts that define the Geoweb. However, there has been limited work on qualitative implementations in GIS, and none of these efforts have connected to the Geoweb. Connecting the Geoweb and Qualitative GIS is an ambitious project. It is critical that these two fields are merged because of the potential domains that could be enriched, from public health to environmental science to the sociology of aging, etc. Researchers need to enhance their geographic understandings beyond the quantitative spatial databases of GIS and begin to provide their work with qualitative geographic capabilities as I will demonstrate in Chapter 7. Without the context provided by qualitative geographic information, the picture is incomplete.

It is important to be able to capture and characterize the complex nature of the context around place based problems within a geographic framework. While tools like GeoNarrative (Kwan and Ding 2008), Grounded Visualization (Knigge and Cope 2006), Geographic CAQDAS (Computer Aided Qualitative Data Analysis Software) (Jung 2009), LocalGround (Van Wart, Tsai and Parikh 2010) and Participatory Photo Mapping (Dennis et al. 2009) have provided a way forward for the capture of qualitative geographic information, none of these tools have provided an accessible analytical method independent of a complex geographic information system. The work in these areas could be enhanced by integrating a new technology that utilizes features of the

3 The term 'cloud' is used to refer to Internet enabled computing tasks where data are stored and/or edited in a web-based system as opposed to a desktop, file-based system.

Geoweb, while simultaneously integrating qualitative spatial analysis within a web-based spatial framework.

1.2 Establishing GeoInquiry

The focus of this research is the development of both the concept and product of GeoInquiry. Combining (1) the ubiquitous nature of the Geoweb, (2) the power of qualitative computer-aided software and GIS and (3) the interactive, exploratory and analytical functionality of geovisualization, GeoInquiry provides a framework for novel analysis of data. Combining these three areas of GIScience research provides a broad base of knowledge from which to draw. All three foundational areas of this research are preceded by the development of GIS, which provides a database-map framework we can extrapolate from to develop new methods for analyzing spatial information. The Geoweb extends GIS into the domain of the world wide web, providing a new framework for interacting with spatial data, thus, blurring the lines between the producer and consumer of these data. Qualitative spatial analytical tools also have been dependent on GIS; the inability to break away from a GIS model has limited access to these ideas due to the complex technical knowledge needed to access the GIS. It is Geovisualization which has moved the farthest from GIS. Limited by the graphical ability of GIS, geovisualization has sought to develop ideas and tools that enable user-driven interactive and dynamic spatial and temporal analysis interfaces. Highly interactive and dynamic linked graphics are the hallmark of geovisualization, however, like GIS, the technical bar to entry has been prohibitively high for the hypothetical average user.

GeoInquiry is a methodology focused on developing frameworks for qualitative inquiry within the Geoweb. The idea of GeoInquiry is focused on expanding the producer-consumer framework to include analysis, pushing beyond simple data production and consumption. While the Geoweb blurs the consumer-producer dichotomy to allow anyone to be both the producer of data and the consumer of other data, those roles represent the limit of the knowledge production available within the Geoweb. GeoInquiry pushes knowledge production within the Geoweb forward by moving beyond data production and consumption and providing an embedded analytical framework that is simple and accessible to both GIS expert and non-expert alike. By also incorporating support for the capture and analysis of qualitative spatial data through open sourced geospatial technologies, this research aims to extend the Geoweb, Geovisualization and Qualitative Spatial Data Analysis in a new direction-one that is open, accessible and has the potential for implementation in a wide array of domains.

1.3 Where GeoInquiry Fits into GIScience

In the domain of GIScience the concept of “cartography^3” is a valuable framework within which to situate new research efforts. Postulated by MacEachren (1995), the cube image (figure 1) situates an array of activities in GIScience with respect to each other. For example, current activity on the Geoweb would sit at point W, offering high map interaction with predominantly public presentation of known information. In contrast, current implementations of qualitative analysis within spatial frameworks would be situated near point Q, allowing for low map interaction that privately reveals unknowns. Finally, it has been well established by MacEachren (1995; 1994) that geovisualization is a private activity, revealing unknowns with high human-map interaction. This research can also be situated within this framework. However GeoInquiry does not fit at a single

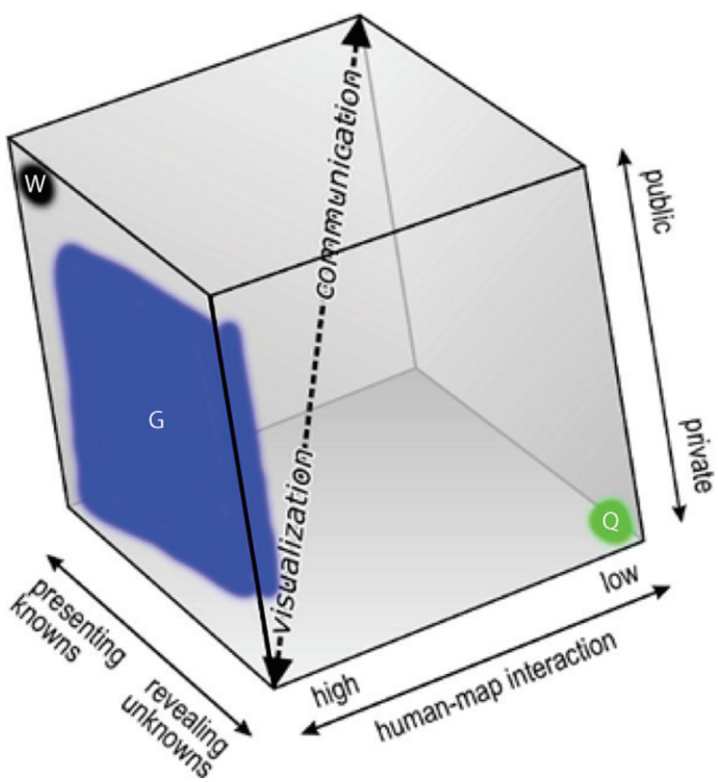


Figure 1.1: MacEachren’s (1994) (cartography)^3 diagram

point, but rather falls into the area G in the diagram. This area spans the continuum of public-private while offering high map interaction for both presenting knowns and revealing unknowns. While this is a large area to occupy, GeoInquiry offers a variety of means of entry, from contribution of data to limited visual analysis.

Because of the wide area that GeoInquiry possesses within cartography cube, it is critical to clearly define its aims. This study seeks to explore the potential of GeoInquiry without pigeon holing it into a strict technical framework. At the same time, GeoInquiry will be demonstrated in one of its many potential tangible forms. So, GeoInquiry is both a methodology for interacting with qualitative spatial data, as well as a usable technological construct that is currently available.

1.4 Research Questions

To fully establish GeoInquiry, this research project is focused on the over-arching question: "Can location-based qualitative data be constructively captured from public users, consumed and/or captured by a new Internet-based system and visualized and analyzed by domain experts using GeoInquiry?" Therefore this project will address the following aims through the execution of a multi-methodological study:

Aim 1. To design and implement one possible conceptualization of GeoInquiry, from concept to deployment of an alpha system via the Internet. This goal entails the conceptual design, construction and implementation of web-based software guided by the tenants of New Spatial Media, the Geoweb, Geovisualization and CAQDAS.

Aim 2. To evaluate the implementation of GeoInquiry through both user acceptance and formal usability testing. These evaluation methods will capture the strengths and weaknesses of GeoInquiry as it is implemented.

Aim 3. To conduct a qualitative analysis of the publicly-contributed data using the GeoInquiry system. This aim will test system functionality and determine if the implementation can handle simple coding and visualization of qualitative spatial data.

Aim 4. To develop insights about how GeoInquiry can uncover and extend traditional analysis capabilities for contextualizing and hypothesizing about public health research problems - in this case supporting a spatial deprivation index for the purpose of identifying social factors that may impact infant mortality. This goal will begin to construct the context and provide structure for new hypotheses to build upon. However, the transdisciplinary approaches required to develop conclusions directly about infant mortality are beyond the reach of this study.

Completion of these goals are the result of work with researchers working on public health in Dane County, Wisconsin, as well as with residents in selected census geographies based on the areal deprivation characteristics of the neighborhood. This study combines an innovative theoretical application with technical construction and novel research methodologies for pertinent issues in public health.

Exploration of these aims presents a wide array of implications. Within the field of geographic information science, I present a novel paradigm for GeoInquiry. This paradigm shift could impact not only the Geoweb, but also public participatory geographic information and other areas of geographic information science. By addressing the challenge described by Michael Goodchild (Schuurman 1999) to bridge social science and GIS, this project provides a clear example of how to navigate these two sides of the intellectual divide for the benefit of both. Second, the findings of this case study provides insights into how the study of the geography of health and well-being can improve the social deprivation index model. Further, these impacts will be relevant in understanding both positive and negative health outcomes within different populations. A case is constructed for the need to include qualitative context in addition to quantitative statistical analysis in epidemiological studies. Lastly, the experimental design of this project provides a jumping off point for continued multi-methodological geographic research both in health geography and in other domains.

1.5 Dissertation Structure

This dissertation is structured in eight chapters. Chapter one introduced the research questions and framework for the research in New Spatial Media and qualitative spatial analysis. Chapter two reviews the literature from four areas of influence on this current work —Participatory mapping, Qualitative GIS, Visualization and Health and place (including social epidemiology). Chapter three proposes both the theoretical framework and the concept of GeoInquiry by following the pathway between Geoweb and other relevant research topics like Qualitative Coding and New Media. Chapter four illuminates the framework underpinning this example of GeoInquiry, describing the construction and development of the pertinent components and the rationale behind those decisions. Chapter five illustrates the methodology undertaken over the course of the research. Chapter six presents the results of the usability testing for the GeoInquiry system with both full user test participants from UW-Madison and the SUS (System Usability Study) questionnaires captured during the case study data gathering. Chapter seven describes the case study where the GeoInquiry system was implemented and discusses the findings both in terms of the GeoInquiry system, and the substantive understandings gained using the system. Chapter eight concludes the dissertation and provides insights about the significance, limitations and future directions suggested by the results of the study.

Chapter 2—Review of Existing Literature

The impetus for this work is two-fold, to demonstrate new methods of capturing and incorporating qualitative spatial data in a research framework and to illustrate the potential for qualitative spatial data in public health research and practice. This chapter highlights the previous work influential in the construction of both the research questions, and the research methodology. This chapter provides an overview of the history and progress of the Geoweb leading to my reconceptualization of New Spatial Media. Next, the complementary tracks of participatory, critical and qualitative GIS are reviewed, providing a basis for this current research to emerge. A brief review of the history of geovisualization and geovisual analytics provides a framework for understanding how this work incorporates another sub-field of GIScience. Finally, a description of work in health and place will provide insights into the manner in which health, place and epidemiology have been addressed, migrating from geography to social epidemiology to infant mortality and to quantitative measures that evaluate place effects on health.

2.1 Participatory Geography

The idea of a New Spatial Media is the culmination of years of effort by researchers like Elwood (2006; 2009), Schuurman (2000), Al-Kodmany (2000), Ghose (2005) and many others to democratize mapping for a larger public. While the research efforts have been largely present after an important meeting of GIS practitioners and social theorists at the Friday Harbor WA conference in 1992 (Sheppard 1995), I will argue that this effort began in the late 1960's with the work of Bill Bunge and the Detroit Geographical Expedition and Institute (DGEI) (Horvath 1971). Tracing the time line from Bunge forward, I will demonstrate how the concept of New Spatial Media is a direct descendant, and in many ways an improvement, on the idea of the DGEI.

2.1.1 Bunge and the Detroit Geographical Expedition - The first participatory mappings

William Bunge has emerged in the past ten years as almost a cult figure in Geography (Johnson 2010). While accounts of his work are sparse, it is clear that the final evolution of the academic Bunge is an important starting point for this work. Not the quantitative deterministic Bunge (Bunge 1966), but rather the Bunge of the DGEI - a novel and in many ways unparalleled effort to not only obtain spatial data from a public, but to turn the interested public into the expert - both cartographically and substantively.

2.1.2 Fitzgerald Neighborhood

The impetus for the DGEI was Bunge's passion for the Fitzgerald neighborhood of Detroit (Bunge 1971). During Bunge's tenure at Wayne State University, he began an ambitious project to understand and describe the tortured history of race and geography in this single neighborhood. This effort resulted in a detailed ethnographic and historical account of the neighborhood - both the conditions from which this area evolved to be a white enclave - to the social change that occurred as the neighborhood began its transition to a majority minority (black) neighborhood. Bunge's book about this project, Fitzgerald (Bunge 1971), described in detail the historical development of the social upheaval of the 1960's. His work also included strong critiques of American culture and people in general. Criticisms of atomic energy and atomic warfare appear (a precursor to Bunge's Nuclear War Atlas of the 1980's), in addition to the detailed account of "Fitzgerald's Revolution". The rhetoric is extreme, however the narrative is fascinating, peppered with creative and novel cartographic representations of the area that serve to reinforce some of his social critiques.

While the Fitzgerald project was a detailed ethnography, as well as a strong social critique, it also served to aid in the establishment of the Detroit Geographical Expedition and Institute - an organization that was an early proponent and executor of participatory mapping - and maybe the closest link to New Spatial Media as I see it.

2.1.3 The Detroit Geographical Expedition and Institute

The DGEI had a short and tortured history, one that appears in hindsight as being emblematic of the tumultuous times in which it existed (1969-1971). Affiliated first with the University of Michigan and subsequently with the Michigan State University Cooperative Extension Program, the DGEI was an attempt to provide university-level coursework for inner-city youth in the Fitzgerald neighborhood. The goal of the DGEI was initially to offer coursework to students for free, thereby removing the cost barrier to a population for whom that impediment served as a gate through which they could not pass. In his account of the DGEI, Horvath (1971) states that the goal was to provide education to the students that would allow them to eventually transfer with sophomore status to Michigan State University.

In accord with the Institute portion of the DGEI, Bunge also wanted to conduct research for the black community. This meant research that went beyond the typical academic-led project to something that the students would both lead and conduct for their own and their community's benefit. These related efforts came to meet most prominently in two courses offered by the DGEI, Urban Geography and Cartography. The students enrolled in these two courses produced a report titled "A Report to the Parents of Detroit on School Decentralization"(DGEI 1970).

2.1.4 School Decentralization Report as Participatory Mapping

Horvath (1971) considered the School Decentralization report as a seminal moment in the course of the DGEI. This project began at a time when funds were low, and students were struggling to remain motivated for coursework that had little life connection in the face of hunger, poverty and crime. Brought to the DGEI by a state senator and a community organizer, the DGEI was asked to conduct a school redistricting study - a result of a mandate by the State Legislature. The local nature of the request as well as the obvious impact upon the community in which the students lived provided the motivation to conduct the research. The students and professors mapped multiple aspects of their neighborhood, demonstrating racial inequities in the proposed school redistricting plan, as well as providing solutions to better serve both white and black communities in the area. The cartographic product was produced in tandem between the students and professors, so not only were students participating in the mapping by providing data about their community, they were also producing the maps themselves with guidance from Bunge and others. This may be the most captivating portion of the DGEI. The DGEI reports served to force the school board to reconsider their expensive redistricting plans (which were highly discriminatory and in some cases found to be illegal (Horvath 1971)). The political outcome is impressive, but from an academic lens, equally impressive are the first descriptions of participatory mapping - efforts that have been largely unimproved upon as the focus of participatory mapping has turned to GIS as the means to foster participation (Elwood 2006; Sheppard 1995).

2.1.5 Connections to GeoInquiry as conceived here

The above description of Bunge's efforts and links to early participatory mapping provide a foundation for the proposed concept of GeoInquiry. Bunge sought to not only provide his students the tools to map their community, but also to arm them with the knowledge necessary to explain the representation. Out of this effort came qualitative maps like figure 2.1. Criticisms of Bunge's work are similar to those that can be leveled against much of the PPGIS literature - high educational barrier to entry, limited community engagement (in numbers), limited longevity beyond the researcher's presence (though in this case due to job loss rather than disinterest). However, given the nature of cartography at the time, it is impressive that the DGEI was able to instruct students in the cartographic trades, at the time all done by hand in extreme detail. Modern PPGIS efforts are aided considerably through the use of desktop GIS and even web maps. At the same time, in some ways, the low-tech methods of the day also created accessibilities that PPGIS efforts have struggled to replicate. Scribes and paper are

Figure 2.1 Map from Warren et al's (1971) DGEI Report depicting community mapping

easier to come by than computers with the requisite components to effectively run a GIS. So the technological barrier to entry in the DGEI model was quite low - and to date unfollowed in the PPGIS literature, though GeoInquiry strives to approach Bunge's model.

2.2 Public Participatory Geographic Information Systems, Participatory Geographic Information Systems, etc

Public Participation GIS (PPGIS) arose from the social critiques of GIS spearheaded by Pickles (1995), and continued throughout the middle and late 1990's. These critiques labeled GIS as positivist, cyborg (shorthand for the human/ computer interface (Schuurman 2000)) and an instrument of government control and surveillance. From these critiques numerous models of "participatory" GIS emerged, all with varying degrees of success. Nevertheless they paved the way for recent developments utilizing Web 2.0[1] and Neogeographic[2] tools to facilitate participation (Goodchild 2007; Miller 2006; Turner 2006). I will describe the origins of PPGIS, how it has been implemented, how it has worked, and finally where this field is headed, which appears to be in multiple directions.

PPGIS emerged from the fierce criticism of GIS that came to a head with the publishing of Ground Truth, the influential volume edited by John Pickles (1995)that called into question the viewpoints and purpose of GIS. One of the chief criticisms was that GIS provided the mirage of cooperation with entities like government, when in fact the reduction of realities to points, lines and polygons minimized the social dialog to nothing more than quantitative attributes. Essentially PPGIS was an attempt to socialize GIS, by which I mean to remove it from its quantitative origins and use it to provide a means to describe the lived experiences of a population through both traditional quantitative data as well as the conversations, images, and descriptions provided by the population themselves.

As a result of the social critique of GIS, the National Center for Geographic Information and Analysis (NCGIA) coordinated meetings to discuss the future directions of GIS (Sieber 2006). The term PPGIS originated from these meetings and was defined as a means to engage the public in applications of GIS, while at the same time to have influence on policy (Schroeder 1996). A division occurred almost immediately where GIS and Society (GISoc) was positioned to focus on GIS and its role within social theory, whereas PPGIS was merely a practice of GIS. From this division others have formed, Participatory GIS (PGIS) and Critical GIS. PGIS is often characterized as tied to the technology as opposed to the practice of participatory GIS. Critical GIS has positioned itself as the umbrella for the entire field, encompassing all of the other divisions. Because the differences between the terms PPGIS and PGIS are often blurred, I will use

1 Web 2.0 refers to Internet applications that facilitate participation, collaboration and the web as a platform (O'Reilly, 2005).

2 Neogeography - new geography. This term has been co-opted to describe the combination of principles of Cartography and GIS for programmers working with maps and mapping typically on the Internet (Szott, 2006).

PPGIS to refer to both PGIS and PPGIS. The term PPGIS however has been inconsistently used and therefore is extremely difficult to define (Dunn 2007).

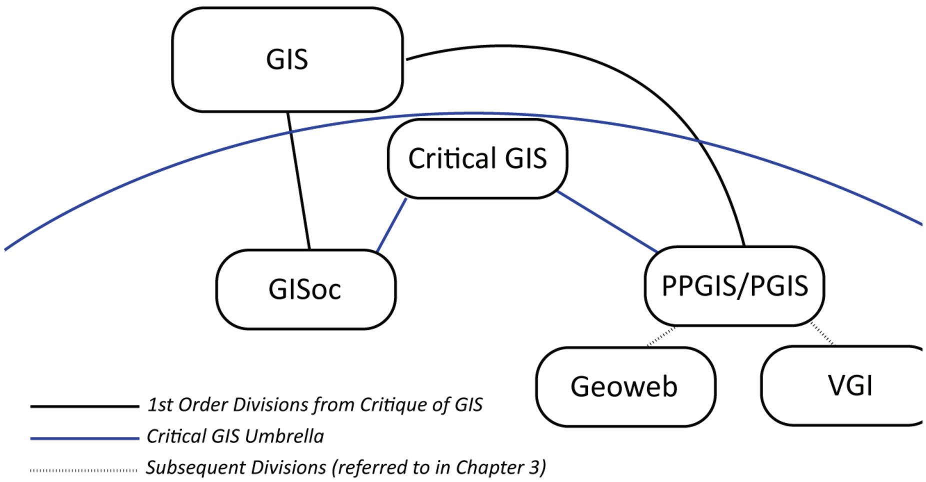


Figure 2.2: Diagram of the divisions in GIS after the social critique

Stepping away from the contested definitions and meanings of PPGIS (and its related fields), it is important to describe what the goal of the entire field is and how its practitioners intended to meet this goal. The ultimate goal was to empower public entities, and by extension individuals, by providing a framework through which they could incorporate GIS for social development and change. PPGIS sought to accomplish this goal by partnering with community organizations and exploring their use of GIS. Elwood, Ghose, Kyem, Leitner and others have teamed with community-based organizations (CBOs) to provide expertise in GIS and often training in the use of GIS (Elwood 2006; Ghose 2001; Ghose 2003; Ghose and Huxhold 2001; Kyem 2002; Leitner et al. 2002). The purpose of these partnerships was to assist CBOs with applying GIS to their mission and to leverage both the academic expertise and the software needed to meet these goals. The veracity of the GIS and the resulting maps are seen as powerful in championing the cause of these organizations, be it to map assets in the community to make a case for service, or to establish a community identify through clever use of multiple forms of map representation of an area (Elwood 2009). It is through this mapping that PPGIS empowers the CBOs with the data and expertise to challenge government policies or officials or the status quo. Throughout the work on PPGIS there has remained a fairly consistent undercurrent of community activism. Early work in PPGIS failed to extend these goals beyond the stated project, as once the academic teams would leave, it was often difficult for the CBOs to continue due to the high bar to entry in the use of GIS (Ghose and Huxhold 2001).

Within most PPGIS frameworks the participants are stakeholders of some kind, often connected to a CBO (Elwood 2006; Elwood 2009; Ghose 2001; Ghose and Huxhold 2001). However, as both Elwood and Ghose describe, this does not mean that the use of GIS is accessible to the entire group. Rather, the complexity of the GIS system often restricts the actual use to a select few from both the research team and sometimes the community (Elwood 2006; Ghose and Huxhold 2001). Limiting interaction with the system to a select few participants diminishes the ownership of the entire group - a problem that Internet-based mapping applications can help to overcome.

2.2.1 Neogeography

Another discipline relevant to this discussion is the non-academic "discipline" of neogeography. The origins of neogeography are somewhat in dispute, with most credit going to the blog "placekraft" for the initial definition. Andrew Turner's 2006 book Introduction to Neogeography provides a clear literature from which to define the field. Ultimately, however, neogeography remains somewhat nebulous - consisting of an ever changing set of exemplars, created through web-based technologies and produced both by industry giants such as Google, as well as new players such as OpenGeo and others. The potential of neogeography is easily recognized; its implementation of in academic circles has been largely unrealized. Christopher Miller's (2006) work on "GIS/2" is to date the exemplar within the academic literature. In this piece, Miller envisioned the next iteration of GIS as closer in scope to Google Maps, with built-in support for the creation of the "mashups". Despite this demonstration, academia has still sought to differentiate themselves from the neogeography community. Sessions organized at the Association of American Geographers Conference in Washington DC saw both neogeographers like Sean Gorman (2010a)(who admittedly comes originally from academic geography) and many leading participatory geographers come together. In these sessions the tensions between the groups became apparent as participants like Sean Gorman and Renee Sieber offered disagreement over the perception of and the context around the term "volunteer". Gorman argued that the term "volunteer" was demeaning and a further example of academias' attempts to own the realm of neogeography, while Sieber countered that a volunteer just added data to the system, without placing value on the term volunteer. The session concluded without agreement, and a sense that nothing was settled through the debate, with both sides remaining steadfast in their views. Gorman (2010b) later wrote that neogeography is outside of the domain of academia and terms such as Volunteered Geographic Information (VGI) are inappropriate attempts to corral neogeography within the confines of academic controls of spatial data infrastructures and data standards. Gorman further argues that terms from academia like VGI only serve to demean the work of neogeographers, and attempt to put these ideas into a tidy package that doesn't fit the breadth of the neogeography domain. Despite this antagonism, the ideas and applications in neogeography ranging from Yelp[3] to ChicagoCrime.org, are novel. For example, Yelp allows a user to provide evaluations of services, from restaurants to stores, that are attached to location, simply by using either a mobile device or a computer. ChicagoCrime captures data from the Chicago Police Department and maps the reported crimes. The resulting crime map is a live mashup using Google maps that provides daily updates on crime in and around the Chicago area. Rather than attempting to fit these into a neat academic box, it may be more fruitful to follow Crampton's lead (Crampton 2010) and expand on his idea of New Spatial Media to understand how these related

3 Yelp is a place-based tool allowing people to read reviews that are crowdsourced about businesses in a community.

yet disparate geographic phenomena are interconnected. New Spatial Media and the Geoweb, which are in many ways two different names for the same phenomena, will be discussed further in the next chapter.

2.3 Qualitative and Critical GIS

From the GIS debates of the 1990's emerged the idea of Critical GIS. And from Critical GIS, the possibility that qualitative data could be part and parcel of a GIS was entertained. This current work owes much to the overarching ideas of Critical GIS and its subset of Qualitative GIS—both as a foundation, as well as for opening up the pathways upon which this work seeks to expand.

As Knigge and Cope (2006) state, qualitative GIS "enables rich explorations of place"(p.2035). This value has been seen by many researchers (Elwood 2009; Knigge and Cope 2006; Kwan and Ding 2008; Kwan and Knigge 2006; Pavolvskaya 2006) through the construction of examples, maps and ArcGIS tools, yet has been limited in large part to the originators of each method and not adopted at a broader scale. Sheppard (2005) cautions that research that utilizes "traditional off-the-shelf GIS is always in danger of accommodating its research to that software." This has proved especially true in qualitative GIS. Knigge and Cope (2006), Kwan and Ding (2008), Matthews et al (2005), Jung (2009), and Jung and Elwood (2010) have all situated their efforts in qualitative GIS around off the shelf GIS software produced by ESRI (www.esri.com). This has both enabled these research efforts to go forward with reduced software overhead, but also has limited the opportunities for further development outside of the reported research. Despite these shortcomings, this body of literature is a critical foundation upon which the current work builds.

Crampton (2010) argues that following critique, especially one as vigorous as the GIS debates (Schuurman 1999; Schuurman 2000; Sheppard 1995), the technology under critique is forced to re-situate itself, or to evaluate its current incarnation and modify itself according to the debate. This has been partially true for GIS. The actual re-imagining of the software emerged from the GIS debates in the form of PPGIS or Qualitative GIS depending on the focus of the researcher. Beginning as traditional GIS used by participants under the guidance of experts (Elwood 2006; Sieber 2006), it has included adaptations of GIS that remain in the hands of domain experts and researchers (Kwan and Ding 2008; Matthews, Detwiler and Burton 2005). Despite these reworkings of traditional GIS, the integration of qualitative methods and GIS has been slow due to the technical barriers.

One of the initial applications of qualitative data and methods in GIS was presented by Stephen Matthews and colleagues at Penn State. In this example, Matthews et al. (2005) mapped ethnographic data to spatialize individual ethnographies. Borne out of ideas such as Hagerstrand's Time Geography[4] (Hagerstrand 1970), geo-ethnography mapped any geography mentioned during the course of ethnographic research on a study of welfare, children and families. Building tools in ArcObjects, the default development environment at the time in ArcGIS (www.esri.com), Matthews et al. produced analysis modules to visualize and examine through analytical means the spatial character of the ethnographic data. This linking of ethnography and GIS allowed the research team to analyze the spatial footprint of the participants providing new insights into the lived experience beyond the textual ethnographic data.Numerous other qualitative GIS efforts were underway at the same time. For example, in 2005 at the Association of American Geographers meetings, a session on qualitative GIS was conducted that led to a special issue of the journal of Environment and Planning A, edited by Mei-Po Kwan and LaDonna Knigge (2006). Within this issue, four distinct envisionings of qualitative GIS were presented (Dennis 2006; Knigge and Cope 2006; Pain et al. 2006; Pavolvskaya 2006). Of these, the effort most insightful for this work was produced by Knigge and Cope (2006) on what they termed Grounded Visualization. Similar to Matthews, Knigge and Cope used the base tools in ArcGIS and built upon

4 Time Geography was developed by Hagerstrand. It involved the development of a space-time cube to show movement over both space and time.

that framework. However, in this work, Knigge and Cope incorporated multimedia into a map, in the form of photographs, audio and video. Each component was linked to the map and grounded theory analysis was conducted on the spatially linked artifacts. Linking these qualitative data to the map enabled the researchers to visualize the spatial character of the qualitative data.

One issue that can be raised is with the link to the term visualization. In this case the visualization is more cartographic visualization (data mapped in a static representation) than it is visualization in the dynamic manner Dykes, MacEachren and Kraak (2005) envisioned. Interactivity and multiple representations are largely absent, as is the interaction between analysis modules. Rather, this work is closer to multimedia cartography (Cartwright, Peterson and Gartner 2007). Despite these shortcomings, the idea of marrying grounded theory and visualization is ripe for exploration and an avenue that this research explores.

The final research efforts to mention here are the most closely related to the current work-integrating geographic information with qualitative data. Kwan and Ding (2008), Jung (2009) and Jung and Elwood (2010) have described work that relates most closely with the system in this work. Kwan and Ding's "geo-narrative" is related to Matthews et al.'s (2005) and Hagerstrand's (1970) Time Geography by linking time and space in a GIS framework to understand the qualitative landscape of lived experience. Specifically, Kwan and Ding focus on the qualitative method of narrative analysis - a mode of study which analyzes the stories of people's lived experiences around a major event at a specific point of time (Chase 2005; Clandinin and Connelly 2000). Building off of the ideas of visual methodologies from Gillian Rose (2001), Kwan and Ding developed a plug-in for ArcGIS that facilitates the visual interrogation of narratives. Using a space-time coding scheme, events from the narrative were coded for both location and time. Once coded, a 3-D space-time diagram was constructed allowing for visualization of the lived experience and the interpretation of that experience by the researcher. Ultimately

Kwan and Ding's work is an extension of previous work by Kwan (2000) merging the ideas of space-time paths and qualitative analysis in GIS.

Jung (2009) and Jung and Elwood (2010) take a slightly different approach to the problem of incorporating qualitative data into a spatial framework. Jung and Elwood build links between traditional CAQDAS and GIS, rather than building new modules within a GIS to support qualitative data (Matthews et al 2005, Kwan and Ding 2008). This means that Jung and Elwood code buttons in ArcGIS to launch NVivo to add qualitative data, and then allow those qualitative data to be accessed by the ArcGIS document. While Jung and Elwood's work (Jung 2009, Jung and Elwood 2010) demonstrates a powerful means of integrating off the shelf GIS and qualitative analysis software, the barrier to entry to using their system is still quite high. By using commercial GIS and CAQDAS software packages the tools do not ameliorate the steep learning curves that can be prohibitive to quick and simple analysis of qualitative spatial data and to non-expert users who don't have the expertise to adopt these technologies for their analytical aims. Removing the expert context surrounding these packages reduces the bar to entry and enables users to quickly visualize and analyze their datasets without cumbersome loading of large software packages. This is a major goal of GeoInquiry. The trade-off is obviously that the magnitude of analytical capabilities is far reduced, but by maintaining all of the qualitative spatial data in a spatially-enabled database it allows migration to a more sophisticated suite of analysis software that can provide the desired analytical packages.

While critical GIS often engages with the theoretical aspects of qualitative GIS (Schuurman 2000; Schuurman and Pratt 2002; Sheppard 2005; Sieber 2007), my work is focused on extending the application of these critical ideas into a transdisciplinary methodology and tool, similar to the aims of the case studies demonstrated by Matthews et al. (2005), Kwan and Ding (2008), Knigge and Cope (2006) and others. As Corbett and Rambaldi (2009) state, qualitative mapping is about "community building, networking and communication" outcomes that are achievable within an internet based framework that supports free form qualitative data like the proposed GeoInquiry system.

2.4 Geovisualization and Geovisual Analytics

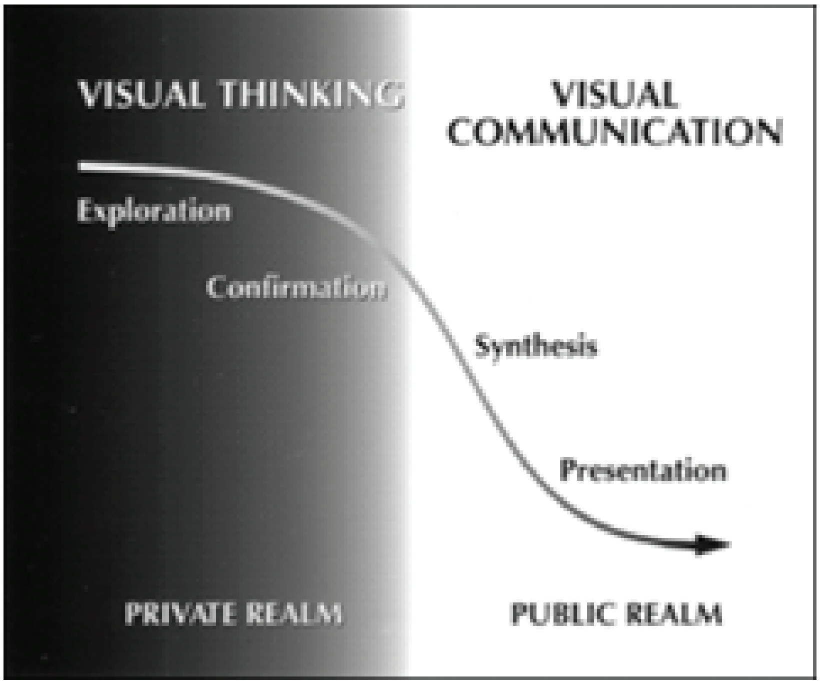


Figure 2.2: "Swoopy"-DiBiase's (1990) visualization research framework.

The literature on Geovisualization, and its successor Geovisual Analytics, offers a different perspective to Critical GIS. When viewed in the context of DiBiase's "swoopy" diagram (Figure 2.2), visualization and geovisual analytics focus on private interactions to explore questions in a visual environment (DiBiase 1990). Conceptualized by MacEachren (MacEachren and Ganter 1990), Geovisualization is focused on discovering unknowns using qualitative visual analysis of quantitative geographic data.

Geovisualization tools have been used in support of research in fields ranging from historic geographic pattern analysis (Weaver et al. 2007) to epidemiology and disease analysis (Edsall 2003; Griffin 2004) to migratory patterns of birds (Andrienko, Andrienko and Gatalsky 2000). The incorporation of highly interactive visual interfaces and large datasets, requiring large scale computing efforts, are hallmarks of these studies. Work by Gahegan (2005) and Robinson (2008) have pushed beyond the "bells and whistles" of computing prowess and into understanding how to design these tools to support users' attempts to develop understandings of the phenomena under study. The idea of geovisual analytics has begun to supersede geovisualization, based on efforts outside of Geography (Thomas and Cook 2005). Conceived of under the direction of a national center with a focus on homeland security, geographic concepts have been added to append the "geo" to the visual analytical vernacular. The goals however, remain the same albeit with a new focus on decision-making, to develop tools to handle extremely large data sets using visual interfaces to glean new insights and understandings.

It is the migration to the very large data set that has characterized the shift to geovisual analytics (Andrienko et al. 2007). Tying in ideas from the data mining and machine learning communities, visual analytics has seen a tight integration between visual methodologies and analytical frameworks (Thomas and Cook 2005). Gahegan's (2005) call to incorporate increased analytical capacity has been realized in numerous geovisual analytic interfaces.

Despite these visual techniques for qualitatively exploring geographic data, MacEachren (2010) has noted that non-numeric data have remained sparse in Geovisualization research. Andre Skupin has worked extensively with concepts of spatialization, providing a spatial structure for non-spatial information – maps that use abstract data space to communicate information about the conceptual relatedness. However these efforts have, until lately, stopped short of migrating to a truly geographic view of qualitative (geographic) concepts (Skupin and Fabrikant 2003). Skupin's recent work has begun to incorporate geographic space into these efforts. Slingsby and colleagues worked with Google Earth to map tag clouds (structures of words sized by their frequency in a given text document) (Slingsby et al. 2007). These data were acquired through the analysis of web documents and searches. This mapping of qualitative data presents a different model for incorporating qualitative data on the maps than we have seen in the qualitative GIS literature. Despite providing a spatial representation of qualitative (and relatively a-spatial data), the resulting tag maps failed to become tools to analyze discourse – rather they were used to summarize relative frequency of terms in the viewable areas. In my view, the idea of incorporating tags on the map has merit – for example mapping conceptual codes from qualitative analysis for the purpose of visualizing the landscape both in Cartesian space, as well as in code intensity. Responding to MacEachren's (2010) call for the inclusion of qualitative data, as well as leveraging the first steps taken by Slingsby et al (2007), and to some degree Skupin (2003), it is apparent that a design that seeks to support qualitative data analysis would extend the current framework of geovisualization and geovisual analytics in novel ways.

2.5 Health, Place and Epidemiology

Modern epidemiology has evolved a scientific, positivist approach to the study of disease, with a gaze on society at large, and with particular focus on individuals within the population (Leung, Yen and Minkler 2004). However, as Tom Koch (2011) points out, it is critical to see disease at every scale, from the cell to society. To effectively see disease across these scales, Koch makes the case that mapping provides both a historical basis as well as opportunities to understand the entire disease process (Koch 2011). As Koch says “the map presents the specific condition not as an isolated thing, but more importantly in relation to geographic and social elements that may (or may not) promote or inhibit this or that congress of deathly symptoms” (2011 p. 4). My work draws on two related, yet distinct, areas of research that incorporate a focus on place: social and cultural epidemiology and health/medical geography. Within each of these areas the focus of this review will center on the use and potential for the incorporation of place and quantitative information - akin to the work of Bunge tying qualitative experience with locations in Detroit (i.e. Maps like figure 2.1 from Fitzgerald) (Bunge 1971).

2.5.1 Social Epidemiology and Place

As a distinct field, social epidemiology is situated closely to the ideas postulated by Snow in the 1800's that geography and society have a role in disease. Probably the leading proponent of this set of ideas is Nancy Krieger of Harvard University. Krieger's work on geocoding health disparities has been groundbreaking in epidemiology (Krieger 2009; Krieger et al. 2003a; Krieger et al. 2005; Krieger et al. 2003b; Krieger et al. 2002a; Krieger et al. 2002b). Combining area-based socioeconomic measures (ABSMs) to better understand the societal impacts of disease, Krieger's Public Health Disparities Geocoding Project, has identified ABSMs that are useful predictors of health outcomes, and has demonstrated the potential of georeferenced data to help researchers better understand and evaluate epidemiological phenomena (Krieger 2009). However, despite Krieger's adoption (to great success) of geocoding and GIS, her work has remained firmly in the domain of quantitative analysis, neglecting the potential of incorporating qualitative place-based information to better understand the social framework contributing to the question at hand.

Despite these criticisms, Kreiger's work is innovative. She returns geography to epidemiology, while at the same time staying aware of the potential and the pitfalls surrounding the use of GIS in these analyses (Krieger 2009; Krieger et al. 2005; Krieger et al. 2003b; Krieger et al. 2002b). Other leaders in social epidemiology highlight the need to incorporate non-traditional data, but often fail to connect explicitly to place. MacIntyre and Ellaway (2003) are a prime example. They highlight factors that might influence health including employment, education, transportation, housing, retail, recreation, "incivilities", policing, land use, health services, environmental hazards, social networks and social cohesion, cultural norms and values, geology, and climate. They also describe environments that contain both health promoting and health detracting components -

1. Physical features of the environment shared by all residents.
2. Availability of healthy environments at home, work and play.
3. Services provided to support people in their daily lives.
4. Sociocultural features of a locality (including degree of community integration).

5. Reputation of an area (perception by residents, service or amenity planners, and investors).

Further, questions are asked about whether the poor health of people living in deprived areas is due to the genetic characteristics of the residents or a result of features of the local environment. In this literature, it is postulated that people with more educational and financial resources may range over wider territories for a number of activities (i.e., recreation, employment, education, retail) than do people with a more local orientation or less money. Yet, throughout their work they do not specifically address space and place. Rather, they leave these as unspoken concepts contained within small area aggregated data.

As social epidemiology has re-discovered the spatial variability of the landscape, numerous relationships between geography and health have been articulated. Patricia O'Campo and her colleagues (O'Campo et al. 1997) found that per-capita crime is positively correlated with low maternal education and low birth weight. Additionally, low wealth and high unemployment is negatively correlated with prenatal care access. O'Campo also postulated that poor birth outcomes are more prevalent in areas with a high degree of social integration and low informal social control. Said another way, people or groups within a strong but isolated community, for example a racial minority enclave, have worse health outcomes than those who live in areas integrated into the community at large. This relationship between social isolation and internal social cohesion has been found to have a negative effect on health by others as well (Shaw, Dorling and Smith 1998; Stansfeld 1998) and is informative to this research, which attempts to conceptualize how to map social isolation in an environment.

Geographic correlations between crime and poor birth outcomes were also studied by Sampson (2003). Sampson found that more than 75% of tracts with high homicide rates also contained a high level of clustering for low birth weight and high infant mortality. The ecological concentration indicates geographic "hot spots" for a number of unhealthy outcomes beyond just poor birth outcomes (Sampson

2003). Sampson postulated that low social capital (trust, reciprocity and voluntary associations) equates to greater risk of poor self-rated health. Sampson argues that the challenge is to integrate multilevel methods from epidemiology with complex spatial processes (e.g. spatial relationship between crime and health), articulating the need for multilevel methods for contextually based research. Both Sampson and O'Campo et al make a clear case for the social drivers of birth outcomes. However, the lack of qualitative context is notable and is an area where geographically framed qualitative data can be useful to further develop understanding of the context in which these outcomes exist and therefore allow researchers to construct a more robust frame of study to capture the drivers of a shifting infant mortality rate (as my study proposes). Social epidemiological research has also spent considerable resources characterizing deprivation at small areal units (Kirby, Coyle and Gould 2001; Martens, Derksen and Gupta 2004; Messer et al. 2006; Sampson 2003). Sampson states that deprivation appears to be adequately assessed by personal and household circumstances (i.e., household income or household "family" structure). Area-based measures of deprivation are not optimal substitutes, though they are often an accessible means to understand the social makeup of small areas. To improve on area-based measures health policy needs to target people as well as places - essentially making the case for qualitative data in addition to the aggregated quantitative place-based data. Prominent examples of deprivation indicies include Messer et al (2006), the Scottish Index of Multiple Deprivation(SIMD) (SIMD 2009), Krieger (2003b), Kirby et al (2001) and Martens et al (2004). In all of these cases relevant Census data served as the main driver for the analysis, though by basing an index on national census characteristics the potential for replication may be limited to the country of origin -a good example being the SIMD where replication is made difficult due to the use of specific questions asked in the British Census that do not appear in the US Census. Each of these indicies is limited to the areal unit, with attempts to understand the individual level conditions unavailable. However these attempts of characterize health in context, and answer the call from both Diez-Roux (1998) and Macintyre et al (2002) to incorporate context into epidemiological analyses.

2.5.2 Cultural and Popular Epidemiology

As epidemiology has developed, there has been a call for the framing of "new epidemiologies", of which social, cultural and popular epidemiology would qualify (Leung, Yen and Minkler 2004). While social epidemiology is considered "new", cultural and popular epidemiology are nascent.

Popular epidemiology, and its cousin, lay epidemiology, focus on engaging the public in measuring their own disease and health risks (Trostle 2005). This focus dovetails nicely with work in community-based participatory research frameworks (Cole, Todd and Wing 2000; Stoecker 2005; Wing and Wolf 2000). Popular epidemiology has gained a foothold specifically in environmental epidemiology where there is a clear call to conduct 'community-driven' research (Wing and Wolf 2000). By seeking to describe risk as a collective rather than as an individual phenomenon, popular epidemiology becomes less focused on individual outcomes and more on community outcomes.

Steve Wing's work with community members around the health conditions surrounding large hog operations is a clear example of a public participatory research framework. Residents around the farms recorded various activities in journals, as well as voluntarily used air monitoring equipment. By engaging in a form of citizen science, this exercise in popular epidemiology enacted social change by demonstrating the racialized landscape of hog farm location resulting in new ordinances to regulate the farm's activities and protect residents (Cole, Todd and Wing 2000; Wing and Wolf 2000).

Including participatory geography strengthens popular epidemiology by providing a contextual dataset unavailable from official sources. While these data may possess potential errors, the context provided is difficult to obtain through non-primary reports. Trostle (2005) postulates that graphical displays can convey epidemiological statistics to poorly educated populations in ways that text alone cannot. Further, Trostle argues that participatory mapping techniques can be used by the community to better represent the neighborhood disease burden to decision makers. Using interactive mapping technologies expands the tools available for use in popular epidemiology. Disease mapping by community residents and participatory mapping strategies are just a few of the opportunities Trostle identifies to employ graphic and demographic methods to bring researchers and community members closer together (Trostle 2005).

2.5.3 Health (and Medical) Geography

The transition of medical geography to health geography (a movement from small scale to large scale inquiry) has expanded the potential for embedded research into neighborhood and local place. Tom Koch (2011) takes a historical viewpoint on health geography but continuously demonstrates how geography has been needed to understand health at multiple scales - including a local scale. The integration of these multiple scales presents a challenge however. Studies have traditionally focused either at the regional level (Cinnamon and Schuurman 2010; Cromley and McLafferty 2002; Meade and Emch 2010; Schuurman et al. 2011) or at the local level. Another dichotomy exists between quantitative “spatial epidemiology” (Atkinson and Molesworth 2000; Cressie 2000; Wakefield, Kensall and Morris 2000) and qualitative studies of health and place (Dennis et al. 2009). These splits demonstrate how the field of health geography is quite large and diverse.

In a special issue of Social Science and Medicine, Kearns and Joseph (1993) argued that place offered a synthesis of the social forces that make up the landscape. In addition, they made the case that the particularity of everyday life is composed of the specifics found in places such as work, home, school and neighborhood and that going forward studies of health that do not account for place, and subsequently social context should take their interpretations with caution (Kearns and Joseph 1993). In the same issue Duncan and his colleagues make the case that contextual geographic differences are not captured in the statistical findings (Duncan, Jones and Moon 1993). However, Duncan and his collaborators clearly argue that this is merely a call to refine place sensitive research, not to abandon the cause. Simultaneously, Scarpaci (1993) calls for increasing the use of qualitative methodologies in health geography to fully understand place effects.

Around the same time as the Social Science and Medicine special issue, Jones and Moon (1993) offered another take on the need for place and space in medical geography research. Here, Jones and Moon offer that as people are not equal to statistical aggregates, so too places are not generalizations. Jones and Moon go on to argue that medical geography needs to be sensitive to the context and compositional effects that come along with spatiality and that research at multiple scales is necessary to capture these effects (1993). From here the idea of including context into research acts as a driver towards the health geography shift.

Curtis and Rees Jones (1998) argue that context is required to support individual level analyses - going as far as to say that health differences are a combination of both individual characteristics and place. Duncan et al (1999) supports this assertion by making the case that the place effect is 'contextual' - meaning that place can make healthy choices more difficult, but that place doesn't necessarily impact health directly. As the movement towards health geography accelerated, Kearns and Moon (2002) offered a clear picture of how the migration from medical to health geography manifested itself. They make it clear that place is the "talisman point of reference in the new health geography (p. 610)." However, they caution that place knowledges are place bound, meaning a study about New York City would not necessarily offer new information about Chicago, let alone neighboring Newark, New Jersey. Landscape studies were highlighted by Kearns and Moon as being the most connected to the new health geography. The understanding of complex layerings that converge on a place offered by landscape studies were seen by Kearns and Moon as emblematic of the type of study forthcoming. The use of GIS was championed as the main mode of entry into multi-level analyses.

Once health geographic research was established more fully, studies calling for connecting research and activism (Valentine 2003), critical analyses of gender differences (Parr 2004), social capital and its relationship to place (Veenstra et al. 2005) and deprivation (Barnett, Pearce and Moon 2005) became common in health geography. GIS also finds its way into the pursuit of context, using technologies like network analysis to re-define context outside of the area-based means used previously (Pearce, Witten and Bartie 2006).

A recent example of a geospatial look at health and place comes from Jeremy Mennis and Michael Mason (Mason and Mennis 2010; Mennis and Mason 2011). Mennis and Mason build the case that place-based research should address perception of place and its influence on an individual's behavior. Additionally, the emotional interpretation of place will influence that behavior. They stress that focus on "home location" fails to account for other places that the person frequents. Background and past experience will influence a person's experience and interpretation of a place—beyond the general label that is affixed to a place. Further, social influences are not aspatial, but are embedded within place and play a significant role in creating a sense of place through the social interactions that occur at a given location. After Turner (2003), Mennis and Mason assert that how place influences human behavior is one of the fundamental questions of human geography and health sciences. Mennis and Mason found that incorporating information about the activity space of a person could provide insights into behavior patterns. Hence, the belief is postulated that neighborhood influences outside the home impact behavior. Finally, they assert that personal interactions at a location will constitute a place as much as any physical feature at a given location. It is these personal interactions which manifest themselves in qualitative description rather than quantitative data points. The findings of this work are both timely and pertinent to my own work.

The use of GIS and spatial analytical methods is a dominant area in the study of health and place. Spatial statistical modeling of large-scale disease phenomena closely resembles the work found in epidemiology on national, state and municipal scale problems (Atkinson and Molesworth 2000; Cressie 2000; Wakefield, Kensall and Morris 2000). Nadine Schuurman has worked extensively both in British Columbia and in South Africa on studies of health and place. In British Columbia, Schuurman has studied access to palliative care - a specific example of a common theme in GIS and health, that of modeling access to care through spatial analytical methods (Cinnamon and Schuurman 2010). Schuurman has also analyzed South African admissions data to determine distance traveled to care and the barriers confronted by residents due to social factors (Schuurman et al. 2011). Sara McLafferty has demonstrated the utility of GIS in public health both from a general standpoint (Cromley and McLafferty 2002) and through spatial analysis of the clustering patterns of disease in specific communities (Timander and McLafferty 1998).

To develop an understanding of health and place, it becomes critical to capture the perceptions of people in terms of their health (measured) and their feeling about their environment as Scarpaci argued for in 1993. Dennis et al (2009), Collins and Kearns (2001) and Carpiano (2009) all provide useful qualitative pictures of the perceived relationship between health and the environment in which an individual lives. By linking medical records or basic health measures with thick descriptions of the environment, how the environment is navigated and reactions to the environment, researchers can begin to grasp the relationship between health and place. Quantitative models alone do not provide answers. Therefore by obtaining qualitative description, in the form of narrative, interviews etc, about place, the respondent’s relationship to place becomes critical to attempt to determine factors that lead to a quantitative difference in health outcomes.

Carpiano (2009) provides an example of the types of qualitative data that are important to health and place. Utilizing a "go-along" interview, Carpiano captured place-bound perspectives and experiences of the interview subjects. The data included feelings, emotions, and perceptions about place and linked these to health outcomes. In Carpiano's example, the place-based data was obtained by the researcher in close contact with the participants. However, the data was not provided directly by the participant, rather from the researcher's observation of the participant during a neighborhood walk.

Extending the qualitative geographic rubric directly to the participant is a logical next step. Dennis et al (2009) achieved this by surveying children about their relationship with their neighborhood through a method dubbed participatory photo mapping. Children from a local community center were grouped together and provided a camera and a global positioning systems unit. Each group was then asked to walk their neighborhood and photograph their environment - particularly locations that had some meaning for each individual. Once each group returned their camera and GPS unit, the data were aggregated using a GIS and then displayed for a focus group to contextualize the pictures both from the perspective of the author, and of the entire group. This type of explicitly spatial qualitative analysis provides a highly local perspective on health and place. My work seeks to build upon this foundation by extending these concepts into a different style of qualitative place-based health research model, one that integrates qualitative data analysis and spatial visualization in order to develop understandings about the problem in question.

Tom Koch's work (2005; 2011) provides a historical perspective on the study of health and place. He has written extensively about the relationship between 19th-century epidemiology and modern-day health geography. His assertion, that we are only now returning to the manner in which early epidemiologists worked is obvious in hindsight. Koch highlights how capturing the entire geography of an area, such as weather, landscape, human features, as well as the distribution of a disease, is necessary to “spatialize” the problem and produce effective geographic and health research (Koch 2009). As a historical writer, Koch excels at demonstrating how the Broad Street cholera epidemic is an exemplar that holds today in large scale studies of cancer and other diseases (Koch 2011). In Koch’s most recent work, Disease Maps (2011), he uses the Broad Street Map as a foundation through which current epidemiological research can be framed. Koch then goes on to look at modern cases, including revisiting the Broad Street map through a GIS, to demonstrate the linkages between the work of Snow and disease mapping up to now.

Using quantitative, qualitative and historical perspectives on health and place, we can begin to put together the pieces of the complex puzzle. Using multiple methods to analyze a problem is both productive and valuable, whether in health geography, epidemiology, participatory research or the social mapping of a neighborhood community in Detroit.

2.6 Discussion

The preceding literature review has followed a winding path between multiple, and in many cases only loosely connected, bodies of knowledge. Connecting these disparate fields is both challenging and an area ripe for development. GeoInquiry seeks to not only connect these disciplines but to combine relevant portions to facilitate forward motion in each. Beginning with the work of Bunge, GeoInquiry attempts to re-imagine Bunge’s initial participatory roots in a new digital framework that offers nearly the same level of cognitive access that he provided his collaborators in the Fitzgerald neighborhood. However, GeoInquiry aims to provide a framework extensible beyond a single research site - though this expansion is outside of the scope of this dissertation. To provide the ability to extend the method, GeoInquiry must draw on a transdisciplinary body of knowledge.

The geospatial literature is at the core of the GeoInquiry model. Understanding the background and pitfalls of participatory mapping through the 1990's and 2000's offers many case studies in the strengths and weaknesses of its implementation. Participatory mapping efforts described above have often retained very technical GIS systems, many times at the urging of the public engaging with the research (Elwood 2009). Central to GeoInquiry is the effort to place the user at the control of the mapping framework, unmediated by experts. By building off of the work of the vast and growing neogeography community, it is possible to provide a user-centered design. Without the pervasive presence of Google Maps, Mapquest, Bing and other mapping websites, along with the numerous mashups and the spatial presence found through the Internet, an effort such as GeoInquiry would be difficult to create and even more difficult to promote for adoption. By using commonly accessible tools, GeoInquiry moves beyond the highly technical GIS model into the Internet frameworks that are already commercially successful.

Simultaneously merging qualitative efforts in GIS with the potential of geovisualization offers a new path for both fields. Removing the GIS from the equation and implementing both qualitative data capture and analysis opens this methodology to a wider audience. This democratization also provides a re-conceptualization of qualitative mapping and analysis that not only doesn't require GIS, but breaks free to some degree of the constraints placed on these data in a GIS. While GeoInquiry still retains a database model similar to GIS, the architecture of the tool itself offers more flexibility to accommodate these data, as will be seen in Chapter 4.

Geovisualization too is opened to qualitative data in ways that it has not often been to date. By limiting the visualization interface to only two interactive components the cognitive load that is often a challenge for the user to understand geovisualization is vastly reduced. Reducing the cognitive effort in viewing these data allows the user to engage more fully with the visualization concept and removes the very high technical barrier that exists in current geovisualization. With the exception of Sligsby et al (2007) and the potential of MacEachren's most recent work with SensePlace (MacEachren et al. 2011), the presence of qualitative information in geovisualization has been limited. While GeoInquiry doesn't expand the domain of Geovisualization in a drastic way, the novel re-imagining of qualitative data in geovisualization is a subtle effort in the right direction.

As for health and place, the literature makes it clear that both social epidemiology and health geography offer research niches that GeoInquiry can fill.

Health geography's focus on context, both conceptualizing the concept and understanding the substantive nature of context, is still under development. While many studies have demonstrated the importance of these ideas, GeoInquiry establishes a means to analyze context by capturing the qualitative spatial character of the lived experience the researcher is interested in to inform studies looking at health and place. Context requires not only the quantitative data available from large-scale data, but also the qualitative place-based information that a customizable system like GeoInquiry can provide.

Chapter 3—Characterizing GeoInquiry:Theory and Conception

This chapter provides detailed background on the core areas of influence from which the theoretical foundation and conceptual framework of the GeoInquiry system emerged: Qualitative coding, New Media, Geoweb and New Spatial Media. Combining the distinct areas of qualitative coding and the Geoweb enables GeoInquiry to be established as both a theoretical construct as well as a web-based application. The subsequent discussion will survey these techniques and disciplines and from these areas, the strengths and gaps of each will be articulated, leading to the proposal of the core concept of this work: GeoInquiry.

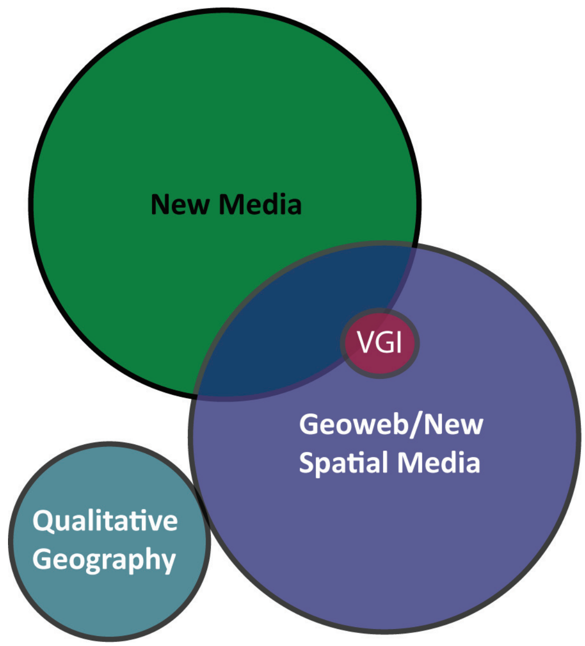


Figure 3.1: Depiction of the relationship between the fields of New Media, Geoweb/ NSM, Qualitative Geography and VGI

3.1 Qualitative Coding

Qualitative coding is a core methodology in this work, in particular the manner in which this research aims to extend the qualitative coding framework. GeoInquiry supports the development of testable hypotheses by providing tools for the use of the Grounded Theory methodology as well as general qualitative coding (ranging from ethnography to phenomenology to narrative analysis). This method does not aim to support the testing of hypotheses directly, rather the construction of hypotheses for testing in subsequent studies.

Johnny Saldaña (2009) describes qualitative coding as a method outside any particular qualitative analysis framework. Similarly, Meghan Cope (2005) also describes coding as a standalone analysis tool. Both Cope and Saldaña stress that coding provides a means of abstracting, or reducing, the dataset to allow it to be manageable for the purpose of analysis. Coding consists of a combination of first cycle codes - attribute, descriptive, magnitude and simultaneous (Cope 2005; Saldana 2009), and second cycle codes - pattern, focused, theoretical, analytical (Cope 2005; Saldana 2009). First cycle codes tend to be categorized as more descriptive, or as labels and categories, while second cycle codes dig deeper into the context. Saldaña (2009) argues that a "touch-test" should be applied when coding. Essentially in Saldaña mind, if you can touch something it is a first cycle code (for example the name or a property of a physical object), and during second cycle coding the researcher should strive to extract more abstract concepts (e.g. acceptance or fear, etc). Another type of code supported is the in-vivo code described by Strauss and Corbin (1990) - codes that are direct phrases from the research which often appear as first-cycle codes.

Saldaña (2009) work in particular illustrates the broad array of coding styles, ranging from attribute codes to emotion codes to hypothesis codes. Each coding style is directly tied to the type of desired outcome and direction of research. However, throughout discussions of coding options (Charmaz 2006; Cope 2005; Saldana 2009; Strauss and Corbin 1990) there is no explicit coding for geography or geographic location. This gap is where the GeoInquiry coding module blazes a new direction. The geographic code is not a code in the same manner as described by Saldaña, Cope or Charmaz, rather the geographic code is obtained by explicitly linking and capturing the spatial character of the data point. By obtaining geography explicitly from each user, a geographic code is immediately entered into the data structure. These geographic codes complement the qualitative data by affixing location to each qualitative description. This explicit linkage allows coded data to be consistently spatial in character, allowing the subsequent module to carry a qualitative-spatial character into the analysis process. In turn, this allows the emerging themes to take on not only a textual character, but also to present a spatial character as well. By providing this spatial character, for example the description and identification of unsafe places discussed further in Chapter 5, this coding framework extends qualitative coding methodologies beyond their existing text-based framework and into a spatial-textual realm that as of yet has been only lightly explored (Knigge and Cope 2006, Kwan and Ding 2008, Jung and Elwood 2010)

3.2 New Media and Cyberculture

To begin the task of both establishing the theoretical foundation for GeoInquiry and then constructing a conceptual framework on which to build the system, we must first describe New Media. The idea of New Spatial Media, and ultimately GeoInquiry, emerged from the conception of New Media. Lev Manovich (2001) describes the shift to New Media as the movement of culture towards "computer-mediated forms of production, distribution and communication. (p.43)" New Media goes beyond simply the digitization of prior media forms such as television, newspapers, etc (Lister et al. 2009; Manovich 2001). Rather, New Media establishes the idea that media are not only consumed in a uni-directional format, but rather they are media simultaneously consumed and produced in a bi-directional manner. This producer option opens New Media to many options such as blogging for social struggle (Kahn and Kellner 2004) and interactive and distance gameplay (Lister et al. 2009). At the same time, Enzenberger (1999) sees New Media as oriented towards action and the present as opposed to contemplation and tradition. In Enzenberger's view New Media is devoid of intellectual property and is instead a socialized means of production and consumption of media. Murray (2003) sees the foundational properties of New Media as procedural and participatory. By this she insinuates that the "interactivity" required within New Media is begat by these foundations.

Van Dijk (2007) argues that New Media transcends space and time (or reduces these components to insignificant properties). Van Dijk defines New Media as the integration of telecommunications, data communications and mass communications in a single medium or what he calls a "process of convergence (p. 7)." Van Dijk posits that space and time are both expanded and contracted in new media. Social networks may span all spheres but they do not remove the space and time divisions. Critically, Van Dijk believes that public networking will not bring us together, nor will it tear us apart - and the network society in principle tends to become more unequal than mass society, known as the Matthew effect—the rich get richer. Time, money and other constraints make wide adoption of new media difficult. The idea of GeoInquiry therefore seeks to mediate this divide of the Network Society, though it is likely that community organizing will be required to bring importance to the phenomena beyond those who are currently engaged in multiple forms of network communication

Murray's (2003) supposition that New Media is defined by interactivity may be the core feature of new media. While definitions of new media are both bountiful and vague, the idea that new media is defined by interactivity is the simplest way to settle on a definition for the purpose of my work. Interactivity includes the producer-consumer framework Van Dijk highlights, and it serves as a clear delimiter between expert held forms of production and societal forms of production. The idea of GeoInquiry that is posited here is centered on a production-consumption framework that demands interactivity and continuous change. The media are not static, and it is the producer-consumer continuum that both enables the concept but also must be expanded to effectively integrate these media within the analytical framework of GeoInquiry.

3.3 Geoweb and its Relatives

Concurrent to the development of neogeography discussed in the last chapter, has been the academic pursuit of the the idea of the Geoweb. The concept of the Geoweb is one that is still under some debate. The term Geoweb has come to serve as something of an umbrella term that encompasses a wide range of spatially-enabled and related (i.e. applications where a map is only present but not a focus) web applications. Some terms emphasize the cartographic representation outcomes including ubiquitous cartography (Gartner, Bennett and Morita 2007) and web mapping (Plewe 2007). Other terms place an emphasis on the data themselves, like Volunteered Geographic Information

(Goodchild 2007), user-generated content (Sieber 2007), and collaboratively contributed geographic information (Bishr and Mantelas 2008). These naming debates have given rise to terms attempting to capture the array of events taking place under one label—Geoweb, Participatory Geoweb (Sieber 2006) and New Spatial Media (Crampton 2010). As Elwood (2008) has stated, these naming debates are a critical step in understanding the components of a new idea, as well as to provide focus to emerging research through a detailed research agenda.

The first attempt to define the Geoweb is attributed to Lake and colleagues in 2007. Lake et al (2007 p. 15) defined the Geoweb as "an integrative, discoverable collection of geographically related web services and data that spans multiple jurisdictions and geographic regions." This original definition retains a strong link to desktop GIS - in particular narrowing the Geoweb to include predominately those layers and services that can be consumed by GIS software. Subsequent definitions from industry both extend Lake et al and serve to differentiate two visions of Geoweb. ESRI has defined the Geoweb as a service-based model where spatial data and geographic information content are continuously available through web-based services and map mashups that are becoming part of the underlying fabric of the Internet (esri 2006). Matt Ball (2008), on the other hand, declares that the Geoweb is not yet a GIS, but rather is a framework providing the opportunity to integrate a collective geographic knowledge.

Previous definitions of Geoweb have largely come from industry. Academia has concurrently attempted to define the Geoweb, though these definitions have focused more on the Internet aspect of the field, rather than the GIS aspects. For example, Sarah Elwood and A. Lesczynski describe the Geoweb as follows:"'Geoweb' refers to the merging of geographic information with web-based content, often with an implied emphasis on Web 2.0-based frameworks and services, especially those that emphasize user interactivity and user generation of content. (Elwood and Leszczynski 2011)"

Goodchild (2007) argues that the Geoweb represents a paradigmatic shift from a model in which national governments were the lead actors in producing carefully 'curated' data sets to a new multi-vocal model in which citizens, states, and private entities are all involved in producing 'patchwork' data sets that bring together curated and volunteered information. At the same time, Renee Sieber summarizes the Geoweb by a widespread availability of geographic content and data on the Internet, its platform- independence, and its opportunities for integrating user generated content (Sieber 2007). It represents an "architecture of participation," a system that encourages user contribution by its design (O'Reilly 2004). Earlier, Sieber's research group at McGill University defined the Geoweb in terms most associated with a position similar to industry. In a recent discussion on Twitter, Sieber and Matthew W Wilson debated the nature of the Geoweb. Wilson argued that the term Geoweb is useful to demonstrate that the web is material and not just a technical exercise. Sieber agreed that the Geoweb is material, but also that it expands from location to application development to avoid being exclusively about location and place names. Elwood and Lesczynski feel that a central practice of the Geoweb is the geotagging of online content or the assignation of place names, while Wilson disagrees, stating that the presence or absence of geotags should not limit the idea of the Geoweb. Ultimately, Elwood and Lesczynski feel that the Geoweb represents an omnopticon—the many surveilling the many (Rose-Redwood 2006)—which is an apt description given the blurring of the roles of producers and consumers, both in the Geoweb and New Media.

A component of the Geoweb that invites further investigation is the concept of Volunteered Geographic Information or VGI. Development of the idea of VGI (Goodchild 2007) occurred at the same time as the rise of Neogeography. As postulated by Goodchild, VGI is directly related to the Web 2.0 concept of crowdsourcing—the idea that many individual users contribute to a larger project, therefore making the whole project greater than the sum of its contributions. In VGI the information is contributed by volunteers to document a geographic phenomenon, and may be as discrete as the eating patterns of a lone individual. The initial implementations of VGI focused on basic road map creation in the UK (OpenStreetMap), to provide robust and detailed road data outside the purview of the Ordinance Survey, who charged high costs to obtain these data. From these beginnings the concept has been implemented in other examples of citizen science as well multiple studies about the veracity and reliability of contributed data. Work on the reliability of VGI has struck a nerve in the neogeography community, as the differentiation between volunteer and expert has been criticized and even the term volunteer has been described as a slight (Gorman 2010). VGI appears to remain in some debate regarding its meaning and acceptable forms in the academy. Despite the VGI orientation towards a single, individual volunteer of information, the field appears to struggle to break free of the idea that it is linked to crowdsourcing (Howe 2006), which involves developing a consensus built upon numerous submissions. This link to crowdsourcing considerably narrows the scope of the field and limits its potential to a tightly defined set of circumstances and blessing by a limited number of scholars. While initially appearing to be a large and promising area of research based on Goodchild's writings, defenders of VGI, including some who were present at the initial meetings at the University of California-Santa Barbara in 2007 on the topic, have pushed to focus VGI on a small area of research—particularly around trained volunteers contributing information willfully to the map, like in the example of OpenStreetMap (Kishor, personal correspondence).

3.4 The Bridge to New Media: Crampton's New Spatial Media and the Geoweb

Crampton's (2010) idea of New Spatial Media (NSM) appears to present the umbrella term that best fits this overarching lineage and diversity of applications. Devoid of a formalized definition, New Spatial Media corresponds to the apolitical definition of Geoweb that would appear at first exposure to fit the term—an idea of the Web 2.0 application of a diverse and ultimately participatory framework for the construction and use of spatial information. In Crampton's description he hits upon the same set of ideas as I have earlier--VGI, neogeography, etc. It is the links to these concepts that situates NSM as an ideal umbrella term. Labels like VGI and neogeography have too narrowly defined their territory to properly situate as an umbrella term. However, NSM doesn't carry this same baggage.

Crampton has coined the term and yet he makes no attempt to pigeonhole the idea with a formal definition. And that is likely for the best. Without a definition we can freely navigate the space, keeping in mind that any NSM framework should possess some basic characteristics: 1) It should be people-powered (meaning participatory), 2) it should be open to many or all people (experts and non-experts alike), 3) it should reside either on the Web, through mobile devices or both. If we take these simple guidelines to heart, it is clear that NSM can serve not only to encompass other Web 2.0 ideas, but also allows for a return to the open and accessible framework that Bunge first used in the Fitzgerald neighborhood.

In personal correspondence with Crampton, he articulated that in his mind New Spatial Media and the Geoweb were synonys for the same ideas. However, Crampton's choice to connect back to New Media suggests that the two are not identical, but are instead closely related. A thorough discussion of New Spatial Media as an extension, through a new producer-consumer framework, of the Geoweb is necessary to illustrate the extensions proposed by NSM.

New Spatial Media follows most of the basic tenets of the Geoweb. Ideas such as crowdsourced data production as the basis for data are at its core. Three advantages of the Geoweb/New Spatial Media over traditional geographic data production are the use of the crowdsourced data from sources like VGI, the use of open source tools (like openLayers) and free services (like Bing Maps) and the use of the web as a platform, which fosters participation and syndication. Each of these tenets is a baseline for a Geoweb based framework. However, the idea of the web as a platform has to date been underdeveloped in work on the Geoweb.

By investigating the potential of the Internet as an application platform NSM begins to look at ideas beyond what has previously been presented in work on the Geoweb. Crampton sees the web as an invitation to encourage participation, not just knowledge acquisition. However, in Geoweb applications, the web has repeatedly provided an opportunity to contribute data. This "local" knowledge has challenged the hegemony of "official" spatial knowledge, which often casts doubt upon "unofficial" forms of knowledge as less than reliable. What appears to be missing from NSM/Geoweb is the ability to extend and analyze these knowledges and the idea of the web as a platform beyond just knowledge acquisition is an area of research available for exploration.

Linked with the idea of the web as a platform is the connection between NSM and New Media. While New Media writings, as discussed above, can delve into spaces far beyond what is necessary to understand the Geoweb, there is one major concept put forward that applies here. Van Dijk's producer-consumer framework not only connects with the ideas about the Geoweb, but also provides an extension to a new paradigm of NSM. Both Crampton's writings and the principles of the Geoweb point to interaction as key. However, the producer-consumer framework appears to be more than just an opening for interaction. Rather, the producer role moves in my mind from purely interacting or contributing information to actually analyzing information. It is this movement to actively consume geographic information in an analytical framework that has been unexplored in Geoweb, but is also why NSM, to me, offers advantages as a concept beyond purely a nomenclature difference from Geoweb.

Crampton's recent writings seeking to drop the term media as "old hat" (Crampton 2012) only serve to illustrate the missed opportunity to more deeply link NSM and the Geoweb to the ideas that can be gleaned from New Media. It is this extension beyond simply the producer-consumer dichotomy to the "producer-consumer as analyst" framework that I explore in the next section on the conceptual framework of GeoInquiry.

3.5 GeoInquiry

By combining the producer-consumer relationship from New Media with the open source/user-generated content from the Geoweb, and extending both ideas to a model that allows analytical capacity, a new conceptual model can be articulated. GeoInquiry borrows from the tenets of qualitative and critical GIS that seeks greater use of qualitative representations and data. Pavlovskaya has made it clear that GIS is open to a multitude of qualitative forms of analysis, however these have been woefully under-represented in the available tools on offer. To accomplish this goal, I propose an online suite of tools that can connect to a GIS to offer rich qualitative analytical capabilities and still allow for both web and desktop interaction with the resulting data.

To develop GeoInquiry as a novel concept, a shift away from the standard Geoweb use of contributed geospatial data is necessary. GeoInquiry develops and implements qualitative analytical tools in an open Geoweb system. Supporting analysis allows the Geoweb to move into the third site of reflexive, positioned research proposed by Rose (2003)—the site of interpretation. GeoInquiry also allows access to data extending from purely visual representation to analytical opportunities, in tune with Dunn's (2007) call for PGIS to open control and access to information contributed in new, extensible ways. Opening analytical functionality also meets Surowiecki's (2004) call to allow people independent opportunities to analyze information so as to avoid influence of their judgments by others. To date, Geoweb applications have allowed limited visual analysis, but the idea of crowdsourcing information can limit analysis to only an amalgamation of the mass consensus—restricting the Geoweb's opportunity to meet Surowiecki's call.

GeoInquiry establishes one example of New Spatial Media. By providing integration at the level of services and types of data as well as capitalizing on the rise of interactive media GeoInquiry builds on the foundations of New Media. By constructing an environment that allows for users to interact with spatial information, both for data entry and data analysis the system meets the characteristics of New Media in a spatial analytical framework. GeoInquiry is best captured by Van Dijk's third level of interactivity[1] - the behavioral dimension, where the analyst and the person inputting data can switch roles at any time. The final level is acting and reacting with an understanding of meanings and contexts by all actors involved— what Van Dijk describes as the mental dimension necessary for full interactivity. Traditional television, online map interfaces and ideas like Volunteered Geographic Information are all concepts which relate to old media, media which may be interactive, but are largely a unidirectional data transfer process. This is in direct contrast with the two-sided or multilateral communication that constitutes the first level of interactivity. VGI would fall under the information traffic pattern Van Dijk calls 'registration', the collection of information by a center or organizing entity. In contrast, New Spatial Media would be a "conversation'', an exchange of information by two or more people.GeoInquiry is both an example of New Spatial Media as well as a hybrid version of New Media. In the form used in this research the goal of a true NSM is not reached due to the mediated nature of the survey administered. However, the potential for a deeply embedded qualitative research effort would yield the type of full interactivity, in data gathering and data analysis, which would embody a full fledged NSM. As tested, GeoInquiry would be more reactive than interactive; however the analysis portion would be fully interactive. In addition, GeoInquiry offers the potential to capture all perspectives, both dominant and dissenting. Dissenting perspectives can be as informative as the dominant position and their inclusion in GeoInquiry increases the value of this method.

New Media is defined as the two way communication and production of information between various parties. NSM furthers this idea by constructing the map as well as supporting the consumption of it. This is the same set of ideas that define

1 The first two levels are multilateral communication(space), and degree of synchronicity (time)

the Geoweb, and its principal exemplar, Open Street Map. However, GeoInquiry goes a step beyond the construction and consumption of the map. Adding the ability to analyze qualitative geographic data incorporates the multi-directional character of New Media. Van Dijk correctly posits that the digital divide (unequal access to digital technology in society) is a concern. New Spatial Media can overcome this divide by creating a lightweight digital framework that will only require basic Internet connectivity and browser software. By minimizing the hardware and software requirements as the barrier to entry, NSM strives to bridge the digital divide. While impossible to remove this completely, a medium that requires only an Internet connection is a major step in the direction of improving access to spatial media. Removing digital barriers to data entry will further move toward this goal.

The remainder of this dissertation will articulate one model of GeoInquiry, from the technical framework behind it, to the testing of its implementation and the deployment of the tool to collect and analyze contributed geographic information. The idea of GeoInquiry is predicated ultimately on the idea of opening geographic analysis of qualitative information to the producers and consumers of that information. This changes the producer-consumer dichotomy from a polar model to a triad where the producer-consumer-analyst can exist as possibilities for all participants, from expert analysts to novice users.

Chapter 4—A Framework for GeoInquiry

As described in the last chapter, Crampton (2008; 2010) suggested that the Geospatial Web or Geoweb, at its most basic, is a combination of map and location-based services (LBS)[1] available on the web. Lake et al (2007) defined the geoweb as: "An integrative, discoverable collection of geographically related web services and data that spans multiple jurisdictions and geographic regions." For use in this work, I define the Geoweb as the geospatial data existing and accessible in a web-based framework that can be either consumed by an online mapping application or leveraged in a location-based service accessible via a mobile device. Following this idea, my conception of New Spatial Media seeks to extend beyond maps and LBS—involving ideas such as spatial data capture and spatial data analysis. The implementation of GeoInquiry involves designing and building a system for collecting, consuming, visualizing and analyzing qualitative spatial data that can in turn be produced, both as a methodology and as a web-based program using New Spatial Media technologies.

This chapter will describe the development and construction of the GeoInquiry system, paying attention to the specific components of the system. In addition the rationale and background support for the decisions on qualitative coding will be articulated. Finally a short segment will propose the opportunities for alternative systems and the links to prior works.

4.1 Construction of the GeoInquiry System

Previous attempts to link qualitative data, maps and analysis have focused on integrating powerful CAQDAS software within a geographic framework, either through linkages or through customized application connections (Jung and Elwood 2010; Kwan and Ding 2008). My work takes a different approach. Recognizing the depth of qualitative software capabilities, and the high barrier to entry into use, GeoInquiry re-imagines qualitative software by simplifying and making it more accessible, for a

1 "A wireless-IP service that uses geographic information to serve a mobile user-any application service that exploits the position of a mobile terminal" (Steiniger, 2004)

focused geographic analysis. This is not to argue that the method developed is superior to the previously reviewed works, rather to suggest that GeoInquiry takes a different approach—one that is accessible to a wider audience, both for general use and analysis of data. Figure 4.1 represents a visual interpretation of the interconnected components of the GeoInquiry system developed here. The subsequent sections will describe the technical and conceptual details of each of the components shown in figure 4.1

4.1.1 Database and Hardware Structure for GeoInquiry

The GeoInquiry system shown in figure 4.1 lives on the World Wide Web. However, from a technical standpoint, the system is supported through a more traditional hardware and software model—a model that unfortunately still requires significant monetary, time and support overhead, both in terms of startup and maintenance. This is acknowledged as a drawback in the setup as it is currently conceived, though the development of cloud-based database and hosting capabilities through services such as Amazon.com and others provides a potential for near-term improvement on this system limitation.

The base hardware requirement is an Internet-enabled server setup. There are no minimum hardware requirements beyond the ability to support PostgreSQL with a minimum of three gigabytes of storage space. The PostgreSQL documentation doesn't offer specific technical requirements beyond a "modern server."[2] For the purposes of this work, the application and database domain is housed on a Windows 2008 server virtual installation, behind a firewall housed in the Department of Community and Environmental Sociology Computing Cooperative. The system is installed to include a basic Internet address of http://vgi.apl.wisc.edu, from which the subsequent applications are hierarchically nested in sub-domains of this address. Due to the length of the web address for the specific applications, the link shortener bit.ly was used to significantly reduce the character length of the address and to also improve the potential for retention of the address by participants, leading to three web addresses

2 http://www.postgresql.org/docs/8.2/static/install-requirements.html accessed 6/13/2011

for the study: bit.ly/geoinquiry_input, bit.ly/geoinquiry_coding and bit.ly/geoinquiry_cloud.

The applications PostgreSQL, PostGIS and openLayers are loaded on the server to support the web application, data collection and visualization. PostgreSQL provides a relational database to store submitted data, as well as to serve the data to the visualization and coding applications. PostGIS is a plug-in for PostgreSQL that enables the base database to store and serve spatial information. Through the deployment of

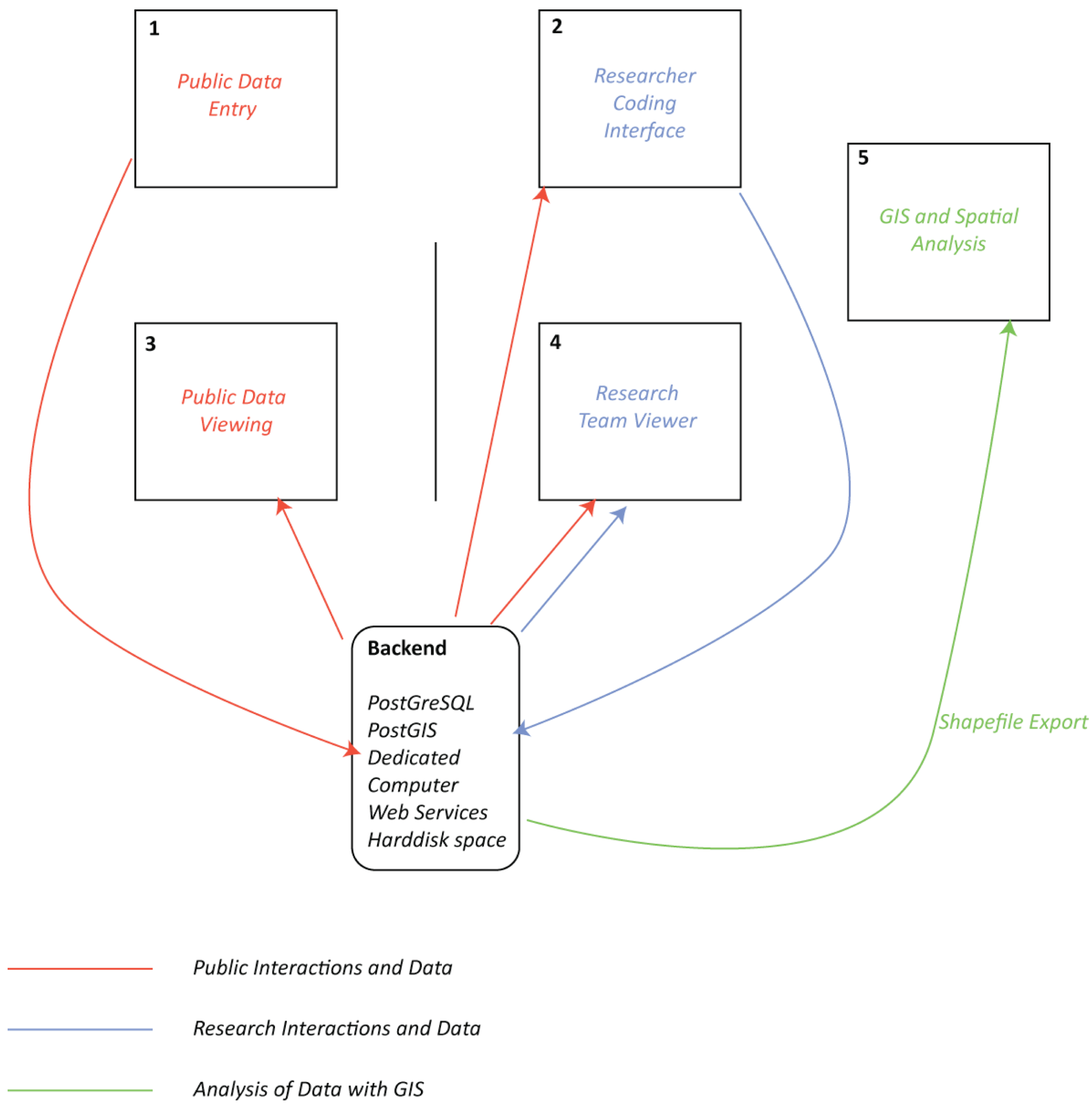


Figure 4.1: Schematic Diagram for the GeoInquiry Framework

PostGIS, geographic shapes can be loaded into the database through the data entry application and the database can then link the spatial coordinates and type (point, line or polygon) of the feature for later viewing. Further, this spatial linkage allows the submitted data to be re-presented for subsequent attribution through the coding interface.

The final server-side component is the web-based mapping application OpenLayers. OpenLayers provides the user with a javascript implementation to load standard Internet maps based on one of the major providers of spatial map data (Open Street Map, Google, Bing, Yahoo) as well as custom cartographic inputs provided through a web mapping service (WMS) published and available online. For this application, the base data chosen comes from Microsoft's Bing maps service. This was chosen due to its similarities to Google Maps, yet a preference of the author for the cartographic representations provided through the Bing Maps interface.

Through non-scientific observation of users of Internet based maps in multiple applied projects with community members, I observed that users expected the maps to behave in a manner similar to the major map providers applications, like Google Maps, Yahoo Maps or Bing Maps. OpenLayers allows for this type of map interaction, while at the same time providing opportunities to develop new tools to enhance the the map beyond the pre-packaged capabilities provided by the respective map provider. Hence, the openLayers user experience is visually similar to what a user expects from an Internet mapping application, with a minor difference in layer management and zoom bar design that can visually cue the user that the system is outside of the standard framework with which they are familiar.

4.1.2 GeoInquiry Data Entry

The primary mode of public engagement with the GeoInquiry research process occurs in the data entry module. Located in Figure 4.1 box 1 - the data entry module provides users with a question prompt and the means to answer the question. This application is a combination of multiple files from the web server providing the framework to combine into the web-based presentation.

The application is fully customizable, providing the ability to adapt the questions and spatial character of the questions to create new questions and responses. Stored within an JSON document (javascript object notation-see appendix A.) the question is provided in clear text and the type of expected response can be defined in this same document through a simple declaration of answer type. This clear text customization is a deliberate attempt to enable the system to be adaptable to any desired study framework. This provided an opportunity for the application to exist beyond the application in this study in a simple format for any imagined spatial survey questionnaire.

Linked with the JSON question definition is a php (Hypertext Preprocesssor) document that provides translation of the data input in the webpage for storage in the postgreSQL database. This translation is a requirement to ensure that the responses from the participants are formatted correctly, enabling the database to properly store and subsequently re-present these data in later modules. Through the php document, the data entry application is dynamic, allowing for each user to offer as many answers as needed to a question with the php code instructing the database to produce new columns automatically to accommodate the novel answer form.

Figure 4.2 shows the web-based standard form for the data collection module. The question at the bottom may consist of multiple elements—free-form answer, multiple choice answer, spatial representation or some combination. These multiple forms enable each data point to be linked with a spatial representation—despite these forms appearing as distinct during the interview process. Through the JSON document mentioned earlier, the questions can be adapted throughout the course of the research to focus on particular themes as they emerge.

Further, the data entry application allows for a free-form entry of data in a final component. This free-form data entry is akin to the social mapping ideas postulated by

Bunge in the late 1960's, with community members creating maps freely, without being guided by the researcher's agenda. Outside of the realm of the structured interview process described for the data entry module, this free-form data entry option enables the public user with the ability to own the application and tailor the response to a feature or event in which they are particularly interested, even if it exists outside of the structured interview. For example, a resident engaged with the survey could use this free-form response to highlight an area of interest that they wish to share with

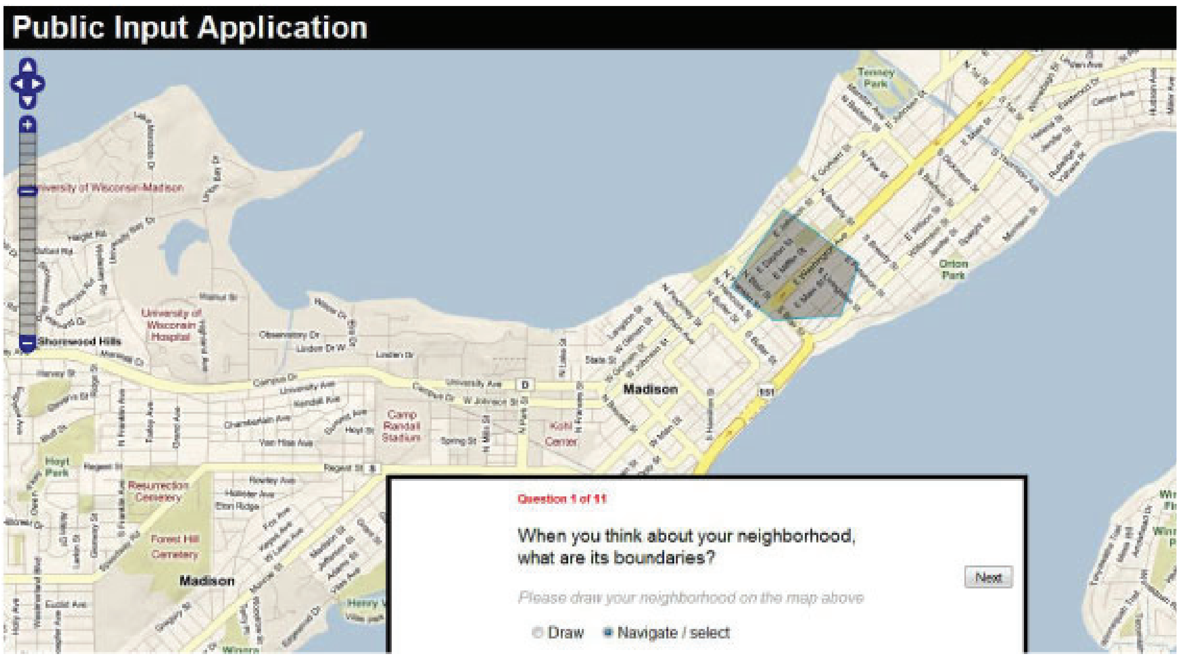


Figure 4.2: Screenshot of the GeoInqruiy Data Entry application

other community members who might use this application. This free-form idea allows the community to customize the application for purposes beyond the structured survey, such as adding data over a long period about amenities. This free-form entry was created for two reasons. First, it provides the public with greater ownership of the process and allows them to adapt this system to potentially be more useful to the general public than just a structured set of interview responses. Second, these free-form entries can contextualize the structured responses during analysis and allow a richer understanding of the spatial character of the study to emerge.

4.1.3 GeoInquiry Public Viewing

The public viewing interface (Fig 4.1, box 3) is a unique component of GeoInquiry that is outside the framework of many of the qualitative and participatory GIS applications described in chapter 2. The GeoInquiry public viewing interface allows the participants to directly view all responses to the structured query. Designed as a simple internet map viewer, participants' data are loaded into the map and the user is afforded the opportunity to click on the shape and view the content connected to the specific shape. While the visualization interface is also accessible to the public when enabled by the researcher (in this study the application address was provided to the public), the public viewing interface ensures that the submitted data remain accessible by the community for further use outside of the current study. It is hypothesized that the free-form entry portion of the data collection module will prove to deliver the most wide ranging and potentially the most interesting data in this application. By providing access to all submitted data, the public viewer allows community participants to view their responses and gain value from the research process.

From an ethical perspective the greatest challenge to this public viewing application is the protection of privacy for both users and non-users of the system. During this work, the community stakeholders who offered both space as well as access to their community members were asked to serve as moderators for the public viewing portal. These moderators were provided with the power to review submissions and remove potentially offensive or dangerous posts before approval for public viewing. Despite stated desires to ensure that all data would be provided to the public users through this application, from a legal and privacy standpoint, this was untenable. Therefore, a moderation scheme was enacted. In subsequent iterations of this framework, a "flagging" method for offensive content will be implemented, bringing the entire framework into line with the principles of a "wiki" (http://wikimediafoundation.

org/wiki/Terms_of_Use). The ramifications (i.e. such as disenfranchisement due to removal of valid data entry) of this type of gated access is beyond the purview of this study.

4.1.4 Facilitating Qualitative Coding

The public facing modules (Fig. 4.1, boxes 1 and 3) center around data capture and data dissemination; box 2 represents the first analytical module in this system. In the researcher coding interface, the ability to assign qualitative codes is supported. These codes are assigned by the researcher based on the submitted text and geography input in the data entry module. A review of coding and its links to spatial data is covered in the following section.

Qualitative coding is facilitated in this application through an interactive process between the web site and the database. Figure 4.3 illustrates the qualitative coding application. Here, the researcher can represent the data captured earlier and display both the geographic representation as well as the associated qualitative data. The analyst can then select the spatial feature and choose to add a new code or activate a checkbox to assign an existing code. At the outset, no codes exist so the researcher's

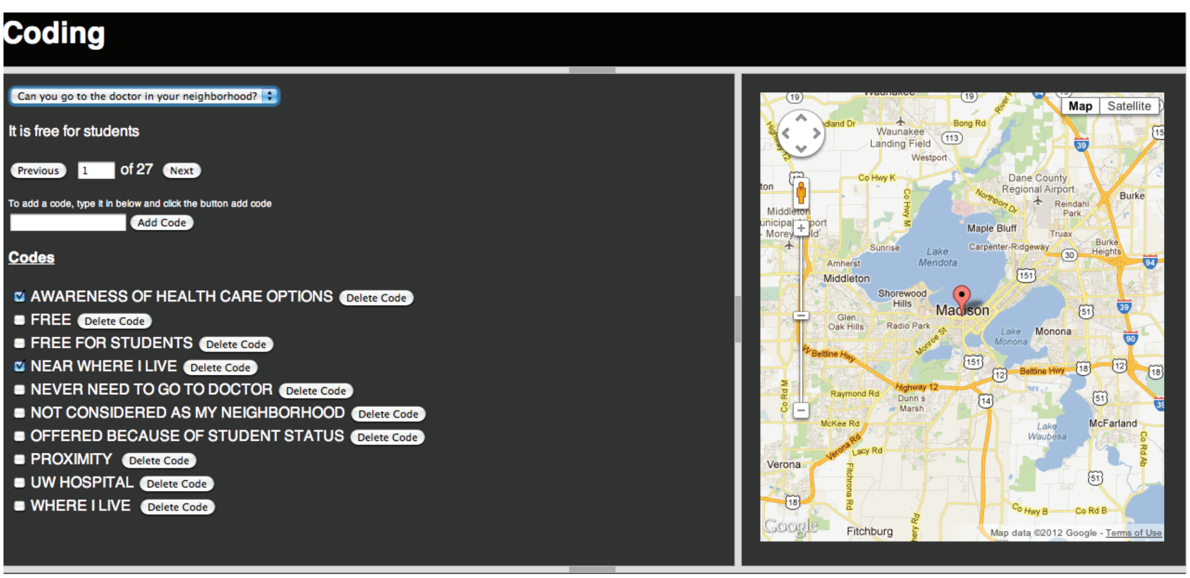


Figure 4.3: Screenshot of the GeoInquiry Coding Application

only option is to add a new code. The analyst selects the shape to be coded, enters a code in the text box (the code can consist of a single word or a phrase) and clicks the ADD button. Here, the relationship between the web page and the database is invoked. Via PHP, the code addition triggers the database to add a new column, and assigns a value of "1" to indicate that this code has been assigned to this feature. All other features are assigned a value of "0" for this code - meaning they have not been assigned this code. However, the coding now becomes an iterative exercise, as this first (and all subsequent) code(s) now appear as an option to assign to every other feature in the database. Therefore, as a new code is assigned, it becomes important for the analyst to re-evaluate each feature for the code's potential utility - similar to what the grounded theory methodology requires, iterative and reflexive coding of the data (Charmaz 2006; Glaser and Strauss 1967).

Each feature in the dataset is assigned a code or codes based either on existing codes or through the new code creation mechanism. Multiple codes can be assigned to a single feature or just a single code, depending on the content of the data. The database stores these codes as a Boolean variable, thereby minimizing the disk space required and allowing the number of potential codes to remain limited only by disk space. While admittedly not as powerful as traditional CAQDAS such as Nvivo or NUD*IST, this method allows analysts of all skill levels to interact with these data for the purpose of analyzing spatial data through qualitative coding. Further, once a code is assigned, it can be removed by "unchecking" the box for that code. In that regard, it facilitates the recursive, reflexive nature that is required by traditional forms of qualitative inquiry and analysis. Ultimately, each code is linked via the database to a geography - which is outside of the purview of most CAQDAS software packages and is unique to the GeoInquiry framework.

4.1.5 GeoInquiry Visualization of Qualitative Spatial Data

The final web module builds on the ideas of geovisualization (MacEachren and Ganter 1990) and Public Health Informatics (PHI) (O'Carroll 2003), though on a limited basis. Using the geovisualization idea of linked modes of exploring data, the visualization application (Figure 4.1 box 4) connects the mapped dataset with a representation of the assigned codes in a "word cloud" (Steinbock 2006). From Public Health Informatics, the idea of using a systems approach to public health practice and research is followed. The drawback to using a PHI approach is a clear exclusion of geography from the process—a short sighted vision that does not live up to the efforts of luminaries like Krieger and her work on Area Based Socioeconomic Measures that highlight their utility in epidemiological studies.

In this implementation of GeoInquiry, a word cloud is in actuality a "code-cloud" (Figure 4.4), essentially a visual display of all assigned codes sized by their frequency of use. However, in the vein of interactivity expected in visualization (DiBiase 1990; Edsall 2003a; Edsall 2003b; Gahegan 2005; Griffin 2004; MacEachren and Ganter 1990), the code cloud doubles as both the means to re-select the spatial data but also as a representation of the codes associated with the displayed spatial data. Essentially the visible set of data and the code frequency are linked through the size of the code in the cloud. This means that the cloud only displays the codes for the spatial content on screen, and not those codes associated with disabled layers or outside the visible area of the map. By selecting a code in the cloud it activates all geographies that have been assigned the selected code. Selecting multiple codes restricts the output to only those geographies containing one or more of the codes. This allows the researcher to select opposing codes (for example fear and fun) to determine if the spatial character overlaps in some fashion.

The visualization application is intended, much like other geovisualization applications (DiBiase 1990; Edsall 2003a; Edsall 2003b; Gahegan 2005; Griffin 2004; MacEachren and Ganter 1990), for the purpose of hypothesis generation. Analysis of the coded data drives the development of ideas and can be used to either provide context

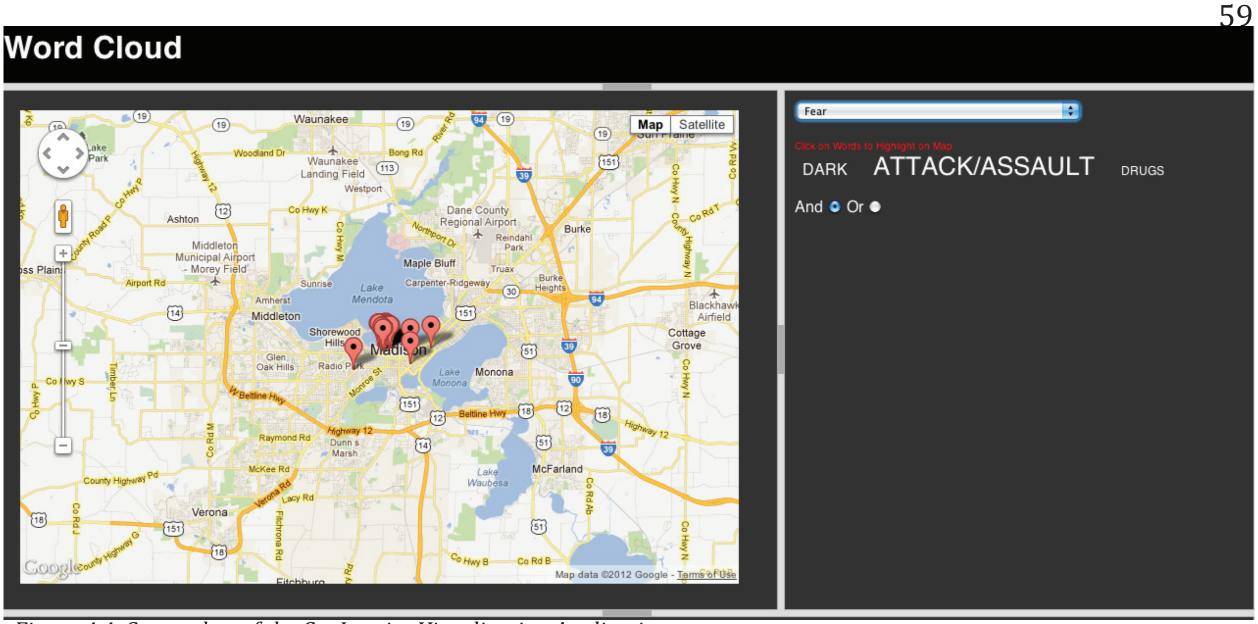


Figure 4.4: Screenshot of the GeoInquiry Visualization Application

to a quantitative study or to develop new testable hypotheses that seek to incorporate the spatial character of the qualitative dataset.

4.1.6 Beyond the web framework - into GIS

While the web-based GeoInquiry system facilitates the capture and limited analysis of these data, it is likely that most analysis will require further interrogation of the dataset. Therefore it is critical that these data are enabled to extend beyond the web framework. In that regard, the use of the PostGIS module within PostgreSQL is important. Each data point can be exported as a unique observation in a larger dataset. This export can occur in the standard and open shapefile format (ESRI, 2002). Data can be exported by question or as a complete dump of all points, lines or polygons (however each geometry type must export in its own shapefile) with the coded data and the description included in the shapefile database table. This means that data involving the capture of polygonal shapes is separated from data captured simply as points. However, in the GIS both (or all) of these layers can be loaded concurrently and can be explored in tandem through either visual methods, or through spatial analytical methods and algorithms. Appendix B illustrates the database format for the shapefiles.

Once exported into the respective shapefiles, quantitative as well as qualitative analysis becomes possible. Shapefiles are supported within the R statistical computing environment (R, 2008), allowing point pattern statistical analysis on point layers through spatstat (Baddeley and Turner 2005) and performing spatial autocorrelation measures to determine a measure of spatial clustering, to name a few analysis options. These analysis options allow the NSM framework to extend beyond the web and integrate both desktop, web and server to produce a linked, contextualized environment for analyzing and visualizing qualitative spatial data.

4.2 Potential Alternatives and Grounding GeoInquiry

As evidenced by the structure of the online (and offline) system, GeoInquiry should be thought of as more than a web-based spatial data environment and instead be considered to be an integrated spatial data capture, sharing, and analysis framework. The implementation of GeoInquiry described here should not be seen as the only option for GeoInquiry, however. The characteristics of GeoInquiry that are required would be best articulated as ease of access, web-based entry and dissemination of data, and online and offline access to both visualizing and analyzing these data. By mandating these components, we begin to frame GeoInquiry without confining it to a very specific configuration of components. It is important to enable GeoInquiry to be flexible to allow for new imaginings and potential alternatives in the framework and development. This is especially important to enable the concept of GeoInquiry to begin to establish a broad framework under which qualitative and participatory spatial data can organize. At the same time, it is critical that the lessons of work such as Bunge’s DGEI remain at the forefront of GeoInquiry development. GeoInquiry should seek to accommodate as wide an audience as possible, not just those who can afford access to the web through mobile devices requiring high-cost data plans.

Chapter 5—Research Methodology

This chapter describes the methodology used to test the usability of the GeoInquiry system. Two distinct usability and user acceptance metrics were collected, both in conjunction with either live data collection or analysis tasks. First, three separate data collection exercises were conducted during which residents of specified geographic areas were invited to enter data about their environment including access to resources, safety and health. Second, a content expert usability test was conducted where experts in geographic analysis and qualitative inquiry were invited to participate in a formal usability study evaluating the GeoInquiry system's individual modules.

This chapter begins with a description of the research design. Details about the selection of the public users and the demographics of the participant groups follows. Descriptions of the survey methods used to conduct each session appear next. Finally, the methods from both the simple and formal usability studies will be described.

5.1 Research Design

The process of acquiring the data and exploring the modules within the GeoInquiry application required a multi-step design. This research used qualitative inquiry to capture data using the GeoInquiry system, a System Usability Study (SUS) (Brooke 1996) and a formal usability study to evaluate each component of the system. Following the data collection sessions with public users, I conducted qualitative coding procedures using the coding module to begin hypothesis generation.

This research combines multiple approaches to analyze the usability of the GeoInquiry system, and uses qualitative analysis techniques to study the data submitted by the system users. The research process used both a participatory research framework, requiring participant and organizational support, as well as producing a real-world evaluation situation with public health experts. Ultimately it is a mixture of qualitative analysis and data capture combined with quantitative spatial analysis, and a simple quantitative measure for usability that is used in this research. The process consisted of a SUS (System Usability Scale) instrument, combined with research data capture, rather than test data created solely for usability testing. As a result, this study merges both testing and data capture into a single exercise. Qualitative synthesis occurs at the same time the system is evaluated from an expert user's perspective.

Combining both data collection and usability testing in one environment has both benefits and drawbacks. First, it can make accessing the study materials (in this case the GeoInquiry system) more challenging due to the scripted nature of the testing environment. Secondly, the combination can overwhelm participants who are seeking to engage with the system - especially beyond the rigorous testing framework. However, using a live application that is collecting data on site rather than loading test data provides the users of both the entry and analysis sides with a productive computing environment, one that has value beyond simply testing a system. This ensures that the test is a valid simulation - precisely because it is not a simulation!

The research framework for the case study is based on submitted data which falls within the rubric of descriptive epidemiology (Gordis 2009). Descriptive epidemiology characterizes the conditions around health - in this case the social conditions making up the health landscape in Dane County, WI. This differs from analytical epidemiology where specific hypothesis are tested in a rigorous statistical manner. Instead, my research draws a parallel between descriptive epidemiology and the hypothesis-generation goals of visualization. The goal of GeoInquiry as presented here is to take an epidemiological phenomenon, collect data, code these data and visualize the dataset to develop testable hypotheses that can be applied beyond the current research framework. While the domain interest is epidemiology, the descriptive and hypothesis-generating nature of this work could apply in any setting where qualitative spatial data are useful.

5.2 Participant Selection and Description

A total of seventy participants at three sites situated in the three areas of high deprivation (as defined by Messer's Index of Deprivation) were invited to take part in this research for the purpose of understanding the spatial character and content of specific aspects of the individuals' lived experiences. The three data collection settings were diverse and included the Lakeshore Dorm Commons at the University of Wisconsin-Madison, the computer lab at the Urban League of Greater Madison, and the Kennedy Heights Neighborhood Center.

This research does not explore infant mortality specifically. Rather, it was intended to demonstrate how qualitative data can be used to develop hypotheses and better inform the substantive analysis. In that light this study used Messer's Deprivation Index to identify areas with potentially worse birth outcomes than the remainder of Dane County. This study used the Dane County infant mortality conundrum. a decline in the African American infant mortality rate to the level of white infant mortality, described in detail in Chapter 7, as a starting point, but makes no attempt to explain the causes of this decline. Rather, this study attempts to capture, contextualize and characterize the landscape of deprivation that is described using the methods of Messer et al. This work complements, rather than presents an alternative to the Deprivation Index. Further, by focusing on access to amenities and stressors, this work follows with the work of David and Collins (Collins and David 1990; Collins et al. 2000; David and Collins 2007), who look at the social context around populations where poor birth outcomes have occurred or are considered most likely to occur. Ultimately, this work adds a qualitative geographic focus that provides context through which future studies can frame their understanding of infant mortality in Dane County. Based on this idea behind the study, the choice of participants was not limited in any way beyond residence (or attendance, in the case of the Urban League) within the area of interest. By extending participant selection beyond mothers, it captures a wider range of perspectives, revealing the multi-layered context existing in these areas.

Areas of particular interest—the highest deprivation scores—appear in the red units in figure 5.1. Community-based organizations that were located within these highlighted areas and willing to support research were invited to participate. Distinct geographic locations were required to provide a diverse distribution of participants. The four targeted locations are shown in figure 5.2 and include the Allied Drive Neighborhood, South Park Street, Kennedy Heights and the UW-Madison Lakeshore residence area of campus. Of these the Allied Drive Community proved inaccessible due to an inability to secure stakeholder support and space to conduct the study during the desired period, but the other three locations were willing to participate and support this research.

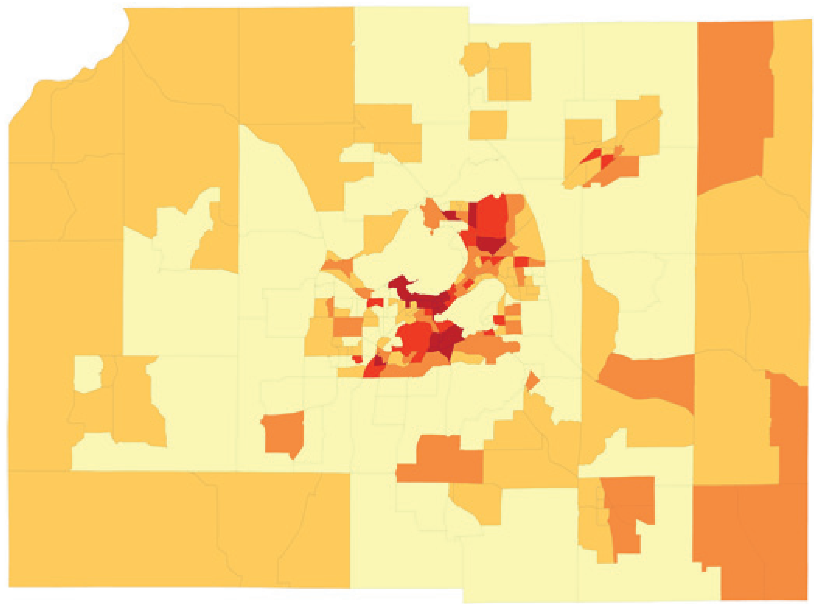


Figure 5.1: Map of the Index of Deprivation (Messer, 2006) in Dane County WI.

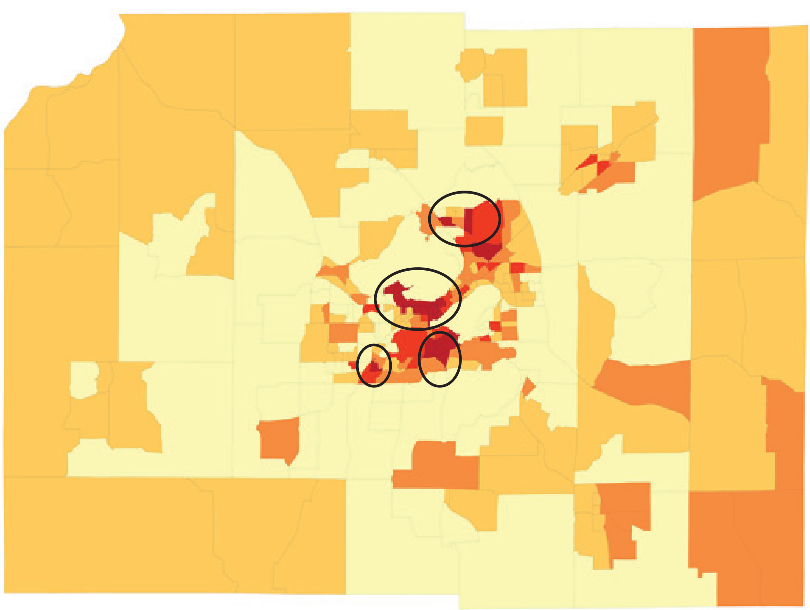


Figure 5.2: Map of Dane County Neighborhoods targeted for case study

The Holt Commons, located in the Lakeshore Dormitory area of the UW-Madison, is situated within one of the most deprived areas of Dane County according to Messer's Index of Deprivation. During a day-long session, undergraduate students who live in the dormitories were invited to participate in the online spatial survey designed to collect information about their experience of place in their neighborhood. In total, 32 students participated, ranging in age from 18-20. All of the students were either first or second-year undergraduates and were recruited as they entered the Commons to sit at one of three laptop computers with wireless Internet access to engage the survey. Each campus participant was offered a candy bar as an incentive to complete the survey.

The Urban League of Greater Madison was chosen due to its location within a highly deprived block group in South Madison. The Urban League also has a state of the art computing facility where computer literacy courses are conducted with members of the general public. Consultation with Urban League executives secured use of the facility in conjunction with a computer literacy course being offered. Participants in the course were invited to remain in the computer lab to conduct the survey, and were offered a sum of $10 for their participation. A total of 25 people agreed to participate during the two hour testing session at the Urban League. These participants ranged in age from 28-65, with the vast majority (20 out of 22) describing their race as black. There were 15 male participants and 10 female participants.

Likewise, the Kennedy Heights Neighborhood Center serves the higher deprivation areas in north Madison. Similar to the Urban League, a computing facility where computer literacy courses are conducted with residents in the neighborhood was utilized for the purpose of the study. Participants were again offed a sum of $10 for their participation. A total of 26 people agreed to participate at Kennedy Heights over a two hour session. Participants at Kennedy Heights were majority female (16 of 26) and predominantly Asian (15 of 26) with the remaining participants reporting race of black (6) and white (3). All of the participants were recruited as they arrived at the Community Center for the weekly Monday night food pantry.

Determining a minimum number of participants for a qualitative study proved challenging. Although saturation is the goal, it is a difficult concept to adequately measure. GeoInquiry is related to grounded theory in both theory generation and coding. Guidance on appropriate sample sizes for grounded theory studies was used to determine the minimum sample size. In this literature Patton (2002), Cresswell (1998) and Morse(2000) offer sample size guidance, with ranges of "saturation", 20-30 and 30-50 respectively. Similarly, Charmaz (2006) suggests small projects should have a sample of about 25, while Ritchie et al (2003) suggest that qualitative samples should be under 50. Meanwhile Green and Thorogood (2004) indicate that in their experience new information is only gained from the first 20 participants, after which information tends to be more repetitive. Based on this literature I selected a sample size of 70, with at least 20 from each site from which reasonable neighborhood perspectives could emerge.

In light of the contextual knowledge that local researchers possess, it was obvious that the campus area could be reasonably excluded from a study on infant mortality. The temporary and voluntary nature of the deprivation on campus, coupled with the small likelihood that a mother would give birth while living on campus make this area an obviously flawed geography for a study about infant mortality. However, this result presents questions about the validity of the index as a means to geographically stratify an area for study. This leads to inquiry about what makes these equally deprived areas different beyond the obvious demographics - questions that can be answered through qualitative geographic data. Admittedly, students present a different population than the population at large. And can perceptions of place, space, access, and safety illuminate differences beyond those that are quantifiable? These questions are central to the development of the GeoInquiry application.

For the formal usability study a total of eleven participants were recruited, from which two participants were chosen, to conduct a pilot study to evaluate the usability testing procedure. Nine people participated in the full usability study. Participants were chosen to represent the range of people expected to use the GeoInquiry system: public data input users and qualitative coding and analysis users. Of the eleven total participants seven had little or no experience with qualitative coding, while four had significant experience. Six participants were experienced with GIS and spatial technologies, while five were novice GIS users. All participants had significant experience with internet technologies, and all participants had at least some experience with internet-based mapping systems like Google Maps.

5.3 Data Collection Measures

The dual goals of the study—to both evaluate the usability of the GeoInquiry system and to attempt to understand the context of the infant mortality changes in Dane County—resulted in two different testing procedures conducted with each participant during the data entry research session. The first portion of the study involved a web-based spatial survey about the participants' experiences with place, health and related factors. The second portion of the study involved a System Usability Survey (SUS) consisting of ten questions on a 1-10 Likert scale (see Appendix C). Each of the measures will be discussed below.

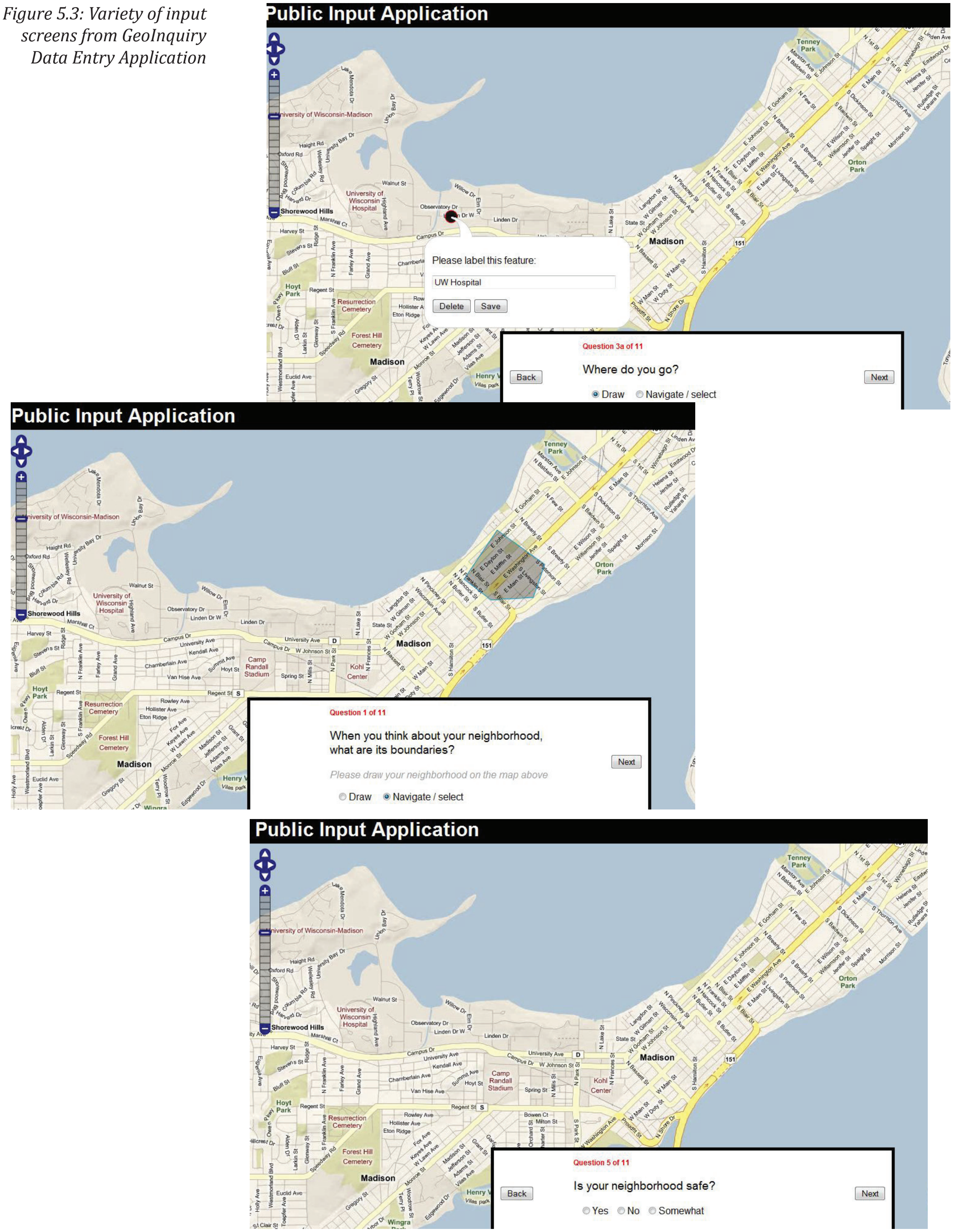
A clear and repeatable script was developed and each participant was instructed how to engage the system via this script (Appendix H). During data collection, participants were instructed to interpret the questions in whatever manner made sense to them. For example, the following instructions were provided while viewing question 1:"What is your neighborhood—Draw its boundaries". As this question was intentionally vague, it offered an opportunity to discuss with the participant how they should evaluate the question and provide their interpretation. Participants were also instructed to avoid using the ENTER or RETURN key on the keyboard, as this key was found to reset the survey to the initial start screen and could pose an obstacle that could make people abandon the survey.

Once the instruction period was complete, participants were encouraged to work at their own pace to complete the survey. Questions that arose during the survey were addressed immediately in a one-on-one setting. Each consultation was noted for frequency to maintain a record of the number of questions being asked while the survey was being completed. At the three sites the frequency of consultation was moderate with 21 instances out of 32 participants at Holt Commons, 12 out of 26 at Kennedy Heights and 16 out of 25 at the Urban League (with eight of these attributed to one participant).

The data entry section of the study began with the participant inputting a basic username and password. These were chosen by the participant and were required to ensure that the participant could re-enter the survey and modify or continue the survey at a later time. This was found to be especially important if the participant hit the Enter key, which reset the webpage to the start page, requiring the participant to login again and move past the questions they had already answered. Once a username and password were entered, the participant was asked some basic demographic questions about race/ethnicity, age and gender. No identifying information was collected. Once the demographic data were submitted initially, this screen would not reappear provided the same username and password were entered at a later time.

Once the demographics were complete, the spatial survey began. Figure 5.3 provides a collage of images in the order in which the participant would see each screen. For each question, the map was the focal point, taking up the majority of the screen. At the bottom center was the question prompt. The participant would read the question and then either click a radio button to begin drawing a shape, or a text box to answer an open-ended question related to a geography that they had just entered. Questions could contain multiple sub-questions and the relationship between these could be obtained in the question count dialog at the top of the question box. For example, question 2

Figure 5.3: Variety of input screens from GeoInquiry Data Entry Application



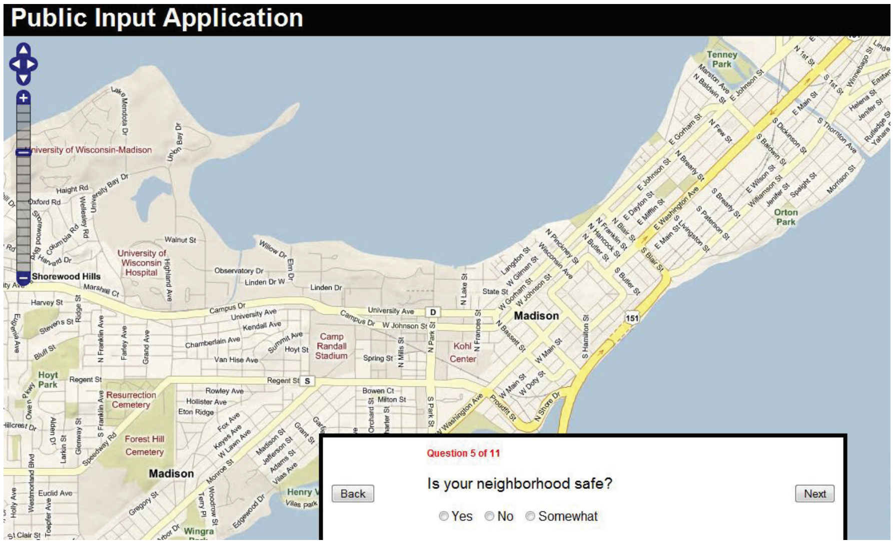
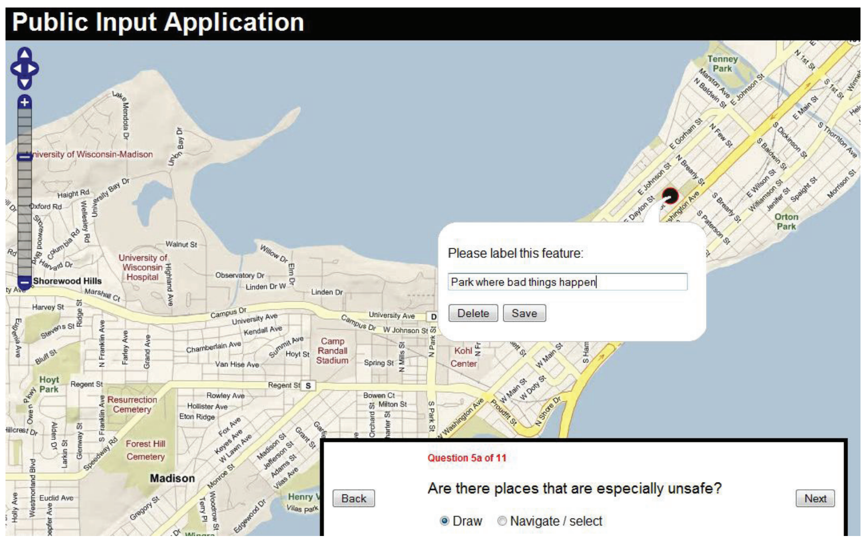
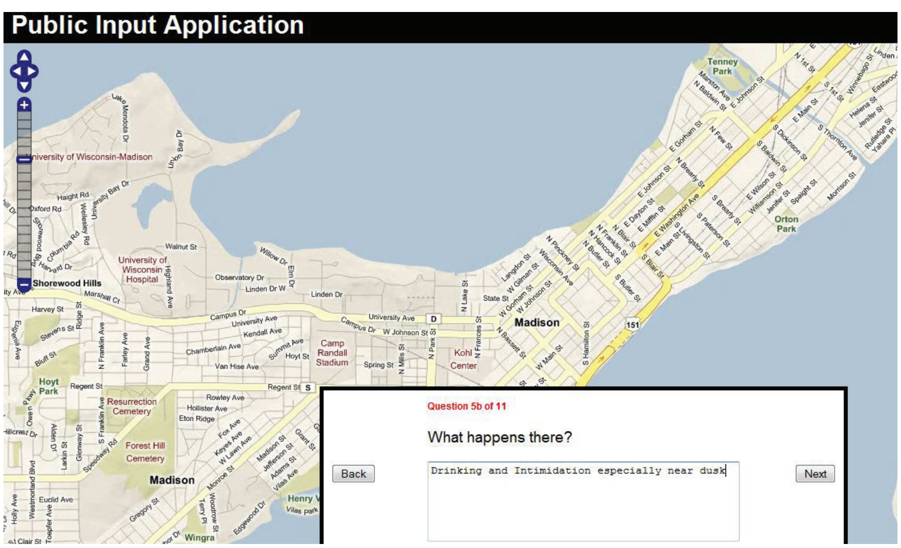


Figure 5.4: Example of Sub-questions during GeoInquiry Data Entry Application





possessed three parts, so the user would see 2a of 11, 2b of 11 and 2c of 11 (Figure 5.4) at each question prompt in the series. Consistency between questions, in terms of the interaction technique, was maintained to allow the participants to learn the structure of the survey. Repeating the format of the task (for example a point always prompted the user for a label) was intended to allow the user to become familiar with the process and to provide consistent, predictable behaviors.

The questions in this study were designed in collaboration with a research colleague in the Madison/Dane County Public Health Department to target areas of specific interest to the Public Health Community Team. During collaborative meetings organized to develop research about infant mortality the idea of contextualizing Messer's Index was proposed. To attempt to contextualize the areas highlighted in the index, I worked with Pam McGranahan—a community health specialist and public health nurse—to develop the questions that would be used in the survey. As I created questions, Ms. McGranahan would evaluate the question for its utility in public health work and would offer suggestions for improvement. Once the questions were finalized they were implemented in the system.

5.4 Usability Methods

Two distinct Usability Measures were used to assess the usability of the GeoInquiry system. The first usability questionnaire was administered in conjunction with the data gathering during the pilot study. In this case, a System Usability Study questionnaire was provided to participants at the conclusion of the data entry session. These participants did not interact with the analytical applications, instead working exclusively with the data input application for the purpose of providing substantive qualitative information to meet the goals of the case study described in Chapter 7.

5.4.1 Substantive Data/SUS Collection

The first set of users, invited from the public in three selected areas, was asked to complete the substantive data collection process first, and upon finishing, to fill out an SUS questionnaire. The SUS questionnaire was an unmodified Likert scale survey originally produced by John Brooke of the Digital Equipment Corporation and replicated by Sauro (2010). The questions that appeared were as follows (a copy of the original survey is located in Appendix C):

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

The questions corresponded to a specific scoring structure with even questions as positive values and odd questions as negative values. Once summed, the resulting score provides a measure of the usability of the website. Sauro has stated on his Measuring Usability blog that he is skeptical of the utility of the SUS method for websites, however the degree of correspondence between the usability scores for websites and applications on the SUS scale has been high, leading Sauro to conclude that the measure appears to remain a worthwhile means of evaluating usability for websites as well as applications. While this is an important point to consider, it is equally important to question the nature of the GeoInquiry system—web-based, but more more similar to the application model than the traditional web site model. Given the success of the SUS method for evaluating desktop applications, it does appear to be a valid measure for this initial analysis of the data collection module of the GeoInquiry system.

5.4.2 Formal Usability Methodology

Following the completion of the data collection efforts, I determined that a formal usability study for all three applications would be necessary to more rigorously evaluate the usability of the GeoInquiry system. The formal usability testing required two phases, a pilot study from which subtle changes to the process and website were performed, followed by a full user test. Both the pilot and full usability studies were conducted on an Intel Macintosh MacBook Laptop equipped with an external mouse to assist participants with the input devices. The usability software Silverback (www.silverbackapp.com) by ClearLeft was purchased and loaded on this computer prior to testing. The Silverback software was used to simultaneously record video and audio (image and voice) of the person participating in the study, as well as creating an account of the actions performed by the participant when directly engaged with the interface through a screen capture recording. At the completion of each usability test, the Silverback application produced a Quicktime ® (Apple Computing) video with embellishments, such as orange click "explosions" on screen to highlight each click produced by the user. These videos included a small video image of the user as well as the corresponding audio in sync with the screen capture recording for later analysis.

5.5 Research Protocol

5.5.1 Public Data Input and Simple Usability Protocol

The protocol for each participant in the public data input portion was standardized following the script in Appendix D. Each participant was provided with an informed consent protocol (Appendix E) approved by the Social Science Institutional Review Board at the University of Wisconsin-Madison at the outset of their participation. The participant was asked to sign the form to signify their consent to participate before moving on to the computer based portion of the study. If the participant had questions about the study, they were encouraged to ask them before signing the consent form. Signing the consent form involved printing and signing their full name, dating the form with the date of the study and also placing their initial near a block that indicated they were willing to allow submissions to the database be used as a direct quote in this work if necessary.

After the initial training overview described earlier, each participant was left to complete the survey without interruption, unless they asked for assistance, at which point, minimal instruction would be provided to facilitate completion. This was a rare occurrence, with the majority of questions surrounding the first question, which was used in the instructional portion of the survey. At the Kennedy Heights location, Hmong translators enabled the survey to be accessible to non-English speakers. This was necessary in 12 of the 26 surveys taken at this location. At the completion of the survey, the SUS paper form was provided to the participant to fill out with ball point pen. Once the SUS form was submitted, the participant was asked to fill out a University payment form and $10 cash was dispensed to the participant upon completion of the form.

5.5.2 Formal Usability Protocol

The formal usability study also began with the participant reading and signing the statement of informed consent in Appendix D. Each of the formal usability studies followed a standard script, found in Appendix G. Participants worked individually with the test computer to complete six tasks—two data input, two coding and two visualizing. Each participant was asked to describe their thoughts as they worked, as well as to provide feedback after the completion of each task. The duration of each of the formal usability studies varied from 25 to 40 minutes and the differences in time were largely due to the time spent on each task by the participant. Once the task was outlined each participant was left to determine when they had reached completion in an open-ended fashion.

5.6 Concluding Thoughts

The two-tiered nature of this study presents a hierarchical process whereby the study aims were carried out. The research design required two distinct user types, from three public and one professional setting. The research entailed two distinct phases—(1) data capture and SUS, and (2) formal usability measures starting with a pilot and culminating with in-depth, recorded studies with expert users. Results and discussion of the user tests will be reported in Chapter 6 with a discussion of the system use and case study findings in chapter 7.

Chapter 6—GeoInquiry Usability Testing

"The most common user action on a Web site is to flee."
- Edward Tufte

This chapter describes the results from 84 data collection sessions conducted in three neighborhoods in Madison WI, and 12 usability sessions conducted at the University of Wisconsin-Madison and the Department of Public Health in the City of Madison. These usability measures are intended to provide input about GeoInquiry that improve the system, preventing users from ultimately following Tufte's lead and fleeing the GeoInquiry system. The usability testing of these modules occurred in inverse order to standard usability studies. The data collection module was deployed prior to formal usability testing and subsequently, the entire suite was subjected to a rigorous usability study in the vein of Andrienko et al (2002), Bhowmick et al (2008), Haklay (2006), Haklay and Tobon (2003), Kuniavsky (2010) and Robinson et al (2005) . The inverted order was the result of a late modification to the research agenda. Initially, I postulated that a simple SUS (System Usability Study) would result in sufficient information about the usability of the interface(s). Additionally, usability was not a major focus of the proposed study. However, following the data collection effort it became clear that in light of the SUS scores (reported later this chapter) there was a need for more rigorous testing. Both the simple and robust usability results will be presented below, along with discussion of the results. The robust usability sections will be broken down by module: data entry, coding and visualization.

6.1 About System Usability Scoring (SUS)

SUS scores are presented in this chapter both as the overall composite score as well as the component parts making it possible to unpack the issues and analyze the usability findings. The composite SUS scale is a 1-100 scale, with higher scores representing a more usable system. Sauro (2010) notes that a SUS score is not a percent usability measure, but rather is a numeric indicator of usability. Hence, a SUS score of

68 would indicate that a system is average in terms of usability, roughly more usable than 50% of systems and less usable then the other 50% of systems. Therefore I will use the score of 68 to indicate that a system is baseline usable; below this value the system would be declared unusable. SUS has been shown to discriminate well between systems which have poor usability and those that are considered usable (Bangor, Kortum and Miller 2008; Brooke 1996), therefore it is a useful measure for analyzing the usability of this system.

The overall SUS score is made up of ten individual questions. On a SUS questionnaire, odd numbered questions represent positives about the system while even numbered questions represent negatives. The scoring mechanisms demonstrate the positive and negative aspects of the questions. For odd numbered questions, they are scored as x (the value,1 though 5, provided by the respondent)-1, while for even numbered questions they are scored as 5-x (again, the value provided by the respondent, 1 through 5). Hence, the higher the score on the odd numbered questions, the more usable the system is with regards to that questions. Likewise, the lower the score for the odd numbered questions, the higher the usability factor. The component scores are then summed to get the overall SUS score.

6.2 Usability Findings for the Data Entry module

The usability findings for the data entry module are presented in two distinct forms. First, a simple SUS score is used to present the usability findings from the 84 public data contributors. These scores were collected at the conclusion of a 30-minute data collection exercise and are the only measure of usability of the interface obtained from these participants. The second set of usability findings were procured during a formal usability study conducted with 11 participants who interacted with all three GeoInquiry modules. For the purposes of discussion, these usability findings will be presented by the site of collection to allow for discussion of the peculiarities of each site.

6.2.1 Usability and User Acceptance Pilot Testing

At the completion of the design and programming of the GeoInquiry system a very small pilot test was run. Three participants—a cartographer, a public health community researcher, and a market research analyst—were asked to use the input system, answer the questions in the survey and provide feedback about problems and areas for improvement. Each participant worked at their own pace and described their thoughts and opinions about the tasks as they completed each question. The SUS measure was not administered during these tests—though I would ensure that a SUS measure was taken in future pilot studies, as this was a missed opportunity to acquire early usability values. Instead of the SUS measure, participants were asked to give verbal feedback. The general message from the participants can be summarized as "the system had potential, both as a general system and for public health applications and beyond." The controls were described as "simple as they could possibly be implemented" by one participant. These three pilot tests gave the impression that the system was ready for the larger tests and data collection efforts.

6.2.2 Usability of the Public Module

The overall SUS scores for the three public test sites are shown below:

Kennedy Heights	61.63
Urban League	72.27
Holt Commons	78.03

The range of scores is in line with my expectations for a newly developed system such as GeoInquiry, though the relatively low scores, specifically in Kennedy Heights, are surprising in light of the positive response from the pilot test. Based on these overall scores, the Kennedy Heights population found that the system was largely unusable, with potentially severe problems using the system. Conversely, the Urban League participants and the Holt Commons users found that the site was more usable than a majority of websites. These differences are not alarming, especially when we consider the demographic differences between the three sites as discussed below. In none of the three cases do the SUS scores reach the target of 80, the score at which the website is considered more usable than 90% of websites, but this is not troubling given the integration of a map within the system and the alpha nature of GeoInquiry.

While it is not standard to analyze the ten component scores that make up the overall SUS score, the differences in the SUS scores between the three sites, coupled with a lack of qualitative data captured during the testing, made an analysis of these scores useful to attempt to understand the differences in the overall SUS levels. For each site discussed below, the component scores and the composite score will be presented for reference.

6.2.3 Discussion of SUS Results and the Case Study Procedure

The following sections describe the setting, constraints and the component SUS scores at each of the three public user testing locations. Each section details the SUS component scores to illustrate the differences in the usability perceptions among the public users of GeoInquiry.

6.2.3.1 Holt Commons

The Holt Commons testing site was located within a food service commons near the Lakeshore dormitory area on the UW-Madison campus. The physical site was located in the entryway of the food service facility and could only accommodate three participants at one time at laptops provided by the researcher. This setting is the typical

SUS Question	Score
I think that I would like to use this system frequently	3.67
I found the system unnecessarily complex	1.79
I thought the system was easy to use	4.24
I think that I would need the support of a technical person to be able to use this system	2.1
I found the various functions in the system were well integrated	3.91
I thought there was too much inconsistency with the system	1.58
I would imagine that most people would learn to use the system very quickly	4.27
I found the system very cumbersome to use	1.88
I felt very confident using the system	4.06
I needed to lean a lot of things before I could get going with the system	1.61
Overall SUS Score	***78.03***

Figure 6.1: System Usability Score Components for Holt Commons

location for outside groups seeking time and input from students within the commons area, and while not optimal for testing, was highly visible to students entering the commons for food, mail and other activities.

Table 6.2 shows the SUS scores, broken into component and composite parts for the Holt Commons participants. Overall, the score was very strong at this site. The participating students all demonstrated comfort with both the computing environment and the mapping components of the GeoInquiry input system. As the first testing site, this was encouraging. The overall score was very close to the score of 80 identified by Sauro as representing a site more usable than 90% of existing sites—a very strong SUS score. This reinforced the idea that the system provided a simple and usable environment to collect map-based data—especially with a technically-adept population.

6.2.3.2 Kennedy Heights

The Kennedy Heights testing site was a narrow hallway in the Kennedy Heights Community Center. Four people could participate at a time via researcher provided laptops. However, the nature of the testing location did not allow participants to sit, rather they were required to stand at a shelf near the end of the hall while interacting the the GeoInquiry system. The available space made for less-than-optimal testing conditions, however the payment provided to the participants encouraged people to wait for both an opportunity to participate, as well as to stand throughout the test.

One constraint that was not anticipated at the Kennedy Heights location was a language barrier. Twelve of the twenty-six participants spoke only Hmong. Fortunately, the community center had a Hmong-speaking staff member who was willing to assist throughout the testing process. Providing translation and guidance to Hmong-speaking participants enabled the data collection to proceed with a group of people who otherwise would not have been able to complete the study. The language barrier was problematic however when entering the neighborhood polygon for question 1. Many users didn't commit their polygons to the database due to the double-click required to submit the polygon to the database. The need to translate the instructions in order to complete the task made assessing this problem difficult. It was unclear if this missing data was due to the participant misunderstanding of the on-screen instructions to double click after completing the polygon or if there were other problems with the polygon submission.

SUS Question	Score
I think that I would like to use this system frequently	3.54
I found the system unnecessarily complex	2.54
I thought the system was easy to use	3.46
I think that I would need the support of a technical person to be able to use this system	2.88
I found the various functions in the system were well integrated	3.27
I thought there was too much inconsistency with the system	2.15
I would imagine that most people would learn to use the system very quickly	3.92
I found the system very cumbersome to use	2.69
I felt very confident using the system	3.54
I needed to lean a lot of things before I could get going with the system	2.81
Overall SUS Score	***61.63***

Figure 6.2: System Usability Score Components for Kennedy Heights

The SUS scores for Kennedy Heights (table 6.3) differed considerably from the scores at Holt Commons. In particular, the negative scores were much higher (often 1 point higher), while the positive scores were somewhat lower. These scores are difficult to take at face value due to the challenges posed by the setting, the language barrier for roughly half of the participants and the presence of the paid incentive. The contradiction in the component scores was also perplexing. The highest positive score indicated that people would learn to use the system quickly, however the highest negative scores were on the items about (1) the need for assistance from a technical person, and (2) the need to learn many things to get going using the system. These scores seem to be at odds and made the interpretation of the scores much more nuanced, as discussed in the summary below.

6.2.3.3 Urban League of Greater Madison

The Urban League setting was by far the most amenable to testing the system. The setting was a modern computer lab with dedicated desktop computers at each workstation. A maximum of fifteen participants were able to complete the testing at a single time. The Urban League offers vocational training at this site and some usability participants were enrolled in on-site classes that included computer lab access (during class). The constraints at this site were minor compared to the previous two sites. The biggest challenge was the geographic distribution of the participants' homes, which was not limited to the neighborhood in which the testing occurred, but rather ranged across Dane County and Madison. Also, many of the participants were at the Urban League to receive computer training for job skills, which made this population more adept with computers in general than the population at Kennedy Heights.

SUS Question	Score
I think that I would like to use this system frequently	4
I found the system unnecessarily complex	2.32
I thought the system was easy to use	4.32
I think that I would need the support of a technical person to be able to use this system	2.64
I found the various functions in the system were well integrated	4.1
I thought there was too much inconsistency with the system	1.36
I would imagine that most people would learn to use the system very quickly	4.27
I found the system very cumbersome to use	3.14
I felt very confident using the system	4.14
I needed to lean a lot of things before I could get going with the system	2.45
Overall SUS Score	***72.27***

Figure 6.3: System Usability Score Components for Urban League of Greater Madison

Table 6.4 shows the SUS breakdown for the Urban League testing population. The negative scores here were higher than at Holt Commons, but lower than at Kennedy Heights. Conversely, the positive scores were actually higher than at Holt Commons, though by a smaller margin than the difference between the negative scores for the sites. The scores for the questions "interest in using the system frequently", "ease of use" and "confidence with the system" are encouraging given their relatively high values. Part of the low score to the "cumbersome" point on the SUS may be from the repetitive nature of the questions, which did elicit a discussion from participants as to "why are they asking this again!?" on three occasions. These positives are encouraging and will be discussed in the next section.

6.2.3.4 Overall Findings

Overall, the three public input sessions yielded good data as well as a sense that the data input module successfully collected qualitative spatial data in a community-based setting. Most users indicated that they would like to continue using the system—perhaps with different questions and inputs to allow for more personally relevant data to be collected. The strong SUS scores for an alpha implementation also are encouraging. While these scores do not hit Sauro's score of 80, they are in general above the score indicating that the system is generally unusable. With language support built into the system, it is likely that the Kennedy Heights score would improve as well.

Despite the general positive testing results, there was room for improvement. Some difficulties with the system included completing a polygon for question 1. While a basic task in a GIS environment, the participants had no experience with GIS and minimal experience with even basic Internet mapping, which made the concept of double click to complete a polygon a foreign idea. As described earlier, the lack of mapping experience coupled with the language barrier contributed to difficulty in completing neighborhood polygons. The failure of the pilot test to identify this problem may have resulted due to the familiarity each of the participants had with geographic information—much higher than would be expected in the the general population. For example, the double click to end the polygon was not foreign to the pilot users, therefore this didn't register as a potential problem. Additionally, the Hmong population had the least success with the double click—a fact that is likely due to a difficulty providing instruction that could be effectively translated to the participants.

Other basic mapping operations proved initially challenging in the testing environment for the public users. When answering a question that required the user to place a point on the map, a prompt to label the feature was automatically displayed. To complete the submission of the point the respondent was required to hit the "Submit" button in the popup box. This submit action was repeatedly ignored in favor of the "Next" button at the end of question, resulting in a loss of the label data. Another difficulty was maintaining a basic understanding that multiple features could be added for most questions. Most users would ask for assistance before adding multiple points out of concern that such an action was not acceptable. This observation leads to questions as to the possibility that other users chose not to add multiple points, but also did not seek guidance about the possibility of doing so either. Again, these concerns could have been addressed with a more representative pilot test population and are easy to correct through improved directions.

The last observed use problem involved the user keeping track of the relationship between the sub-questions and the main question (i.e. Question 4b's relationship to question 4). On multiple occasions in all three testing sites users would ask for assistance to remember what the primary question asked. After this occurrence was observed in all three locations, it became apparent that in subsequent iterations of the system, the major question would need to remain on screen in addition to the sub-questions to facilitate a sense of relationship between the questions. A "bread crumb" trail providing the user with a quick visual cue illustrating where they are in the survey and how the current question is situated (main question vs sub question) would be an area for improvement.

These issues are not major challenges. Rather, reprogramming the input module to improve the following three areas should result in major usability gains. The three improvements proposed to be implemented are:

> 1: Creation of a robust help menu available during use of the system to assist users who are unclear with the process to initiate or complete an action.
> 2: The development of sample, practice questions before initiating the official survey. These sample questions will allow the user to orient themselves to the tools and begin the process of overcoming the learning curve associated with the system.

3: Ensuring that the main question remains visible throughout the sub questions to avoid confusion as to what the sub question is referring to.

6.3 Usability Results from Formal Usability Studies

In this section, the results of the formal usability testing of the Input module of the GeoInquiry suite will be detailed. As described in chapter 5, eleven people participated in in this portion of the usability testing. Each session was recorded in multiple forms and the recordings were later analyzed to both summarize the session and to collect further data beyond the observation during the session. Each of the three modules—Input, Coding and Visualization—was tested individually and the results for each are presented independently.

6.3.1 Findings from the Usability Study of the Input Module

The first module tested was the data input module. The informal SUS measures described earlier highlighted both minor and potential problems with this module. The formal usability study described here was used to understand the usability of this system in greater detail than was available with the SUS measure.

Many of the participants in this portion of the study had at least some experience with GIS and all acknowledged experience with online maps. This familiarity with map-based applications and web sites did not appear to aid the users in their initial exploration of the module—leading to the development of a number of suggested improvements. A common theme from each of the tests was the time required to become comfortable with the system. In each case, the initial input question was followed by a “feeling out” process to understand how the system would react and behave. One participant noted that the data input was “easy, once you had some experience with it and with some guidance.” This comment was echoed by others and further reinforces the notion that a training sequence ahead of the testing module would orient and benefit the user.

There were some issues highlighted that create challenges with an online system. Despite the high level of map use experience, participants found the drawing challenging. Some participants commented that the “drawing was clunky.” This issue was illustrated by minor drawing tasks proving confusing on the first pass. Creating curved shapes with multiple points and adding nodes was a source of frustration as users articulated that using multiple clicks to add multiple points was cumbersome to execute. Some users felt that a free-form drawing tool would make the process easier for users to complete over the click to add a point method. Closing the polygonal shapes with a double click was also challenging, despite the instructions in the question box to double click upon completion. Many users acknowledged that they did not fully read the instructions, but rather engaged the map immediately and only sought further instruction after encountering problems. Panning the map to find the desired area was a challenge for users, despite the users’ high level of experience with online maps. This was especially surprising as the panning tools were modeled directly after common online mapping systems such as Google Maps, Yahoo Maps and Mapquest. A consistent request was for a detailed help system, which is now under development.

One user commented that “non-technologically savvy users will likely struggle with this. I think that they would find a paper map would be much easier. I know that I would.” This comment was especially worrisome during analysis. Considering the initial hesitation of many of the public survey participants, it seems as if online data input with a geographic focus can be especially daunting for participants. Even the technologically adept participants appeared at least initially uncomfortable with the module. This was surprising given their experience and the simplicity of the design of the module. As a result of these observations it has become apparent that the system should offer a dual input model depending on the setting—both the input system as currently configured, as well as a method to enable users to use a pencil/paper map as the input.The users also commented frequently that they felt the system was interesting and that they could see uses in their own domains of interest. Almost all of the participants commented that once they had learned the input tools they felt comfortable answering additional questions. Further, these users felt strongly that the system could yield good data in applied settings, especially with the inclusion of both a help system and a free form drawing tool for polygonal inputs.

The formal user testing led me to make two improvements to the input system in addition to the suggested changes from the public testing mentioned above. First, the inclusion of a free form drawing tool to make the input easier for users to contribute and to prevent the frustration some users felt from adding each individual node for large and complex polygons. This free form drawing tool mimics pen style drawing, as opposed to a click based drawing method.

Second, the online system appears to be preferable as a data gathering technique if a trained technical person is on site during the data gathering to provide support throughout the data collection period. Unfortunately, this leads the GeoInquiry system back towards the mediated nature of PPGIS, but without either a highly motivated user or a strong support regime, it is likely that the input module would not be used to gain effective results.

Another recommendation is to develop a paper-based input device, one that could work in conjunction with the current data input system and could also load into the analysis side of the system. Fortunately, this type of paper input is already under development. A team at the University of California-Berkeley has developed a system called LocalGround (Van Wart, Tsai and Parikh 2010) that provides paper maps to respondents, who in turn draw annotations on the maps in response to a question or focus. The maps are then uploaded as raster images to a central server where the contributed shapes are separated from the base map and converted to KML (Keyhole Markup Language). Unfortunately, the KML files are currently a raster version only, which is problematic for using these files in the analysis modules because the individual features are not stored as separate entities for coding. Despite this shortcoming, initial conversations with the lead developer of LocalGround have resulted in implementing a copy of the LocalGround system software on the same server as GeoInquiry for subsequent testing. Modifications to the LocalGround setup in terms of automated vectorization of the KML features could in turn be loaded into the PostgreSQL database for consumption by the GeoInquiry analysis side modules (Coding and Visualization). This development will continue as a future enhancement to the GeoInquiry system beyond the completion of this work.

6.4 Usability Findings for the Qualitative Spatial Coding Module

The usability findings of the coding and visualization modules were produced from the formal usability studies. The analysis modules were not tested with the public users but instead were tested only with the invited usability test participants. Public users were not tested as they are not the initial target audience for coding and visualization within GeoInquiry. Rather, these modules are expected to reside predominantly in the researcher domain. The next two sections will detail the findings from the formal usability study with respect to the analysis modules.

The coding module shown in figure 6.4 was tested with all eleven participants. The participants were asked two different questions and required to perform two coding tasks in response. The first question, asked of the 84 participants in the

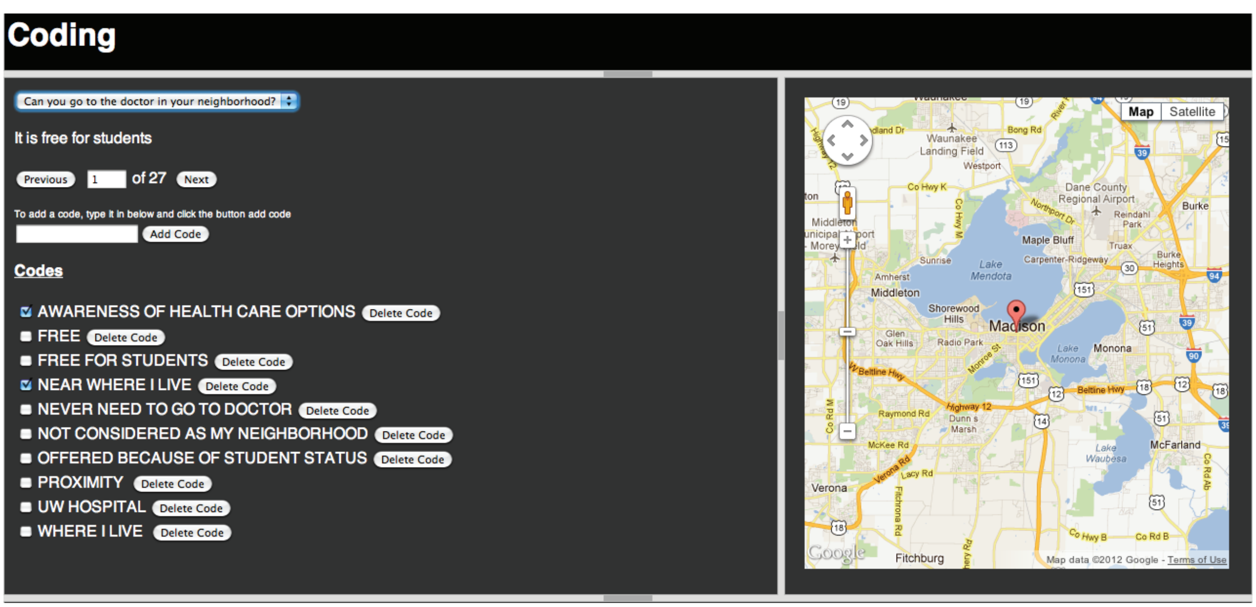


Figure 6.4: Screenshot of the GeoInquiry Coding Module

community study, was "Can you go to the Doctor in your neighborhood?" A sub question asking to contribute the location where the respondent visits the doctor followed the initial question. In this instance, the participants were asked to apply primary codes to the responses provided by the 84 public input users. Each response consisted of the text description entered by the subject describing why they visit their particular doctor, the location submitted on the map (in response to the question "Where do you go for healthcare?") and the tools to add or delete codes for use in the analysis of the question. Usability test participants could apply any code they felt appropriate to each entry and could cycle through the list multiple times to iterate the coding effort to ensure consistency.

The second exercise asked the participants to perform a task envisioned to be akin to secondary coding. Upon entry the code list was already defined and codes applied. In this case the question posed was "How do you get to the doctor?" and again the map and text response were available for inspection by the user. In both testing situations the codes were re-set prior to commencing each test to ensure that the participant was not influenced by other responses and codes provided in prior tests.

6.4.1 Response to Coding Module

The overall response of the participants to the coding module was positive. "Easy to use" and "a great idea" were two of the general comments made by respondents after the conclusion of the testing sessions. There were also many suggested improvements, which can be broken into two categories: superficial (meaning interface layout and subtle design changes) and functional (meaning suggestions for reorganizing the module to match the qualitative coding process).

Many of the superficial changes suggested were consistent between respondents. For example, changing the coding module to order the codes alphabetically, rather than by the order of entry was a repeated suggestion. As one respondent said, "Alphabetical order will make it quicker to find the code and to evaluate similarity between codes."

Other layout changes included reordering the “Previous” and “Next” buttons (Figure 6.6), moving the “On” and “Off” checkboxes for the codes from the right side of the entry to the left side of the entry, automatically turning a checkbox on when a code is added and adding a delete button to each code, rather than requiring a user to type in the code that they want to delete. This last change required adding extra pop-up dialog boxes to verify that the user wanted to delete a code, both to prevent unintentional code deletion from occurring and to ensure that the ability to delete a code remained cognitively challenging, insofar as the user could not quickly hit delete without some form of effort required to confirm their intention.

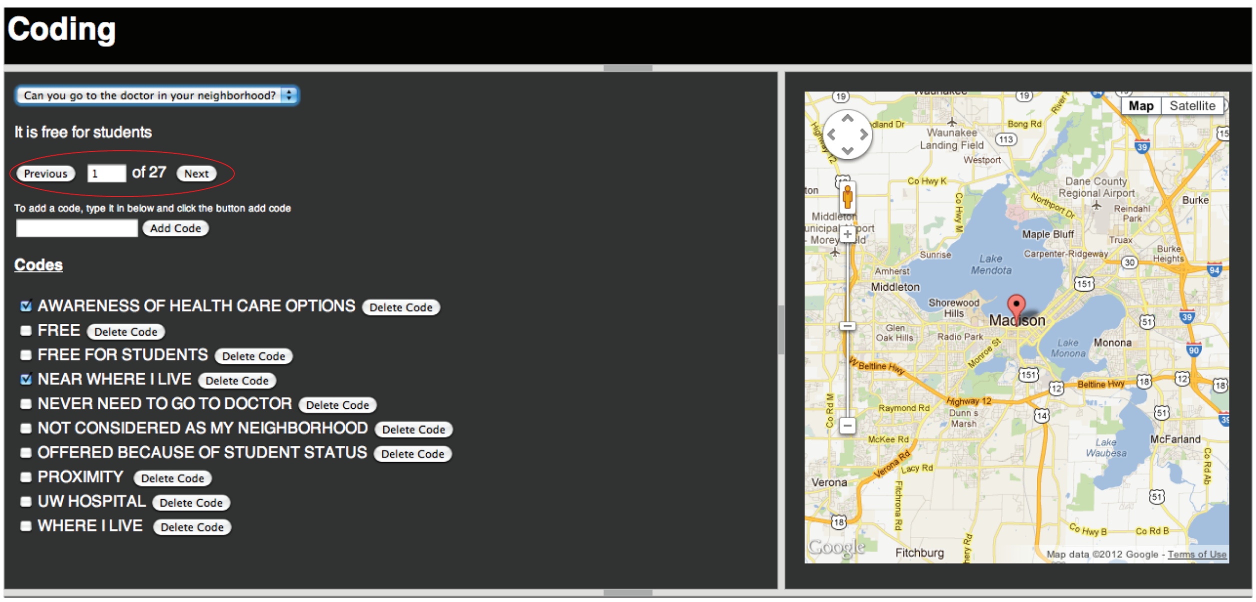


Figure 6.5: Screenshot of the GeoInquiry Coding Module with proposed modifications to navigation buttons

The functional changes resulted in a redesign of the coding module. Initially, the coding interface consisted of a single module that would allow users to add codes and then revise the codes supplied from a previous session. In the user test, the four most experienced coding participants argued that the code revision portion was problematic. Two of the testers indicated that they have never revised another coders’ entries, and they felt this was a problem for the module, as it is not standard coding practice. To solve this problem the users suggested a few changes, including splitting the coding module into two sub-modules, and preferably three. The first of these new sub-modules would consist of everything currently in the coding module, but each user would have an individual login restricting the visible codes to those added by that particular user. Codes produced by others would be hidden from the new user. The second sub-module would be very similar to the first with one major exception, adding codes would be disabled, as the secondary coding sub-module would only allow the users to check or uncheck codes from the final list. The testers felt that this split would not only ensure consistent application of codes to the question, but would also ensure that the independent nature of the coding effort would be maintained, and allow for intercoder reliability to be verified.

The intercoder reliability question led to the design of a third sub-module that is situated between the primary and secondary coding sub-modules. In the intercoder sub-module, the individual entries are still displayed in map form, but the list of codes from each of the coders is presented. This sub-module allows all of the coders to see the spatial and textual entry, and to verify the consistency between the coders themselves. This intercoder sub-module also allows the coders to add "final codes" that are agreed upon during the process. These final codes are the codes that are locked into place for the secondary coding sub-module. These changes required the original coding module to be migrated from a single module to three successive sub-modules. This split also required re-engineering the underlying database structure to capture user/code pairs for each question to facilitate both the initial coding and the intercoder reliability sub-modules.

The usability testing also uncovered one challenge that was somewhat unexpected. Multiple testers admitted to having an "aspatial focus" when coding the initial data. When questioned at the end of the exercise, these testers admitted that they had not used the map provided with the text entry at any point during the coding process. In fact one user admitted she "didn't see the map when coding" despite the map's prominence in the interface (taking up the right half of the screen). While it was not unexpected that the map would not take prominence in the minds of experienced coders given its novelty, it was unexpected it would be "unseen." Although a concern, it seems as if the presence of a map is indeed novel in the coding process. As such, it is paramount to articulate two goals when deploying this application suite. First, it is important to capture and highlight the spatial character of space and place to facilitate analysis within the system. And second, offering a detailed training screen prior to entering the system where the map is prominently described may help to orient the user to its presence and its potential to aid understanding of the context included with the qualitative descriptions submitted. Ultimately, the possibilities of this form of map-based qualitative coding may require case study applications where the methodology can demonstrate its potential as a tool for qualitative inquiry.

6.5 Usability Findings for the Visualization Module

Following the usability testing of the coding module, the participants were asked to complete two tasks using the visualization module. The visualization module shown in Figure 6.7 consists of a drop-down box to select the dataset of interest (typically in the form of the question posed to the respondents), a map showing all of the submitted

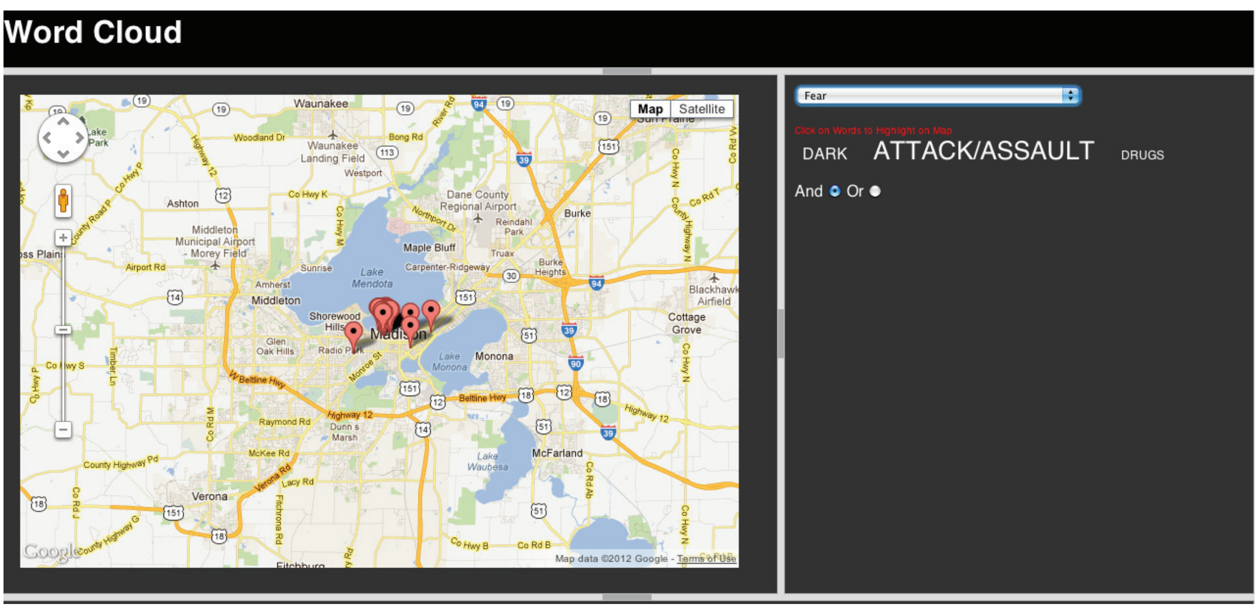


Figure 6.6: Screenshot of the GeoInquiry Visualization Module

points and an interactive code cloud showing the frequency of the code symbolized by the size of the word in the cloud. While word clouds have received some poor press, called the “mullets of the Internet” by one author (Harris 2011), the use of the word cloud style to provide a visual cue as to the frequency of the code was highly effective. Eight of the eleven testers said they appreciated the visual nature of the code cloud to provide a summary of the frequency of the codes.

Like the coding module earlier, the code cloud usability testing revealed improvements of both the superficial and functional aspects of the visualization module. While there were fewer improvements suggested for the code cloud, the findings are important to improve the usability of the module. In the testing module, the points on the map did not provide any information when clicked. This was repeatedly mentioned as a major flaw of the module. Testers commented on multiple occasions that they wished to be able to click on the point to see the universe of codes assigned to that point—either in a popup using typical Google Maps style or in a window below the code cloud interface outside of the map framework. Additionally, a robust help system was requested to reassure the user that they could receive help at any time. The help system for all of the modules is still under development but is seen as critical prior to a full release of the system.

Functionally, the most challenging technical change suggested was to have the word cloud redraw based on the visible points. The ability of openLayers to utilize a window function made this change straightforward. Further, the analytical nature of the system improved substantially by making the cloud dynamic to allow a more detailed geographic comparison of the assigned codes beyond what can be obtained through the interactive nature of the code cloud. The most difficult design suggestion to implement was to provide color coding to the points based on selection. This proves challenging due to the ability to select multiple codes and the potential overlap of codes between points. For example, selecting three codes to inspect requires a minimum of seven

colors to represent the three independent codes along with the four overlap scenarios
present. Selecting four codes would cause the visual nature of the color scheme to become unwieldy with a need for a qualitative scheme beyond nine colors, posing problems (Brewer, Hatchard and Harrower 2003). Therefore, color coding the points has not been implemented in revisions of GeoInquiry at this time.

The usability testing shows that the use of the code cloud can provide analytical power that can aid the analyst in understanding the geographic nature and patterns of distribution of the codes. By removing the code cloud from the map and implementing it in a component adjacent to the map, the code cloud offers interactive functionality not available in other applications such as Slingsby et al's (2007) tag cloud maps. While Slingsby's team possesses the ability to facilitate quick visual identification of the code at an individual point, the lack of interactivity with the cloud on the map make it potentially a source of visual clutter—something avoided by removing the cloud from the map itself.

6.6 Discussion

The SUS results from the public users creates an interesting contrast to the findings from the formal usability study. The overall SUS results show that although the entire system is more usable than 50% of all web systems, it still needs some adjustments, which is not surprising for an alpha system. In light of these SUS findings, the datasets were analyzed both in the web system and within a GIS environment to ensure that any limitations in the system did not affect the data analysis, as well as to match the proficiency of the analyst. Unfortunately, the data capture had no redundancy (for example, writing the results of each click to a local data file in addition to the server database) built in, so instances where the system usability was problematic, such as polygon completion and point labeling, were carried forward into the analysis portion of the study.

The lack of redundancy is a critical weakness of this system in its current state.

The entire conception of the system was intended to be simple to use—a goal that while not completely achieved, is very close to being met. Small tasks, such as double clicking to complete a shape, or failing to deactivate the "Next" button until a label was entered, resulted in lost data and potentially more dissatisfaction with the system. Another improvement to be implemented is a help system loaded in the system. A paper based help provided with the terminal in use would be a good first step. However, a graphical and interactive help system could be of even greater use. While it didn't appear significant during pilot testing, further development of this system will certainly prioritize a graphical help system. Developing a robust graphical help system would be a good start to supporting tasks like polygon creation, point labeling, placing multiple points when asked about locations and supporting inexperienced users of maps on the Internet. In fact, this lack of map use experience would likely be best addressed in the form of a short interactive tutorial at the start of the survey—short enough however to avoid placing undue burden on users who will already answer nearly 35 questions.

Despite the minor shortcomings presented in the SUS data, there is much that is positive. To begin, the SUS scores, with the exception of Kennedy Heights, were all above the 50% usability value of 68—indicating that each of the modules was usable in the present form. These usability numbers indicate that the data collected comes from a strong position of reliability. Essentially, the users were able to use the system effectively to answer the majority of the questions. And problems such as missing labels for points are not critical to understanding—in fact during analysis the name of the points was not missed until questions arose around a single healthy food location and an interest in the name of the establishment.

While there are a few weaknesses in the alpha system, they are far outnumbered by its strengths. Users did not appear to have difficulty placing points on the map. As they became familiar with the system, they began to show more confidence, indicating that the repetitive nature of the tasks increased understanding of best practices while using the system. Another strength is the lightweight architecture. The system can be deployed and modified through some simple text-based changes. In fact, new deployment requires no new code to be written. Public health experts described the ease of coding, along with the combination of map and code cloud, as strengths. Multiple public health participants mentioned that they could see numerous uses in their community-based research—from safe walking programs to understanding community concerns about violence and crime. Ease of use and the simple, clean interface were also mentioned as strengths. In both community use and research use, the lack of extraneous tools made it easier to begin using the system. As mentioned by the web site 37signals, giving users only what they need and nothing more, makes the system easier to navigate and doesn't inundate the users with multiple options that only serve to confuse most users (or are largely ignored) (37signals.com 1999).

Ultimately, the case study results do not appear to be negatively impacted by the SUS findings, beyond the problems at the Kennedy Heights location largely around language barriers to the system. While the entire GeoInquiry system has room for improvement and future enhancement to make the system stand alone and provide high quality independent submission and analysis, it is strong enough in this alpha implementation to provide data that can be used for understanding not only questions of health and place, but potentially any question with qualitative, spatial data.

6.7 Usability Findings Informing Future Work

Despite the use of a lightweight web interface, the idea of a truly open GeoInquiry system is still to be developed. Participants outside of the university asked more questions about how to use the system than their counterparts on campus. This confusion led to one person abandoning the survey at Kennedy Heights, due to a lack of confidence with a computer and an accidental reset of the module three times. While the intention of the design was to function outside of a research setting, it appears that significant community education and organization would be required to facilitate independent and recurring usage. However, it is likely that significant organizing would be required for anyone to engage with this system regardless, so this is not a major concern. Removal of the survey component could encourage further use, likely by demonstrating how to contribute information in an unstructured environment. Similarly, free form data submission could be easily adopted for numerous uses.

To ensure the long term value of the system is realized it is clear that the system will need to be used in conjunction with a well-defined research goal. As a stand-alone laissez-faire data input system, it is unlikely to be sustainable, as this type of system works best around a focused purpose. It was hoped that the construction of the system in this manner would help facilitate the submission of data from dissenting voices as mentioned in chapter 3. GeoInquiry does not aggregate the submitted data, allowing all perspectives submitted to be observed during analysis. This in turn offers the opportunity to see the crowd-sourced or dominant themes, while at the same time retaining the character of any individual dissenting perspective. At the present time, the need for community organizing brings this model of GeoInquiry closer in scope to more traditional PPGIS practice, just without the use of a formal GIS, ultimately making this method more accessible. If the GeoInquiry system is used in lieu of a GIS, this may be an issue for participants. As Elwood (2009) pointed out in her study of Humboldt Park, participants wanted to use the full scale GIS because that was the tool of the powerful. Participants in Elwood's experience were resistant to the idea of using online maps, as they could be seen to be less authoritative. However, the ability to combine GeoInquiry input and analysis with GIS renders this a non-issue.

The flexibility GeoInquiry provides in terms of input, analysis, visualization and variety of responses captured, allows for wide adoption in many areas of interest. The lightweight web browser design is quickly modifiable for either different survey questions or a free form, survey-less deployment. Also, the analysis modules provide a low barrier to entry for qualitative spatial data analysis—analysis that is difficult to facilitate in the most robust of GIS. The pathways for future research and development on this system are numerous, both in terms of technical changes, as well as developing new substantive research questions in both health and non-health spatial research.

The combination of methodologies such as the LocalGround framework for data capture may offer a strong complement to the GeoInquiry system developed here. The data input side of the system is the most challenging from a user perspective, with even formal usability participants showing far greater indecision and hesitancy about interacting with the input module. As mentioned earlier, migrating the input to a paper-based format in the beta version may help to overcome this discomfort and enable a rich data capture system. The analysis portion of the system showed potential throughout the usability study. Participants commented frequently that they liked and appreciated the use of both the coding and visualization interfaces. The simplicity of the two modules were considered pluses. The changes to the coding module, moving from a single module to three separate sub-modules is the most dramatic change prompted by these usability studies. By bringing the coding in line with qualitative coding practice, the module has potential for wider adoption. The key challenge going forward is fostering both an interest and understanding that the "where" can be a powerful aid in understanding. One participant commented "Where is only important in context of the person's geography" and GeoInquiry can both provide the where and the context to understand the submissions in a wider personal geographic structure. Combining the web-based framework with the ability to export all of these data to a GIS enhances the analysts' ability to understand both the context and the content of these data.

The next chapter describes the application of GeoInquiry to a small case study that sought to provide context to a public health question in Dane County WI. This case study provided the opportunity to deploy GeoInquiry in a full data gathering environment and to both collect and analyze data that were outside the "toy" data (prepared data to demonstrate statistical techniques) commonly used in testing environments. Using GeoInquiry in an analysis setting where the results would provide substantive contextual information to an ongoing study demonstrated the usefulness of the system.

Chapter 7—Capturing Context: Implementing GeoInquiry to Contextualize the Social Landscape of Health in Dane County WI

Social Epidemiology, as discussed in Chapter 2, has a standing interest in developing and describing the context around health issues. In this chapter, GeoInquiry is deployed with the goal of uncovering context that is missing in a social epidemiological deprivation index. This chapter begins with a discussion of context in health studies, both in terms of the theoretical value of contextualizing health information and reiterating the current state of efforts to add context in health studies, primarily from social epidemiology and health geography. Building on previous work pertaining to context in the literature, I will briefly describe the decline in the black infant mortality rate in Dane County WI. From this background, the use of a quantitative deprivation index to contextualize a study of infant mortality, and its apparent problems will be articulated. The potential of GeoInquiry to supplement and enhance this quantitative index will then be discussed, followed by a detailed description its implementation to capture context from three areas of high deprivation in Dane County. Finally, the results of this deployment and data capture will be presented along with spatial statistical findings from these data.

7.1 Context in Health and Place

Adding qualitative spatial context to any research question is a strength of the GeoInquiry tools. Capturing, analyzing and visualizing contextual qualitative information adds detail that is missed by purely quantitative methods. To properly frame the case study that follows, it is important to briefly discuss the research history surrounding context in studies of health and place.

Social epidemiology has a long history researching context and its oppositional term composition, using both as explanations of small area variations. Composition refers to the differences in the kinds of people living in a place, while context is the differences between places. A good example of the differences is articulated by

MacIntyre and Ellaway (2003) who state that composition says “the poor will die equally everywhere”, while context says “death rates vary based on the area someone lives” (p. 24). Basically composition is based on the individual and context is based on the area. Because of these differences, composition has prevailed as the main focus in social epidemiology (Macintyre and Ellaway 2003). Context has been regarded as insufficient to explain health differences, and the development of indices has been a major method for understanding the composition of an area (Krieger et al. 2003; Macintyre, Ellaway and Cummins 2002; Messer et al. 2006). MacIntyre and Ellaway (2003) posit that very little research has occurred explaining the influence of local contexts on health, however Kawachi and Berkman (2003) argue that the compositional-contextual dichotomy is an oversimplification. MacIntyre reinforces this by stating that “people make places and places make people” (2003 p. 26) indicating a false division between the compositional and contextual. In MacIntyre and Ellaway’s view, a multilevel approach is prudent—one that can evaluate neighborhoods for: (1) shared physical features, (2) availability of health environments for work, play and home, (3) support services, (4) sociocultural support, and (5)the overall reputation of an area-often based on perception. Based on this framework, GeoInquiry is well suited capture context about health and place, providing the contextual information necessary to address all of these characteristics.

In the health geography literature the contextual-compositional dichotomy is considered problematic. Kearns and Moon (Kearns and Moon 2002) declare it to be a “talismanic” term emanating from sociological studies. They argue that locality and landscape are better terms to understand the health-landscape interaction. But they also argue for greater contextualization in health geography research. In this case, the term context refers to an understanding of the character of a place—people and environment, qualitative and quantitative. In developing GeoInquiry, I use this idea of context. Context is about the features of a place, both cultural and physical, that can be brought to bear on an understanding of health in that place.

Context as health-place interaction fits with my collaboration with public health experts because of a mutual interest in understanding the qualitative character of place and how it shapes health outcomes. Public health nurses in Dane County WI, for example, are particularly interested in the place-based nature of health phenomena. Therefore, working with experts in the department of public health the questions in figure 7.1 were constructed. These questions were created collaboratively to address

Input Survey Questions
Main Questions
Subquestions

When you think about your neighborhood, what are its boundaries?

Can you buy healthy food in your neighborhood?
- *Where do you go?*
- *Do you go anywhere else for food?*
- *How do you get there?*

Can you go to the doctor or receive healthcare in your neighborhood?
- *Where do you go?*
- *Why do you go to this particular provider?*
- *How do you get there?*

Are there other resources or services in your neighborhood you can use?
- *Where do you go?*
- *What does this resource offer?*
- *How do you get there?*

Is your neighborhood safe?
- *Are there places that are especially unsafe?*
- *What happens there?*

Are there places to walk safely in your neighborhood?
- *Where do you walk?*

Are there safe places to play in your neighborhood?
- *Where do people play?*

Are there safe places where people can gather in your neighborhood?
- *What things make it easier to be healthy?*
- *If these things are in a certain place, please mark it on the map.*
- *Are there things about your neighborhood that make it harder to stay healthy?*
- *If these things are in a certain place, please mark it on the map.*

What are the best things about your neighborhood?
- *Where are these good things?*

Are there things about your neighborhood that worry you or create stress?
- *If these things are in a certain place and you haven't noted it already, please mark it on the map.*

Are there any other things you have not mentioned previously?

Figure 7.1: Table illustrating all questions from the input survey

points of interest from the perspective of experts in public health - however these questions were explicitly spatial in character. Realizing that a deprivation index alone could not capture context, qualitative information was targeted as critical to expand our understanding of place. However, it was unclear what qualitative information about place would be useful. Therefore, the questions were both broad and general, attempting to understand the context around the study sites more fully. Ultimately, the context acquired by these questions was intended to help inform the larger study that is attempting to understand the infant mortality decline in Dane County which is described subsequently. The questions themselves, as they were implemented in the case study, do not address infant mortality, but address the context of the county.

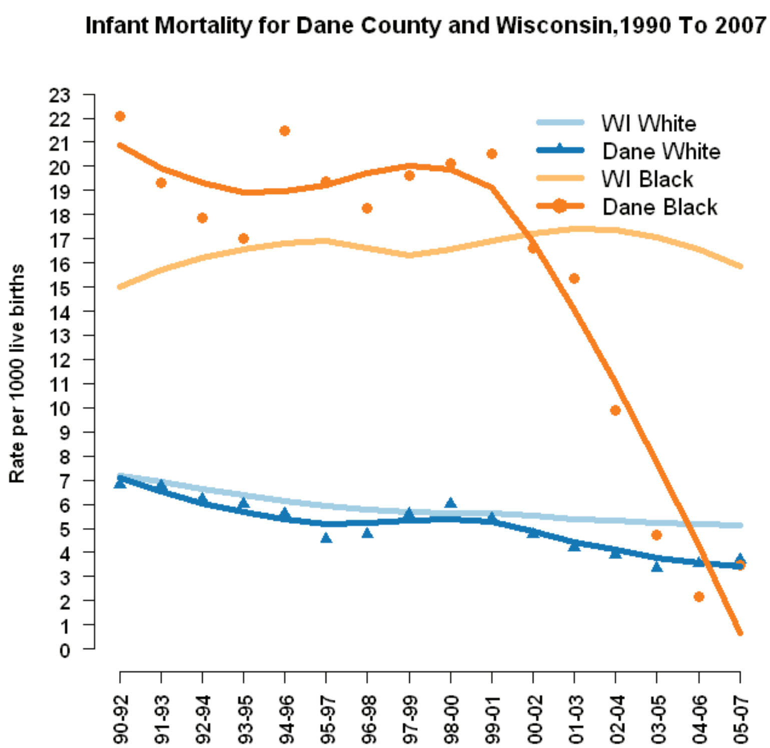


Figure 7.2: Graph of Dane County Infant Mortality Trends 1990-2007

7.2 Background on the Black Infant Mortality Decline in Dane County, Wisconsin

In the late 2000's, officials in the Public Health Department in Madison and Dane County WI noticed an unusual local trend in African-American infant mortality. This trend, shown in figure 7.2, consisted of a dramatic downturn in the infant mortality rate; one that resulted in a rate for blacks that was roughly equivalent to the rate for whites. In American medical history, a finding such as this was unheard of (Schlenker et al. Submitted). As early as 1921, Raymond Pearl noticed that the Black Infant Mortality Rate (IMR) was consistently higher than the White Infant Mortality

Rate (Pearl 1921). And this difference has persisted—even increased—despite improvements in infant birth outcomes, especially among whites (Brosco 1999).

The drivers of this difference in IMR have been many. Collins and David have argued that racism and discrimination result in a more stressful living environment, which increases the difficulty to carry babies to full term (Collins and David 1990; Collins et al. 2000; David and Collins 1997; David and Collins 2007). Likewise, Nancy Krieger has analyzed race-based mortality differences from a social epidemiological perspective and argued that racism plays an important role in mortality differences in the United States between different race groups (Krieger 2000). Quantifying racism, though, is difficult in part because racism is challenging to define. At the same time, obstetrical research has pointed at congenital causes, for example genetic differences, for these race differences in infant mortality (Lee et al. 2001). Both explanations appear to offer only a limited window into this problem—leaving many questions about the changes in Dane County unanswered.

As figure 7.2 shows, the Black infant mortality began a precipitous drop around the year 2000 and continued to drop until roughly 2007. Due to the relatively low number of births to African Americans in the county, it was necessary to produce a three-year moving average to ensure a significant number of births existed in each period (Schlenker and Ndiaye 2009). Despite smoothing the trend, there was still a substantial decline in the African American IMR over this seven year period. It is this decline that was so puzzling, especially in light of the constant statewide trend showing no improvement in Wisconsin over the same period-shown by the blue line in figure 7.2. In Racine County WI, the African-American IMR shot significantly higher. This contrast presents a ripe opportunity to compare these two geographies. Unfortunately, upheaval in the health department in Racine County that saw the entire department staff fired and replaced in early 2010, has made comparative analysis of these two locations challenging. The new staff have prioritized basic service provision and have been unable to support further research efforts.

Explanations for this decline in Dane County are varied. In a recent opinion piece, the former director of public health for Madison and Dane County argued that a coordination of service provision among the major health care providers, coupled with increased social programming led to these improvements (Schlenker et al. Submitted). At the same time, informal neonatology surveys indicated that despite these gains, no major changes in the care of high risk and premature babies have been enacted over this period that would directly impact these rates (Schlenker personal correspondence). An additional layer of complexity results from the fact that Hispanic birth rates over the period from 1990-2007 start much lower than African-American birth rates and remain low throughout the period. David and Collins (David and Collins 2007) argue that accumulated racism that is passed down from mother to mother increases stress and poor birth outcomes among black mothers, but Collins and David argue that the same situation is not replicated among Hispanic mothers. The explanations proposed to understand the infant mortality is devoid of small-scale geographic context. GeoInquiry can provide this context as shown later in the discussion of the field survey.

Research describing the connection between immigrant and/or minority density and outcomes of low birth weight offers some potential for understanding the Dane County decline in black infant mortality. Sarah McLafferty's research on Bangledeshi women in New York City indicates that when the social connectivity of a population is quite low upon first arrival to a location through immigration, likely due to the social isolation of language and culture, compounded by a very small community to interact, the percentage of babies born with a low birth weight is relatively high compared to typical white numbers (~12%). As the density of a similar racial and ethnic population increases this percentage of low birth weight drops by almost half. However once the density exceeds 30 mothers per census tract the percentage low birth weight (LBW) increases again to almost equivalent rates as when there were fewer than 5 mothers per census tract (McLafferty 2008). Figure 7.3 shows the graphical display of this trend. McLafferty speculates that at smaller population values an “isolation” effect takes hold resulting in a lack of support and

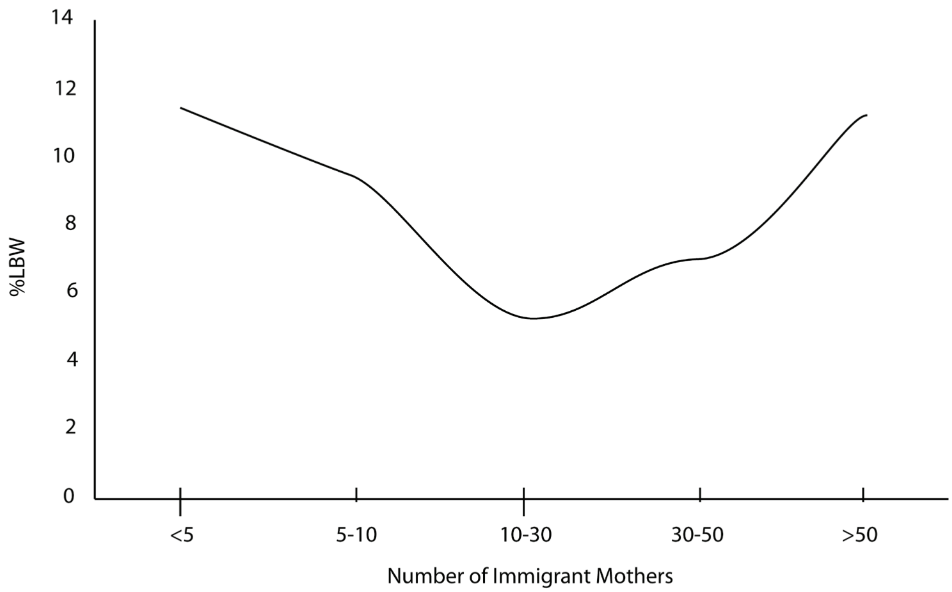


Figure 7.3: Social Isolation Curve after McLafferty (2008)

higher stress on the mothers. With a higher density population however, it is likely that deprivation begins to play a larger role. McLafferty argues that poor access to prenatal care may also be a factor in the high density areas, though I would argue that poor access to care is likely to afflict immigrant and minority (especially low income) mothers across the density spectrum.

North and south Madison appear to be on the two sides of the migration spectrum described by McLafferty. Residents in the north are more likely to have recently moved to Madison and are still establishing broader social connections to the geographic area. The overall density of this population is still growing. Meanwhile residents in the south are more established, having lived in the area for a much longer time in many individual cases (greater than 10 years), and therefore are part of a larger and much more established community. From a community perspective, experts in public health have reported that people who initially move to north Madison tend to move again within a short time frame (1-5 years) while people in south Madison have, on average, lived in the area for more than 5 years. While not an empirical finding, these anecdotal claims (McGranahan 2010) are supported by the deprivation index described in the next section.

7.3 Describing the Quantitative Context around Health and Place in Dane County

To better explore the geographic context of Infant Mortality in Dane County an initial exploration phase was undertaken looking at previous work on infant mortality in a geographic context. Work by Lynne Messer and her colleagues (Messer et al. 2006) provided a mechanism to select the appropriate study areas for understanding the social context of poor birth outcomes. Messer et al. performed a meta-analysis of the literature to survey the different deprivation indices that have been produced in the past twenty years in epidemiology and social epidemiology. As discussed in chapter 2, the calculation of indices of deprivation for the purpose of understanding the social landscape is common in Social Epidemiology. Messer and her colleagues performed this meta-analysis to determine the factors that have been included in these previous indices and to produce a comprehensive list of all factors that have been highlighted in previous research.

Once the comprehensive list of factors was compiled, Messer performed a principal components analysis that identified eight factors most relevant for calculating an index of deprivation for infant mortality. The eight factors, all derived from the United States Census, are:

1. Percent of the population living in crowded housing (defined as more than 1 person per room)
2. Percent of the population with employment in a management position (a protective factor)
3. Percent of the population with less than a High School education
4. Percent of the population earning less than $30,000

5. Percent of the population in poverty
6. Percent of the population using public assistance
7. Percent of the population unemployed
8. Percent of the population in Female Headed Households

All of these factors can be obtained from the Summary File 3 dataset from the 2000 United States Census. Unfortunately the 2010 Census data was not available in time for an updated calculation to take place, but on the basis of 2005-2009 American Community Survey estimates at the census tract level (roughly 4,000 people), the relevant geography was largely unchanged.

Once the values for each of these components was obtained, the data were compiled by census tract or block group and a principal components analysis was performed to determine the proper loadings on each factor. The composite loadings were then multiplied by the values for their respective component in each individual block group or census tract, and the resulting values were summed together to produce the single index for the areal unit. To determine where to target a qualitative study of infant mortality in Dane County, the procedure prescribed by Messer et al. was carried out. The index values ranged from −15 to 76. Areas with low and negative values were areas with a higher percent of people working in management positions, low poverty, low unemployment and higher percentages of upper level incomes.

The areas of highest deprivation (shown in figure 7.4) occur immediately in and around the city of Madison, located at the geographic center of the county. Areas on the south (circle A) and north (circle B) are areas of higher-than-average minority population, as well as lower income than the rest of the county. The block group (circle C) containing the University of Wisconsin campus appears to be the most deprived block group in the entire county, with a deprivation score of 62.6. This is at odds with the intention of the deprivation index as conceived by Messer et al, as few mothers live on campus. It is this anomalous deprivation score that served to

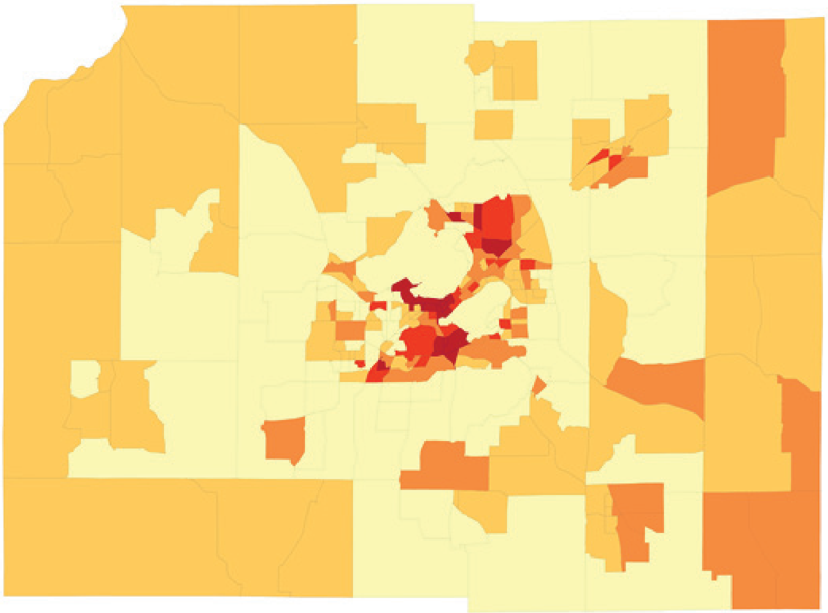


Figure 7.4: Map of Deprivation for Dane County WI

highlight the need for qualitative spatial data to understand the context around the deprivation index.

Out of this discordance with the UW campus exhibiting a high deprivation score, the concept of “pseudo-deprivation” was defined. By pseudo-deprivation, I simply mean to describe an area of quantitatively high deprivation that in reality does not suffer from the potential economic, social or discriminatory hardships that would be expected in an area that is deprived. Rather, an area of pseudo-deprivation is an area where the conditions present as high deprivation in the quantitative index, but the reality is an area that is largely not suffering from any of the three expected hardships. The UW campus is populated with people who do not work in management roles, live in “crowded” dorm housing, many of whom do not have regular employment, and few make greater than $30,000 a year - all high percentages that from a quantitative lens make the area appear to be deprived. However, in this case the combination of a clear effort to better their ultimate economic state (through obtaining a Bachelor’s Degree), in conjunction with the likelihood that many of these students have a safety net in the form of parents or family that can or will support them financially if needed, are significant factors that contribute to a lack of deprivation. Therefore, the term pseudo-deprivation is used to describe this area, and this discordance with the deprivation index is of interest to determine how qualitative spatial information can highlight “pseudo-deprivation” as well as potentially identify deprived areas that quantitatively are not in the highest quintile.

7.4 Capturing Context - Using GeoInquiry to add to the Contextual Understanding of Place

This section describes the results of the data collection from the three sites where testing and data collection occurred -Holt Commons, Kennedy Heights and the Urban League of Greater Madison. In total, 82 respondents provided data that were subsequently coded on a question by question basis. The codes were used to visualize the responses and to begin the process of constructing hypotheses about the relationship between the index of deprivation and the population in each environment.

The goal of this initial exploration is to determine the utility of GeoInquiry to add context to Messer’s Deprivation index and to begin the process of developing hypotheses about the place based social components of a public health problem. The questions shown in figure 7.1 were implemented in the GeoInquiry input tool and deployed during testing at the three chosen test sites.

7.4.1 Analysis of Individual Questions

Participants were asked to complete the eleven questions (with subquestions, shown in figure 7.1) resulting in 33 total questions. Questions were a mix of locational questions requiring the user to either draw a polygonal shape or to place a point on a map with aspatial questions connected to the points asking for further description of the environment around the submitted point. Once the three sessions were complete, the resulting data were loaded into the coding application for analysis. Each question was handled separately with all corresponding submissions loaded into the coding application. Once in the data were loaded into the application, each submission was coded with the codes stored in the database. Visualization of the codes was handled in ArcGIS, outside of the visualization application. This is in line with the expectation for the GeoInquiry system, as the ability to export the coded data to shapefile supersedes the need for the visualization application for users with expertise in GIS. The analysis results for each question, described subsequently, are my interpretations and codings of the submitted data. The user study participants did not code the entire universe of data due to constraints on their time, therefore all coding presented here is coding produced solely by me.

During the data collection sessions, I decided when asking these questions to use polygon representations only in situations where the size of the area could be valuable. Otherwise, points were captured, even in areas that can obviously have varying aerial footprints. These questions can easily be adjusted in advance of survey deployment in the JSON document to capture area, but in this case I felt that the potential of point pattern analysis to provide quantitative support to the findings was more valuable to the study than an attempt to characterize the size difference. The neighborhood question (discussed in section 7.6.1.1) was initially created in discussion with my partner in public health as potentially useful in analysis as a areal data unit. All of the other questions were expected to be easier for the residents to interact with as point level inputs.

7.4.1.1 "What is your neighborhood?"

This question posed problems for the respondents and yielded unexpected results. The definition of the term "neighborhood" was left to the interpretation of the contributing user. However, the choice of the word neighborhood may have caused confusion with the participants. I speculated that participants with greater access to resources would provide a larger definition of neighborhood, as a result of their monetary and social advantages. And to some extent that was true. The Kennedy Heights population provided the smallest areal definitions of their neighborhood. These were on average 1.5 times smaller than the neighborhood polygon size contributed at Holt Commons. However, the contributed polygons from the Urban League were on average 1.5 times larger than those at Holt Commons. This was unexpected - in fact this question was expected to yield an early insight into the differences between “pseudo-deprived” and real deprivation. One possible source of error in interpretation lies in the qualitative difference between the Urban League site and the Holt Commons site. The Urban League site consisted of people from all areas of Madison who utilize the services of the Urban League for resources such as job training, employment support and economic and housing support and are therefore less place bound than those people who participated in the Kennedy Heights and Holt Commons sites. In the case of Holt Commons, it is also possible that there is little need to venture beyond campus, as food, recreation, libraries and other amenities are provided giving a student population less need to venture elsewhere with any frequency. The students are also seasonal, part-time residents in a group quarters setting, limiting access to vehicles and generally reducing their need to roam the city. Further, the setting at the Urban League was in most cases outside of the “neighborhood” of the participant, which may have contributed to a different interpretation of the question of neighborhood compared with participants who took the survey in their own neighborhoods.

The choice of the term neighborhood was in retrospect an unfortunate word to use because it carries varied meanings for a majority of people. The lack of uniformity in understanding “neighborhood” leaves the respondents to interpret the meaning of the question. This reduces the control of the question and makes the results difficult to compare reliably. Alternative terms such as community or home range might be improvements, though each of these terms also presents issues - from preconceived ideas to unfamiliar jargon.

As for the potential of the current data to describe conditions surrounding the health of these areas, it is possible to develop some basic hypotheses from this question, despite its shortcomings. Figure 7.5 illustrates the differences between the three sites in terms of the generalized and aggregated footprint of the contributed neighborhoods. If we exclude the Urban League responses the Kennedy Heights neighborhood illustrates a much smaller area of connection. Coupled with Kennedy Heights' relatively distant location from the rest of the cit—both in terms of access to central services as well as the social isolation, due to geographic barriers such as Lake Mendota—it becomes apparent that the potential to be isolated when living in this neighborhood is increased compared to Holt Commons. Extrapolating the geographic barriers of the neighborhood to the health landscape, the reduced connections to the larger city becomes problematic. Residents in Kennedy Heights are more isolated, surrounded by single-family residential housing, than at the Holt Commons location - despite having a better deprivation score. It is difficult to draw strong conclusions from these observations due to the use of the nebulous term "neighborhood". However, the contributed geographies do allow for some initial hypotheses to begin to form about the isolation of Kennedy Heights which have the potential to inform further studies in the area.

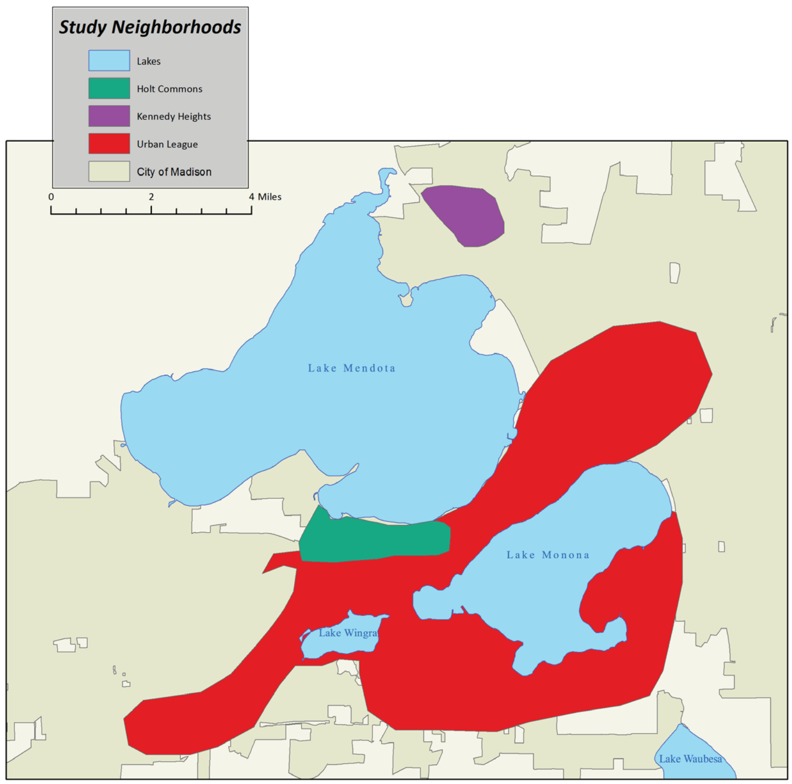


Figure 7.5: Map of Catchment areas from which test subjects lived

7.4.1.2 "Can you purchase healthy food in your neighborhood?"

Access to healthy food was described by a majority of respondents as being plentiful as shown in figure 7.6. While the presence of healthy food options, such as fresh produce, is available in all Madison grocery stores and multiple farmer's markets, the resulting map raises skepticism about its validity. The lack of a formal definition of healthy food allowed the user to decide what their definition of healthy food included. This, coupled with a tendency of respondents to over-report healthful activities may have resulted in a depiction of healthy food prevalence that was in excess of its actual density. Secondarily, by including the term neighborhood in this (and subsequent) questions, the contributed answers could differ based on each person's interpretation of "neighborhood". This means that "neighborhood" size potentially would change based on activity and would likely not correspond to the shape contributed in the first question (i.e a willingness to travel farther for medical care than for basic food products like milk and bread). Roughly 20% of the healthy food locations contributed were outside of the corresponding neighborhood polygons—further illustrating the problems with the term neighborhood, but also contributing to this over-reporting.

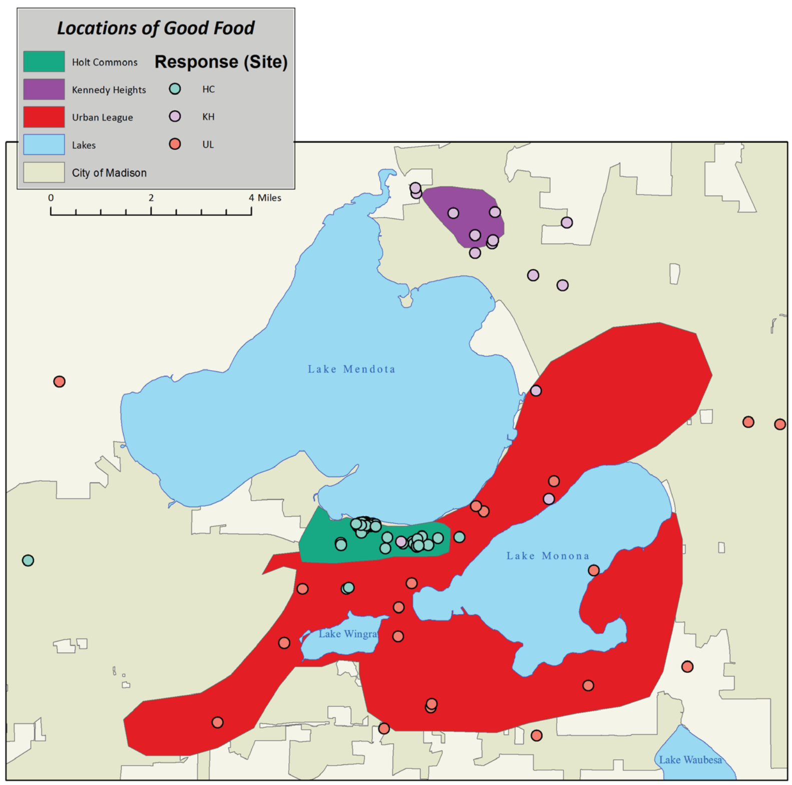


Figure 7.6: Map of locations of good food from case study

Analyzing these data indicates that healthy food is an option in all of the testing locations—however a subsequent question should have been included to ascertain the frequency with which healthy food is purchased, obtained and consumed. This question only gauged perceived access, but failed to capture the actual consumption of healthy foods, leaving the question devoid of some explanatory power.

7.4.1.3 "Can you go to the doctor in your neighborhood?"

Location of healthcare was the first factor where differences between the areas emerged. Respondents at both Kennedy Heights and the Urban League demonstrate both a broad geographic range of providers, as well as a variety of reasons for choosing the provider—from proximity to insurance to the quality of the doctor. In contrast, the respondents at Holt Commons offered only two potential locations for accessing health care - the University of Wisconsin Hospital and the University Health Services. These sites were mentioned by the majority of residents because of proximity and cost (free). The differences between the doctors' locations can be seen in figure 7.7.

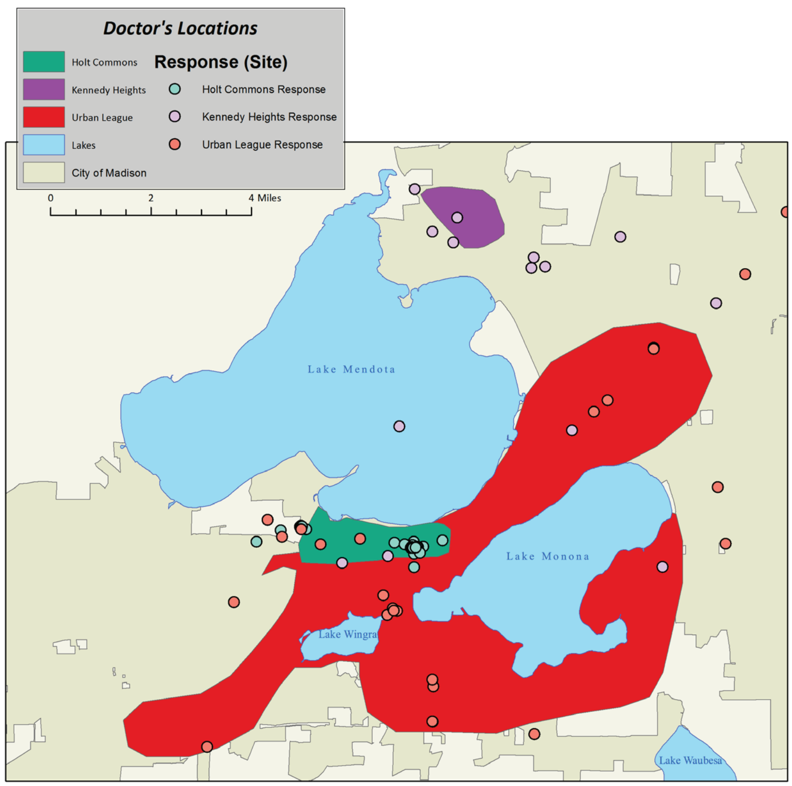


Figure 7.7: Map of locations of Doctor from case study

The dispersed geographic footprint of the health care received by both the Kennedy Heights and the Urban League respondents is symptomatic of the health care system in the United States. In contrast, the compact nature and open access to health care of the Holt

Commons respondents points to a significantly different lived experience than their corresponding deprivation score would indicate—better access to care and a stronger support network available.

7.4.1.4 "Are there other services or resources in your neighborhood?"

This question offered an open-ended opportunity for respondents to offer anything beyond healthcare and healthy food that they felt was a positive in their neighborhood. The geographic distributions of the contributed amenities were all tightly clustered near the generalized neighborhoods derived from the first question. The geographic distributions are shown in figure 7.8.

The amenities mentioned were a stark contrast between Holt Commons and the Kennedy Heights/Urban League responses. The overall geographic distribution of all amenities is shown in figure 7.8. The codes that were derived from Holt Commons responses were library, exercise, leisure, sports, assistance, and technology. Of these, only technology, leisure and sports emerged in the Kennedy Heights and Urban League responses. Library and exercise were almost exclusively mentioned by members of the Holt Commons population. In contrast, assistance and job help

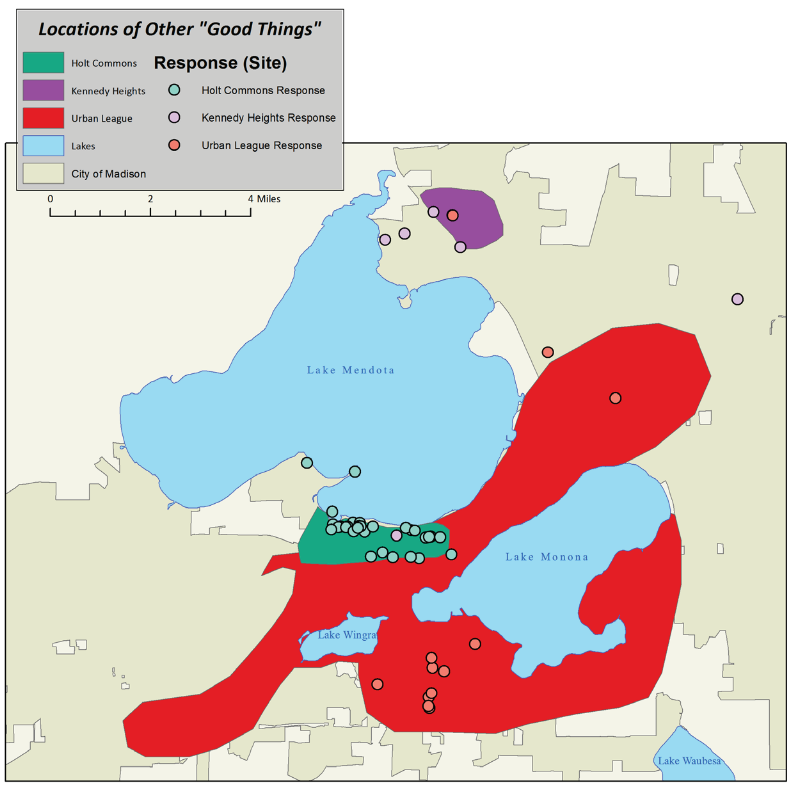


Figure 7.8: Map of locations of other "good things" from case study

were only mentioned outside of the campus population.

Similar to the questions earlier, this question highlights a distinct difference that is masked by the deprivation index. By focusing on classic amenities such as nature and recreation, the respondents of Holt Commons demonstrated an affinity for amenities that are more likely to be consumed by those who are privileged. In contrast, the other two sites were focused on amenities that would assist with financial difficulty - job training and assistance. These are amenities for people in stressed financial situations - not the type of situations portrayed by the Holt Commons population.

7.4.1.5 "Is your neighborhood safe?"

This question yielded similar results to the previous question, again with differences between Holt Commons and Kennedy Heights/Urban League. At the Holt Commons site, females were more likely than males to mention safety as a concern, with more than half of males indicating that no places were unsafe in their neighborhood. Of these reports of unsafe locations, there was a tight cluster of points provided near the Lakeshore path on campus (figure 7.9). These respondents specifically mentioned darkness and night as safety concerns with a reported assault occurring a few months prior to the data collection at the forefront of these concerns. The Holt Commons respondents were the only population where the codes Darkness and Night were applied during coding as unsafe.

In contrast to the responses at Holt Commons, a different array of safety concerns were mentioned at the other two sites. Drugs and Fights were acknowledged stressors only by residents of Kennedy Heights. Urban League respondents mentioned gangs multiple times, with a resident of Kennedy Heights also mentioning gangs as a safety issue. Multiple responses led to the code "everything" being applied to what was unsafe. This code was used twice by Urban league respondents in south Madison, but the lack of further elaboration makes it hard to tell if this is a quick blanket statement or a symptom of a larger issue.

7.4.1.6 "Can you walk safely in your neighborhood?"

The ability to walk safely was consistent across all of the responses. The number of walkable locations was greater at Holt Commons, though this may be due to the nature of student life, requiring walking to many locations in and around the campus area. However, walking was absent in either the Kennedy Heights' or Urban Leagues' respondents. While fewer walkable locations were reported than at Holt Commons and the destinations were spread across a wider geographic area (Figure 7.10), all respondents that indicated they were able to walk safely in their neighborhood. This indicates that the ability to walk safely is not a restricted amenity - though similar to the question about healthy food the survey did not gauge the frequency with which the respondents engaged with these walking opportunities.

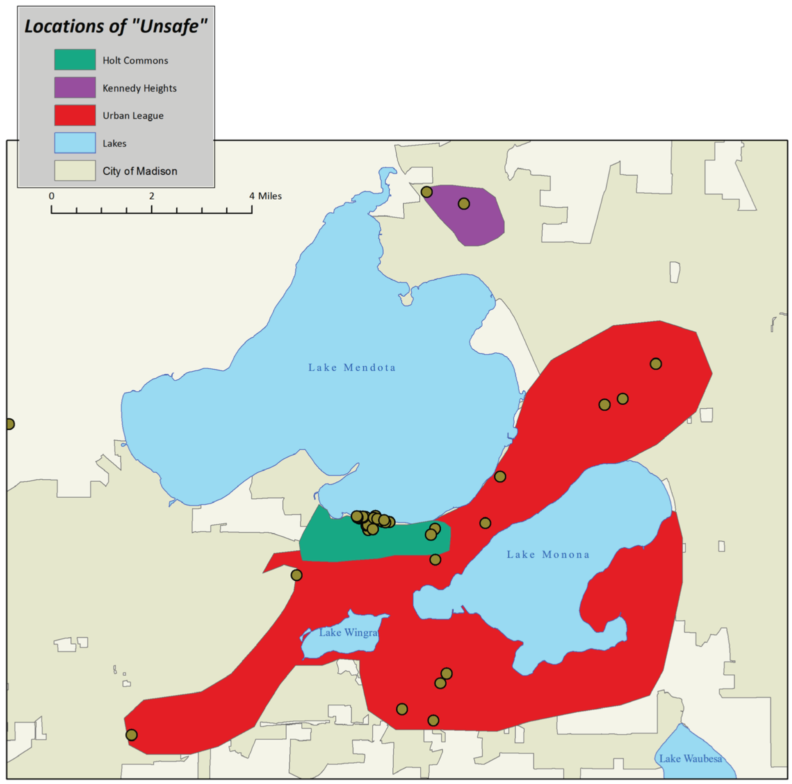


Figure 7.9: Map of locations of unsafe places from case study

7.4.1.7 "Can you play safely in your neighborhood?"

The response pattern pertaining to the ability to play safely was distributed across the entire study area. The main difference is a lack of clustering of points in Kennedy Heights and the Urban League (figure 7.11), demonstrating that the number of places where safe play occurs is more limited than in the Holt Commons area.

Despite a more limited geographic footprint there was a positive response about safe play in all of the neighborhoods. This affirms that each neighborhood has positive amenities.

One issue with this question may involve the use of the term "play." No context was provided, beyond the question listed above-meaning that for many residents they may have answered this question with children in mind. If this question were asked in another study, I would change the question to "Are there places for recreation in your neighborhood?" to broaden the idea beyond a question loaded with meanings of children.

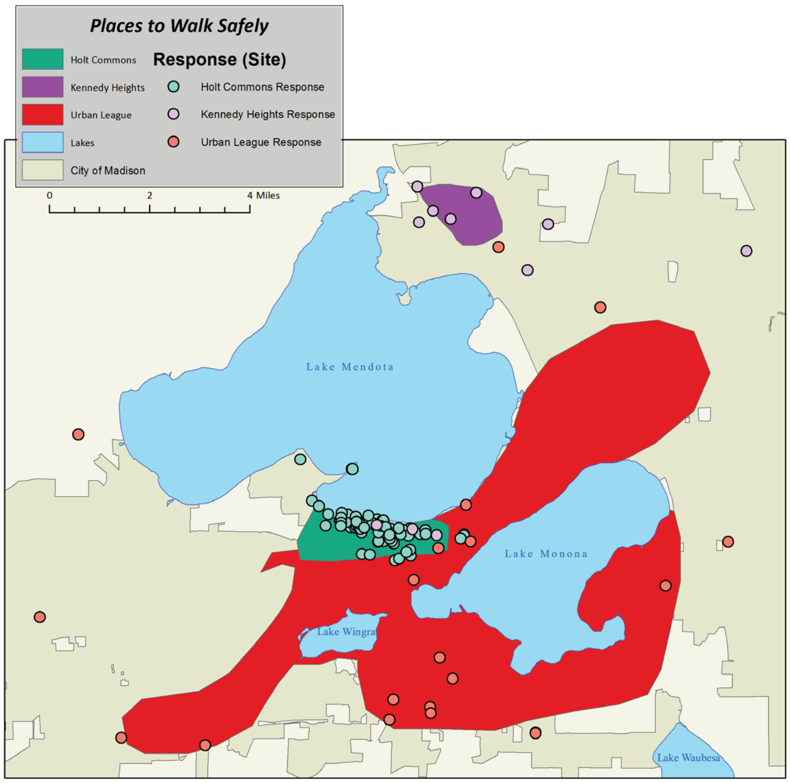


Figure 7.10: Map of walkable locations from case study

7.4.1.8 "Are there safe gathering spots in your neighborhood?"

As has been present in all of the other questions, the Holt Commons responses maintained a clustered pattern in close proximity to the generalized neighborhood (Fig 7.12). The density of the points contributed by the Holt Commons population was high—roughly half of them are closed to the general public, accessible only to students or members of the university community. By contrast, the respondents from Kennedy Heights and the Urban League did not provide any gathering locations that were coded as closed to the general public. The split between many private gathering

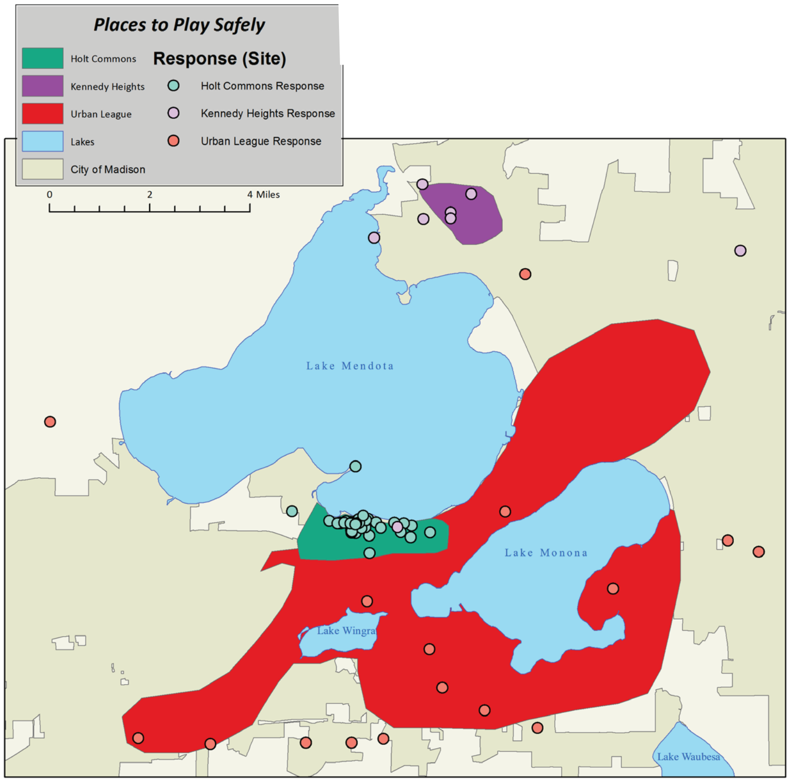


Figure 7.11: Map of play locations from case study

locations in one area versus no private gathering locations in the other two areas leads to a question of the privileges enjoyed by students that are not available to the other contributors.

Another difference is the description of who accesses these gathering locations. At Holt Commons, the term "student" is dominant. However the term "community" is non-existent. Conversely, in Kennedy Heights and the Urban League the terms "community" and "neighbors" are used to describe the gathering areas -but the term "students" is non-existent. While this is a qualitative difference in the description of the population in the area, the deliberate use of the term "students" clearly articulates the contrast between these populations in a way that mitigates the need for a priori researcher knowledge about this population prior to analysis might be required to understand the context around the deprivation index.

A further test of the system with areas with high income would be useful to determine if a difference in income results in a difference in the number of closed gathering locations. Locations such as private swim clubs and other private clubs are noticeably absent but might be more apparent in a wider sampling. The presence of closed gathering locations presents a possible point of differentiation between

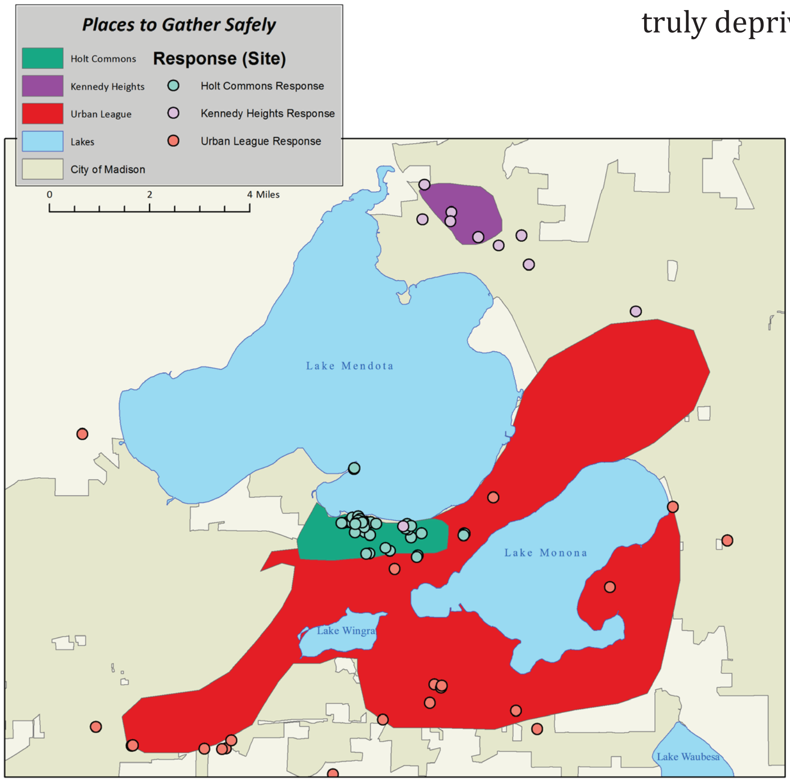


Figure 7.12: Map of safe gathering locations from case study

truly deprived areas and those that register high on the deprivation index score but are "pseudo" deprived.

7.4.1.9 "Is your neighborhood good for your health?"

At all three collection locations there were numerous places that were identified as being positive for health. These positives were coded as exercise, good food, proximity, people, community and safe. The spatial distribution of the code exercise is shown in Figure 7.13.

Interestingly, exercise appears as a code again, and in this question all three sites were coded as providing exercise opportunities. This is in contrast to the question about other amenities in the neighborhood where only the Hoyt Commons residents mentioned exercise opportunities. When analyzed further, it appears that the Holt Commons users identified the indoor exercise facilities as "other" amenities. In contrast, exercise in this question was identified largely as an outdoor activity - making it more accessible. Also by stressing "good for health" as part of the question it brings exercise to the fore—while it appears to recedes when the term amenity is used.

Kennedy Heights respondents mentioned good food in greater quantity than the other sites. This is an interesting finding in light of a lack of adequate grocery options on the north side of Madison. However, the respondents were all attending a food bank providing many types of vegetables along with other healthy food options, which was directly mentioned in the contributed text as a health benefit. So the bias of testing in conjunction with a food bank may have skewed this answer to appear more frequently. This type of bias is important to consider in each of the questions - making analysis of the answers more complicated. However, to harmonize these sites it would have been preferable to target a similar food bank/community center on the south side. This qualitative difference in site type and the purpose for people attending the site is an important consideration for future work of this nature.

Spatial proximity to healthy options was a dominant theme in the Holt Commons population, but largely non-existent in the other sites. In contrast, the "people" in the neighborhood were mentioned in both Urban League and Kennedy Height submissions as part of the positive health benefits. However, in the Holt Commons population mention of "people" as good for your health was absent. Likewise the code of community was predominantly applied outside of the campus population. This question confirms that for the campus population health amenities are recognized in the form of food and exercise, while outside of campus the support of community and

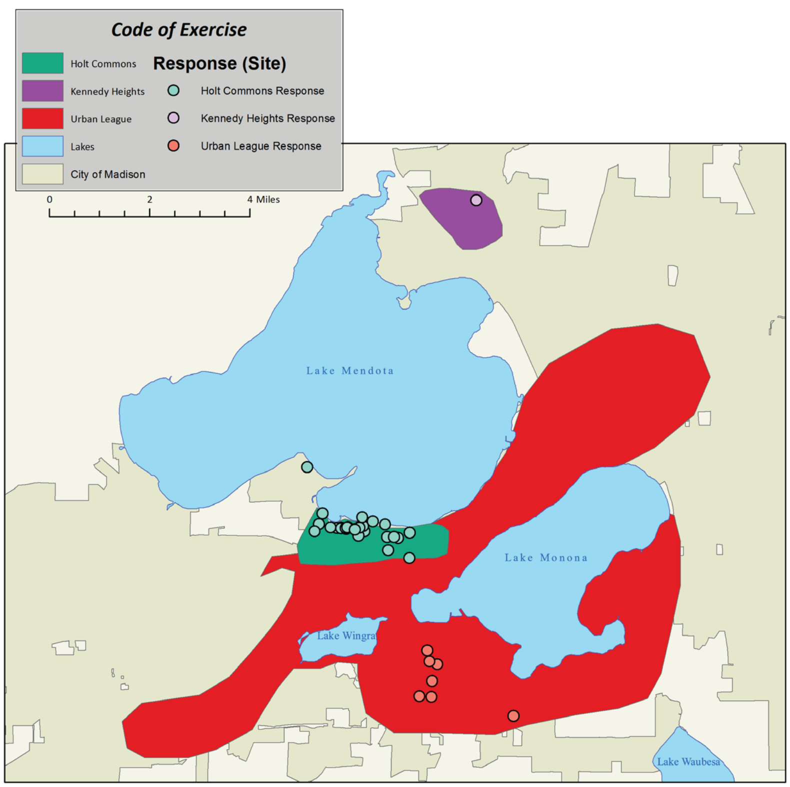


Figure 7.13: Map of locations that promote good health from case study

people are major health amenities.

7.4.1.10 "What about your neighborhood makes it harder to be healthy?"

This question reverses the perspective from the previous question by challenging the respondent to focus on negative aspects of their neighborhood. Holt Commons users frequently mention Bad Food as an obstacle to healthy living on campus. Comments about large quantities and fat were repeated across submissions. This belief that campus food was unhealthy provides an explanation for the absence of "food" as a positive health factor in the earlier question. However, this view that "food" makes it harder to be healthy is in contrast to the second question in the survey asking about access to healthy foods. However, the identity of the healthy food locations in question 2 were not labeled by the users, leaving the possibility that the food service center and healthy food outlets were mutually exclusive.

Aside from the spatial pattern of unhealthy food, this question yielded far fewer answers with any spatial footprint. The codes of crime and people had a distinct pattern related to the Allied Drive neighborhood, but this was due to a single contributor at the Urban League, making it difficult to extrapolate these codes to a larger area. The overriding message from these two linked questions was that the positives of the neighborhoods outweighed and outnumbered the negatives.

7.4.1.11 "What are the best things about your neighborhood?"

This question yielded contrasting answers similar to previous questions. The Holt Commons population offered multiple answers coded nature as being the best thing about their neighborhood, while the other sites' respondents didn't mention nature in any way. In south Madison a focus was placed on retail as the positive. Likewise, the accessibility of transportation was a strong positive in South Madison - not surprising given the close proximity of one of the city's four Metro bus transfer points.

Beyond these codes though, community appeared in a majority of answers at all of the sites. The presence of recreation opportunities was dominated by the resident of Holt Commons, with only a few members of Urban League mentioning recreation as an amenity. Likewise Urban League participants more frequently were coded with the term inclusion, which may be a result of a broader community site that is inclusive of people from across the city and supporting a population that was not within their home community when taking the survey.

The geographic patterns were negligible beyond these patterns. Part of the lack of discernible pattern could stem from the placement of this question, which came after nine long questions likely resulting in some survey fatigue. Also, it appears that most respondents attempted to answer this question with a different answer than provided previously—resulting in a different pattern than may have appeared earlier

7.4.1.12 "Are there other things in your neighborhood that cause stress?"

The final question in the survey resulted in very few responses,with just 7 of the 80 respondents providing information and no significant patterns in the types of qualitative data contributed-this question acted more as a catch-all for anything else the participant wanted to share.

7.4.2 Relationships between Submissions

The submission mechanism in the public survey stored the spatial character of each answer independently from both other users and separate from other questions, resulting in a large database structure populated with fields for each question. This storage design allowed each question to be either extracted individually or compiled with other questions for the purpose of comparative analysis through statistical or visual means. A complete code list for all questions (broken out by question number) can be found in Appendix H. I conducted all of the point pattern analysis using shapefiles exported from the PostgreSQL database and loaded into the statistical package R.

The submission of point based variables and their corresponding textual descriptions were coded using qualitative coding methodologies described in chapter 4. Initial codes based on the submitted text were created in the Analytical Coding module. Once compiled and visualized, second stage codes were contributed. These codes were also visualized spatially, allowing the researcher to analyze the questions independently and in conjunction with other questions to determine if contested spaces existed in these data. One of the benefits of the GeoInquiry system is the ability to extract these data into a shapefile and then use the shapefile in software such as R, the statistical environment, to take advantage of spatial statistical methods like K Cross functions to corroborate the visual conclusions being drawn.

Once the points were loaded into R, point-pattern analysis in the form of K and cross K functions were deployed to statistically analyze the data for trends. K functions test against the null hypothesis of a completely spatially random pattern. In light of the flaws in testing against CSR (Completely Spatially Random)—the main flaw being that from a geographical perspective we know that nothing is CSR—the K function was abandoned as a means of legitimate information. However, the cross-K function was run on second stage combinations of codes to determine if spatial relationships existed. Cross K functions test two different point patterns to determine if the patterns are independent of one another, attracting over a specific distance range or repelling over a range. The graphical nature of the output of this function enables all three of these results to appear in one analysis - with each result a function of the distance between the points.

These methodologies are useful to support the visual analysis of the data with a statistical procedure to corroborate or refute the researcher's visual analysis. However, legitimate criticism from David Harvey (1966; 1967) and Peter Gould (1970) should give pause about the use of point pattern analysis as a means of statistically “proving” that a pattern exists. This work heeds these warnings by ignoring first-order point pattern analysis. Therefore, the point pattern results discussed below are not intended for proving a statistical point, but rather serve as support for the visual evidence seen in the corresponding map. At the same time, there is precedent in epidemiology to utilize point pattern analysis to characterize the nature of disease outbreaks (Diggle and Chetwynd 1991; Diggle et al. 1995; Gattrell et al. 1996). With this contested backdrop, I used the cross-K function to provide an automated approach to support conclusions about the nature of the spatial distribution of the submitted data - specifically the contrast between data coded as Stress or Unsafe with data about locations for play, food, gathering, visiting the doctor and a secondary code of good.

The five comparisons below all compare a code of Stress/Unsafe versus different secondary codes. The code of stress/unsafe is used as a generic code to describe negative aspects of the descriptions. It does not refer specifically to stress or a lack of safety, rather to the questions that asked where potential stressors existed and the manner in which they manifested themselves.

7.4.2.2 Stress/Unsafe v Doctor

Figure 7.14 displays a map of all points in the study coded as Stress/Unsafe contrasted with all of the locations contributed where participants go to receive healthcare. Immediately it is noticeable that there is a separation of location between the stress points and the points contributed for the doctor locations. When a cross K function is run to verify this separation the result is shown figure 7.15.

Figure 7.15 presents a Ripley’s K12 function[1] or a cross L function. The graph presents results with the solid line representing the trend of the dataset and an envelope of high and low values for independence graphed to allow interpretation of the dataset. In figure 7.15, the mapped values, represented by the solid line in

1 Ripleys K12 is a transformation of the K function allowing for easier interpretation of the relationship between two patterns spatially.

the K12 graph, exhibit a inhibition character at short distances. When the solid line drops below the envelope the interpretation is a repulsion phenomena between two groups of points (i.e., the presence of one type of point will "prevent" the presences of the other type within a given distance). Both graphs illustrate a trend line that falls below the envelope at short distances, an indication that at short distances there is a relationship between these sets of data that presents an inhibition pattern—essentially places of stress are exclusive from doctors' locations. As we move to the analysis of a neighborhood-level the graph demonstrates that at a small scale (i.e., the entire county) level doctors' locations and places of stress are independent of each other -therefore they are interspersed at equal rates across the wider area and do not exhibit a global relationship.

The short distance repulsion, however, indicates that doctors' locations are largely outside of the neighborhood stress areas described by the respondents. In light of the nature of the health care system in Dane County, this is to be expected. Despite the indication in question 3 that most people receive healthcare in their neighborhood, the reality is that most of the health care is actually provided outside of the neighborhood environment - or at least separate

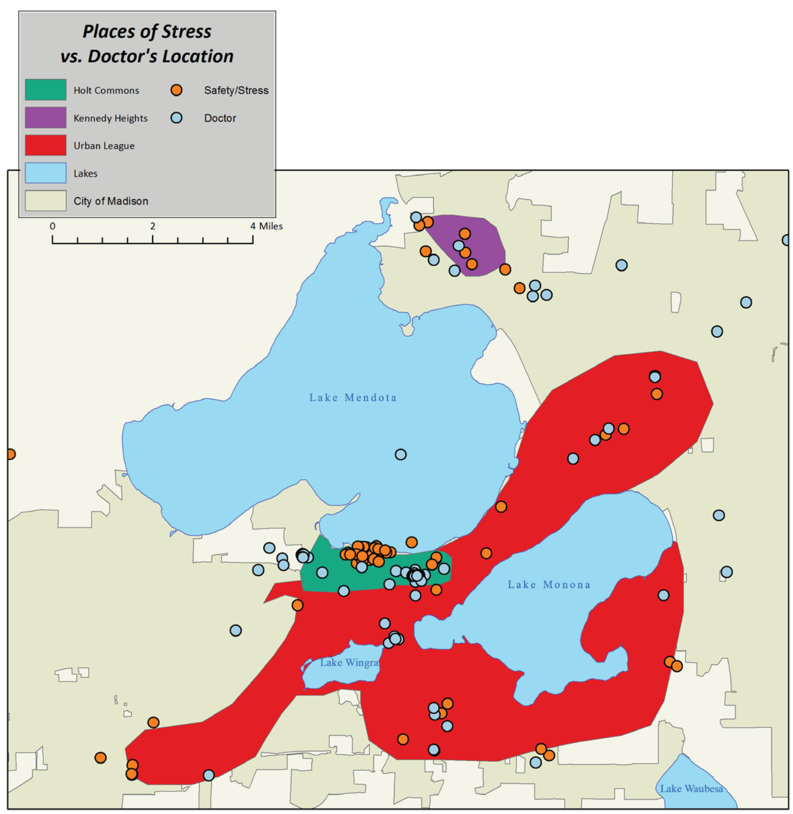


Figure 7.14: Map of locations of Stress/Unsafe versus Doctors locations from case study

from those environs that have a direct stressful impact on the respondents and likely

the larger pool of residents.

7.4.2.3 Stress/Unsafe v Healthy Food

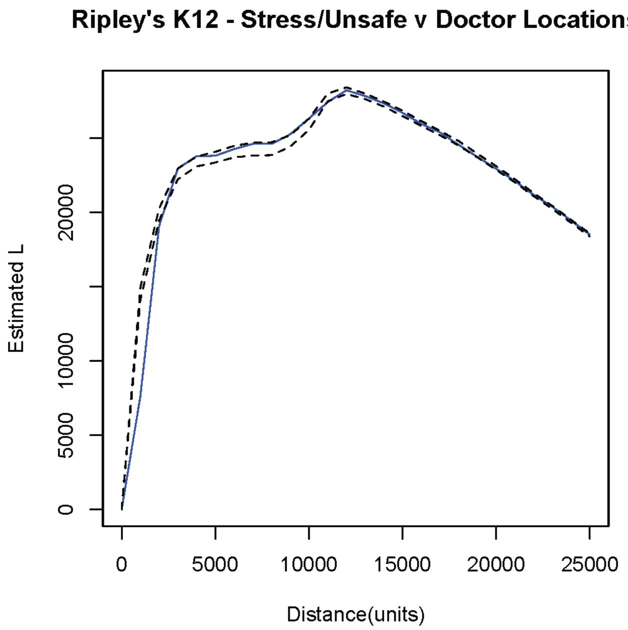


Figure 7.15: Cross K Function output for Stress versus Doctor locations

The map of locations of stress versus locations of healthy food availability (Figure 7.16) highlights no apparent spatial relationship. When plotted in R on a Cross L graph, this independent relationship is borne out (Figure 7.17). Despite extremely tight confidence intervals, the observed values never deviates outside of the envelopes, indicating that these datasets are independent of one another. This result is not a rejection of a null hypothesis as in other statistical tests, but rather points to a lack of relationship between these factors. This finding leads to a hypothesis that the ability to obtain healthy food is neither deterred or removed from the presence of stressful locations.

7.4.2.4 Stress/Unsafe v Gathering Locations

Similar to the map of stress versus healthy food, the map of stress versus gathering locations (Figure 7.18) does not present a clear discernible pattern. However, this difficulty in determining the presence of a relationship makes the use of the cross K function to attempt to uncover a valid spatial pattern appropriate (Figure 7.19). The Ripley's K12 graph both show an observed value that is consistently at the top of the independence envelope, almost trending to an attraction interpretation. However, the observed line never clearly goes above the envelope, leaving the interpretation of this result to remain one of independence with a trend towards an attractive relationship between gathering locations and stressful locations.

From an analytical standpoint, a trend towards an attractive relationship in this case is expected in light of previous work. Previous studies in south Madison (Dennis et al. 2009) have shown that a duality of spaces such as parks is common in south Madison - spaces where people gather for positive interaction may also be spaces of stress and unsafe feelings. Likewise, from respondent to respondent places may have multiple meanings. The layering of meanings in similar locations demonstrates the difficulty in classifying the stress landscape of not only a point but an area as well.

7.4.2.5 Stress/Unsafe v Places of Play

The relationship between stress and play is very similar to stress and gathering as shown by map (Figure 7.20) and cross K graph (Figure 7.21). While not trending quite as close to the attraction border of the confidence envelope, the signature is very similar. This is to be expected given that places of play, like parks and open green space, are often synonymous with places of gathering. And similar to gathering locations, the duality of a location of play and a location of stress not unexpected. As mentioned earlier parks have been shown to exhibit these opposing codes, depending on the time of day and the nature of the activity occurring. The temporal signature of these codes would

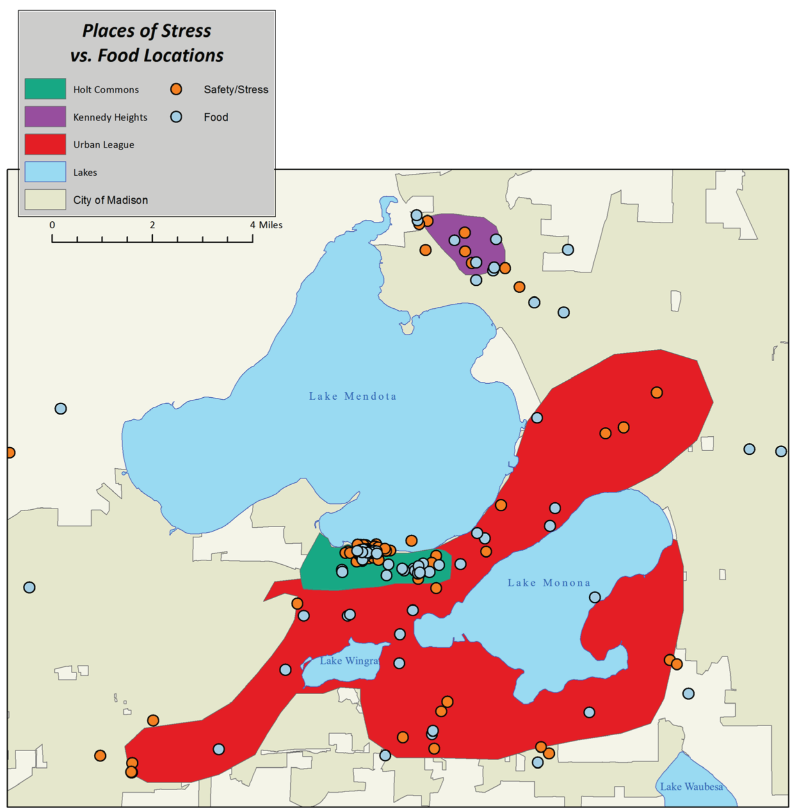


Figure 7.16: Map of locations of Stress/Unsafe versus Food Locations from case study

be a useful addition to determine if the relationships are purely spatial or if there is a temporal relationship as well. Further development of the system could incorporate temporal questions along with the spatial to further illuminate the potential temporal attraction or inhibition, which is testable using a different modification of the cross K function - a space-time K function (Diggle et al 1995)

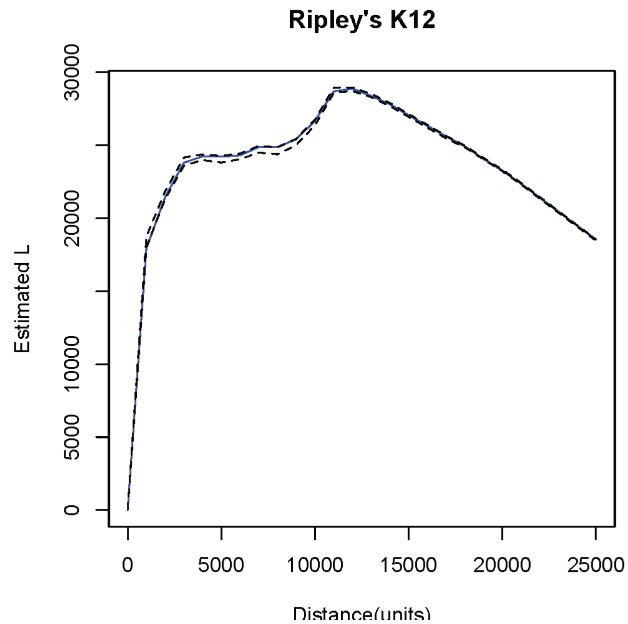


Figure 7.17: Cross K Function output for Stress versus Food locations

7.4.2.6 Stress/Unsafe v Positive/Good

The relationship between codes of stress and codes of “good” was independent. Clearly on both the map (Figure 7.22) and the cross K graphs (Figure 7.23), there is no discernible relationship between these codes. It was noticed during data collection that some students strongly associate spaces of positive amenity and places where safety was a concern. In particular females on campus mentioned the lakeshore path as unsafe at night, but also frequently mentioned the path as an amenity. However the statistical test cannot be performed on a subset of the data (a violation of the assumptions of the K function), therefore only a global statistical curve is generated, which masks these anecdotally observed relationships.

7.4.3 Discussion

These findings demonstrate that the health landscape around Madison WI is a complex situation. The deprivation index provides an initial first pass to understand areas of high need. However, without the qualitative spatial data captured from GeoInquiry, the index itself would miss areas of high need in favor of areas where need is much less great. By capturing additional data outside of the domain of large scale aggregated datasets such as the U.S. Census we can begin to construct the contextual understandings, about things like safety and access,needed to develop a fully formed hypothesis about the health landscape.

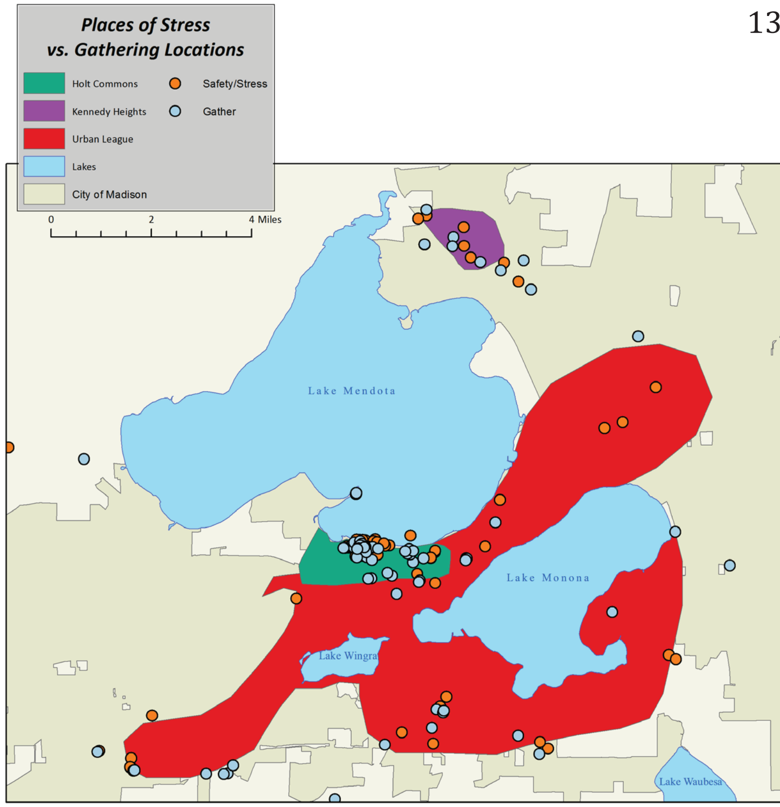


Figure 7.18: Map of locations of Stress/Unsafe versus Gathering Locations from case study

Ultimately, the data capture engine is but one side of the equation. As seen in the discussion of the findings, the ability to quickly apply qualitative codes to these data and subsequently view these datasets in isolation or in tandem is equally critical. The development of hypotheses for further testing is the ultimate outcome of this process.

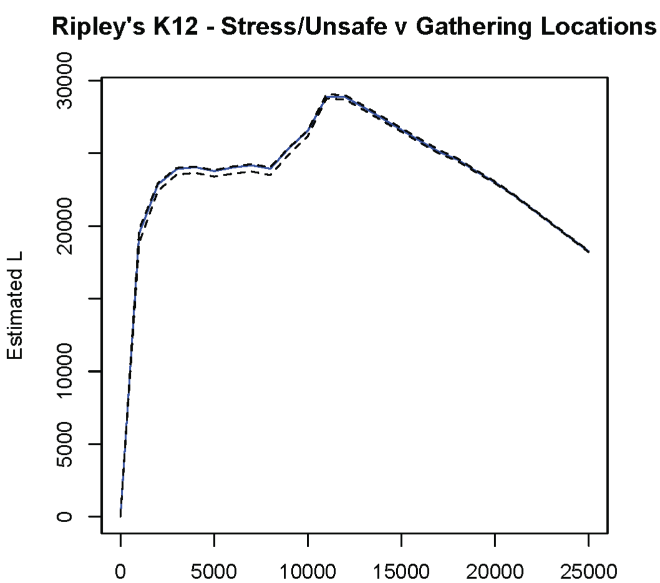


Figure 7.19: Cross K Function output for Stress versus Gathering locations

While the system itself is described elsewhere, the data collected here illustrate a landscape where subtle difference can highlight potential stress differences. Understanding that areas of “pseudo deprivation” are worried about food and to a lesser extent safety while having the ability to engage in amenity consumption provides a possible set of factors that can be used

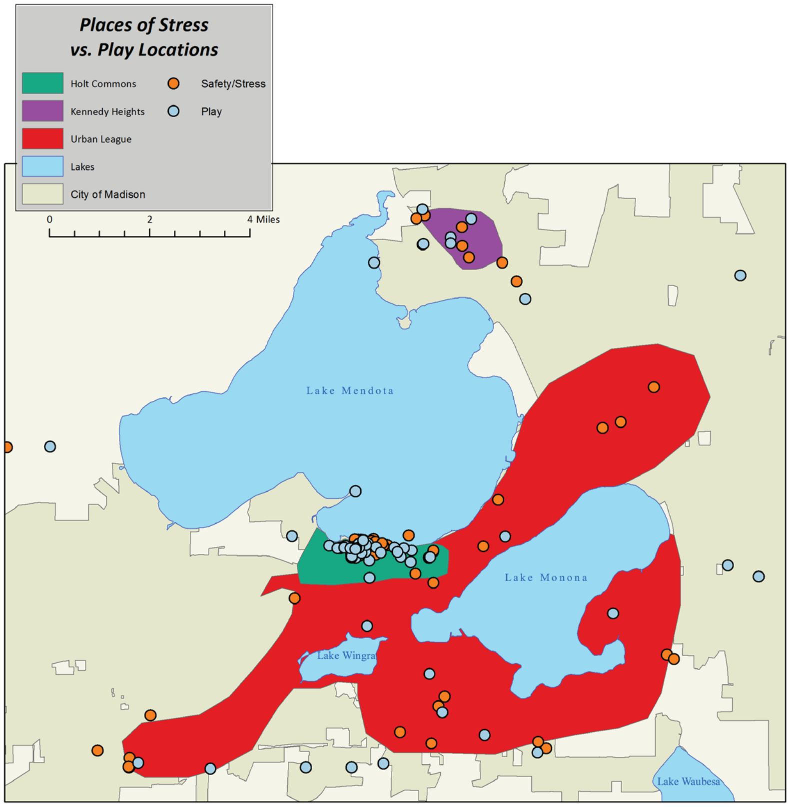


Figure 7.20: Map of locations of Stress/Unsafe versus Play Locations from case study

to evaluate a deprivation score. Conversely, in the other communities, reports of violence, weapons, and amenity descriptions of job help and support presents a stark landscape contrast. In the latter case we can see a landscape where stress is a greater concern and the health outcomes associated with this landscape are likely to be of greater concern.

David and Collins (Collins and David 1990; Collins et al. 2000; David and Collins 1997; David and Collins 2007) have made it clear that they perceive the social conditions and racism faced by black mothers as an impediment to positive birth outcomes. Likewise high cortisol levels from a consistently stressful environment have been shown to negatively impact the ability of black mothers to carry babies to term, resulting in premature delivery and higher potential for undesirable birth

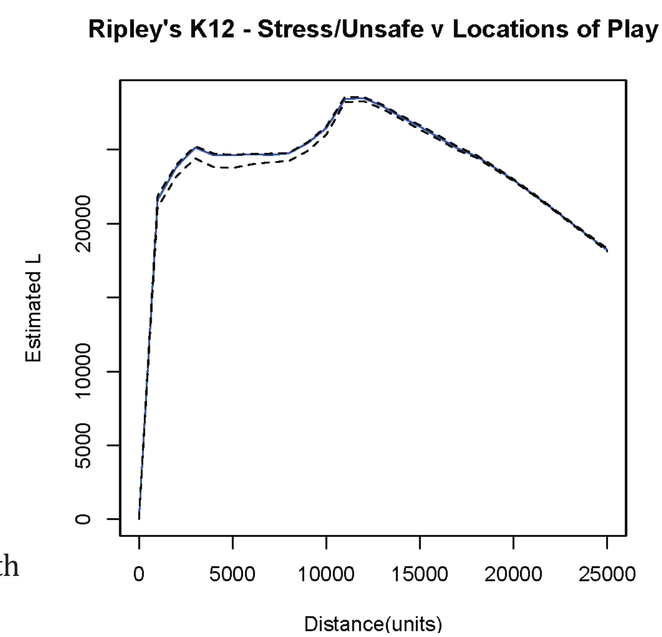


Figure 7.21: Cross K Function output for Stress versus Play locations

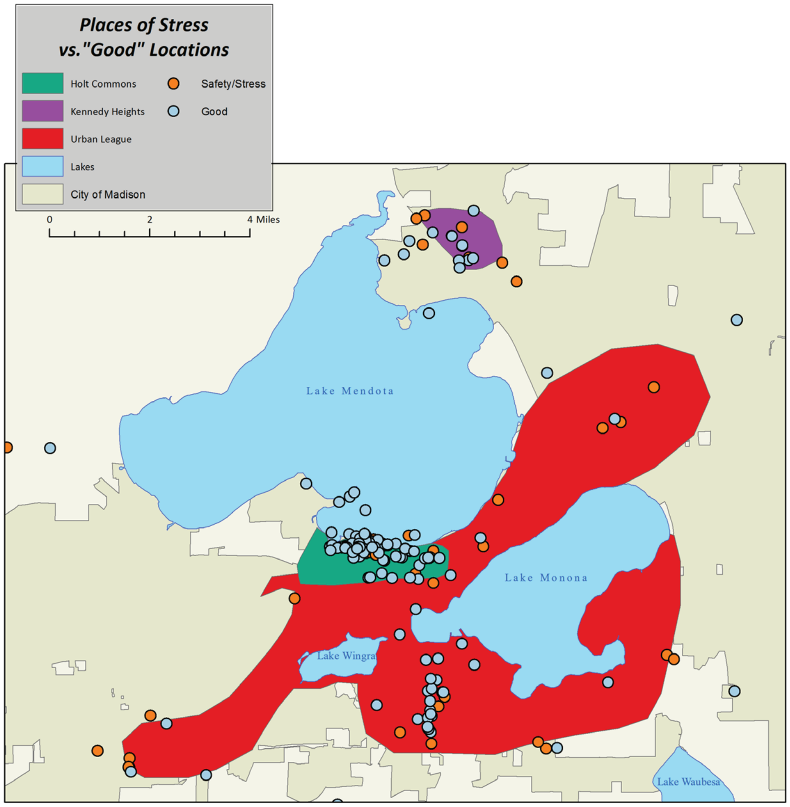


Figure 7.22: Map of locations of Stress/Unsafe versus Positives Locations from case study

outcomes (Rich-Edwards and Grizzard 2005). These insights illustrate the need to understand local context when attempting to develop hypotheses about shifts in infant mortality. By capturing and analyzing contributed information that targets specific questions, we are able to cast our gaze directly on questions of inclusion, racism and stress. In addition this method of data acquisition provides the opportunity to inquire about access to medical care, access to healthy food, and both positive and negative neighborhood and societal impacts. This milieu of data allows researchers to tease out the nuanced conditions that may play a role in the birth outcome question. Ultimately it allows both health practitioners and geographers to develop a more detailed understanding of the social landscape and to incorporate social epidemiological characteristics into a targeted hypothesis that can be tested following traditional epidemiological and medical research design. The next section describes the manner in which I envision this partnership may productively proceed.

7.5 Expanding the Method

The case study described above illustrates the type of questions that GeoInquiry can support and the potential for bringing a qualitative spatial research application

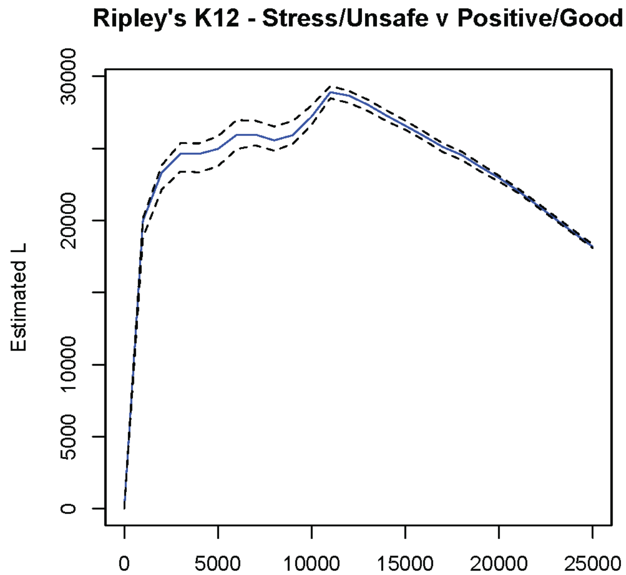


Figure 7.23: Cross K Function output for Stress versus Positive locations

to persons and areas of interest to a public health concern. This study demonstrated that a contextual picture could be painted to complement an area based deprivation index—a device commonly used in epidemiology (Ahern et al. 2003; Kirby, Coyle and Gould 2001; Krieger et al. 2003; Reagan and Salsberry 2005; Rich-Edwards et al. 2003). Given the broad potential it is important that a sound implementation strategy is developed to ensure that GeoInquiry is set up in a manner that both supports and encourages in-depth research.

As described above, the case study was initially conceived as part of a larger research project ongoing in infant mortality. As a geographer, it appeared prudent to focus on expanding the geographic context beyond simply a numeric framework as was proposed early in the larger project. As a white male with no explicit medical training it quickly became apparent that my potential to access the population of interest (Black Mothers) was quite low. Therefore a transdisciplinary partnership made sense as the best path forward. The questions described above illustrate the first step in this type of partnership. These questions were designed in conjunction with a public health community expert to both evaluate the potential to capture qualitative spatial data about community, healthcare, access and stress, as well to gather data on context that could be used in subsequent studies.

At the conclusion of the design of the questionnaire, the effort rests solely with the geographer who then implements the survey in the system. This involves working with the JSON document in Appendix A to construct both the question, as well as the spatial data type that will be captured in each question. Once the survey is constructed, the public input application is modified to ensure that the geographic footprint, as well as the center of the map captures the area of interest. These technical pieces do not require an expert in geography and computing technology, but this expertise can increase the efficiency of the study.

Once the survey is constructed, the partners in public health can take the online survey forward to the community of interest. This would involve securing either computing resources to take to the community or setting up sessions at community centers where online computing is available. The long-term presence of community teams from public health in these areas can create relationships that will make the study much more effective because they are more likely to be able to recruit participants because of the relationships. Further, these relationships will allow a more complex set of questions to be implemented. At this point the survey can either capture general contextual information as in the case study, or the survey can begin to ask more involved questions about birth outcomes to only a target population of mothers. The flexibility in the type and detail of the questions is illustrative of the flexibility inherent in this application.

Upon completion of the collection of the survey data by the public health team the transdisciplinary group would reconvene. At this point the data would be loaded into the coding application to begin the process of coding these data. Coding could occur with both geography and health experts to provide multiple modes of understanding to be applied. Once the data were coded the iterative process of visualizing the coded data, subsequently applying secondary codes and re-visualizing the data would occur. This process would lead to the development of hypotheses that could be tested in subsequent iterations. Also these data could be exported to ArcGIS or R for statistical and spatial analysis.

Once this process was complete, the team could construct further questions to implement in the system if the tool was considered to potentially yield deeper insights. At that point the cycle would begin anew. Or the team could take the generated hypotheses and implement other means of inquiry. Or a combination, which is most likely, could occur. Ultimately, the process could follow this course or only portions of it to provide the information both contextual and substantive that is necessary to support this type of public health inquiry.

7.6 Future Potential

The limited case study carried out to evaluate Messer's Deprivation Index was a good test to evaluate the potential of GeoInquiry to contribute contextual spatial information to supplement a quantitative index. I initially believed that during this initial conception of GeoInquiry, members of the community would find it useful to return to the system and continuously contribute information for their own purposes. This would in turn allow these free form data to be monitored, providing a richer understanding of the community. However, this seems much more unlikely after completing the case study data collection. In its current form, there is not incentive for members of the public to return to the system. Despite an application that displays the contributed data, the nature of the survey renders the content of little further use to the contributing population. While this finding was initially troubling, it is ultimately not an impediment, but rather the impetus to re-imagine the best practices for this system.

The coding and visualization modules provide a clean and lightweight portal for analyzing and visualizing these data. At the same time, these modules are not intended to replace more sophisticated spatial analysis or qualitative analysis software. Rather, these modules provide a first pass analysis mechanism by maintaining the link between the qualitative data and the spatial character of these data—a first pass that is robust enough to stand alone if needed.

The data input changes mentioned in chapter 6, such as implementing a paper based input mechanism, would result in three possible data input streams. The current module would continue to provide structured survey data in a mediated digital environment. These data would be collected in facilitated environments or over a limited time, on paper, following an expert-led introduction. The temporal character of the survey would be limited and the questions could be modified and re-launched to facilitate subsequent or new research aims. A possible third stream of data could be mined from social media, such as Twitter. Newly released packages for R can capture twitter data in a text file, with one of the options for capture involving both the geographic location of the Tweets as well as the content, including the coordinates of the Tweet. These data could be captured periodically or on a regular schedule from the Tweet stream, automatically loaded into the database supporting the NSM application and then coded and visualized in the same manner as the survey data. Before loading into the database, natural language processing algorithms could be run to select only those data that have content directly related to public health interests. The drawback to this method is that only points are captured. However, the constant nature and temporal relevance compensates for the geographic constraints on these data.

Expanding the workflow for data input to GeoInquiry also opens up suggestions for areas outside of public health where the system can be useful. Adding the Twitter stream opens up the possibility of real-time geographic surveillance of the population by public health officials. But redesigning the survey application as a targeted survey also opens up new domains. Urban planning, market research, environmental reporting, community organizing and many other fields could make use of this type of survey to target an understand of both spatial character and qualitative or attribute data.

Chapter 8—Conclusions and Future Directions

Over the past seven chapters GeoInquiry has been introduced as both a methodology and an internet-based tool for qualitative spatial data analysis. In the opening chapter the idea of GeoInquiry is established as combining the Geoweb, qualitative GIS and visualization into one idea. After establishing the literature base upon which GeoInquiry is developed, the idea is presented as a logical outgrowth of work in both the Geoweb/New Spatial Media and New Media. From here the technical design and implementation of GeoInquiry is described, along with both the user testing and case study data capture and analysis efforts. This chapter concludes the dissertation by articulating the significance, limitations and future research paths for GeoInquiry.

8.1 Significance

This study attempted to address one overarching research question: Can location-based qualitative data be constructively captured (from public users), consumed (by a new Internet based system), visualized and analyzed (by domain experts) using GeoInquiry?" To answer this question, the following steps were taken:

1. Design and implement GeoInquiry, from concept to deployment via the World Wide Web.
2. Evaluate GeoInquiry through both user acceptance and formal usability testing.
3. Conduct qualitative analysis of publicly contributed data using the GeoInquiry system.
4. Develop insights about how GeoInquiry can uncover and extend traditional analysis capabilities for contextualizing and hypothesizing about public health research problems—in this case augmenting a spatial deprivation index.

The four facets of the overarching research question—constructive capture, consumption, analysis and visualization of qualitative spatial data—were addressed through the four steps above. These conclusions about these four aspects of the

research are the most important findings of this work. The response to the four facets
of the research question are discussed subsequently.

The system effectively captured qualitative spatial data. While the capture process demonstrated limitations in terms of quick adoption and initial ease of use, the technical implementation proved successful. In a mediated environment, such as existed in the case study, the input module can effectively acquire targeted qualitative spatial data. Adding training modules before entering the submission questions would improve the data input process and make the capture mechanisms more effective. The ability to capture qualitative narrative along with geometries, in this case points and polygons, within a simplified web environment moves qualitative GIS research forward and opens this method to researchers with little GIS training.

The qualitative spatial data contributed by participants at the three sites during the case study, were easily consumed by the background database for use in the analysis and visualization modules. The design of the database structure allowed simple access to these data through PHP. Access to both the contributed spatial character of the individual questions, as well as the qualitative narratives was achieved using a lightweight web framework. The consumption of the submitted data was successfully implemented using a javascript/JSON/PostGreSQL framework, enabling the entire user interaction to occur in a web enabled environment.

The analysis modules changed considerably from the initial design. The originally planned single coding module was expanded to a three step analysis module as a result of the user testing. Expanding the single coding module to include a primary coding module, a intercoder reliability module and a secondary coding module has brought the module in line with traditional coding methods and enabled easier coding access and web-based analysis. The changes have also improved the systems ability to support collaborative research by walling off individual coding streams to avoid code revision during initial coding.

In terms of visualization, the system's design facilitating the visualization of the spatial character of the coded data in conjunction with a Code Cloud was successful during the user testing. Only minor adjustments to the nature of the display have been implemented; the core framework has remained intact and the user test participants indicated that the system provided a useful visualization method.

This research ties multiple, distinct areas of geographic inquiry into a single web framework and applies that framework in a case study focused on geography, health and deprivation. Prior to this work, attempts to connect qualitative analysis and geographic information were strictly limited to GIS. This limited the use of these tools to experts with experience in both GIS and qualitative methods. The results of this research incorporate qualitative inquiry and visualization into the basic Geoweb framework allowing for broad adoption by users beyond solely technical experts. Further, this system illustrates both a theoretical base and a methodology that connects qualitative analysis and spatial data and illustrates a potentially viable research tool that combines the two.

This dissertation contributes to the existing body of geographic research in a number of subareas including qualitative GIS, the Geoweb and participatory GIS. Through the case study, this research also demonstrates methodological applicability in studies of health and place as well as potential expansion to numerous other fields. In this study I have argued that the producer-consumer dichotomy of the Geoweb is limiting because it restricts interaction to either map making and/or map using. The model of GeoInquiry developed in this research demonstrated that including web-based qualitative coding and visualization through a simple web interface was possible. The GeoInquiry model improves on the producer-consumer dichotomy of the Geoweb by opening up analytical avenues within a Geoweb framework. The findings from this work indicate that GeoInquiry supports qualitative spatial data capture and analysis in the Geoweb. Applying GeoInquiry in a case study demonstrated that the analysis portion of the system is full of potential, however the input module has higher barriers to entry than expected. Both of these findings encourage further research to improve and expand the method. Ultimately this dissertation has demonstrated a new framework for opening both data capture and analysis to domain expert who may or may not have experience with GIS. Further, the tool opens analysis to ALL users who are motivated to work within a qualitative spatial analytical framework.

Using a Geoweb model expands qualitative geographic analysis beyond customized tools within the ArcGIS environment. Concomitantly, the potential to direct research in the Geoweb towards a convergence with GIScience is an outcome of this work. GeoInquiry as it is detailed in this dissertation can be implemented in a variety of research settings. At the same time, GeoInquiry has connections to multiple bodies of literature that ground the ideas and concepts underpinning GeoInquiry within a strong foundation of research.

Drawing inspiration from what Bunge implemented with the Detroit Geographical Expedition and Institute, GeoInquiry provides public users with control over the mapping of their own lived experience. Although the implementation is very different (in the form of a survey versus a collaborative mapping project), the opportunities for convergence are many. And Bunge's mapping framework is furthered into analysis that is open and accessible. Although Bunge's work resulted in analysis and maps that could provide provocative findings (i.e. "Where Black Pedestrians are hit by Cars in Detroit" figure 8.1), the technological ability of Bunge's team to provide access to the tools of creation and analysis were both limited, due to the manual nature of the cartographic process at the time, and limited to the population present at the time of the creation. GeoInquiry opens up the mapping and analysis processes beyond the expert user. Internet based tools that are well established and have technical requirements that are not so advanced as to impede widespread use make GeoInquiry a viable method outside of common GIS research frameworks. These low technical barriers allow the participants to access the GeoInquiry system and to create knowledge outside controlled research settings (provided access to the Internet) and without the need for advanced training in mapping practices.

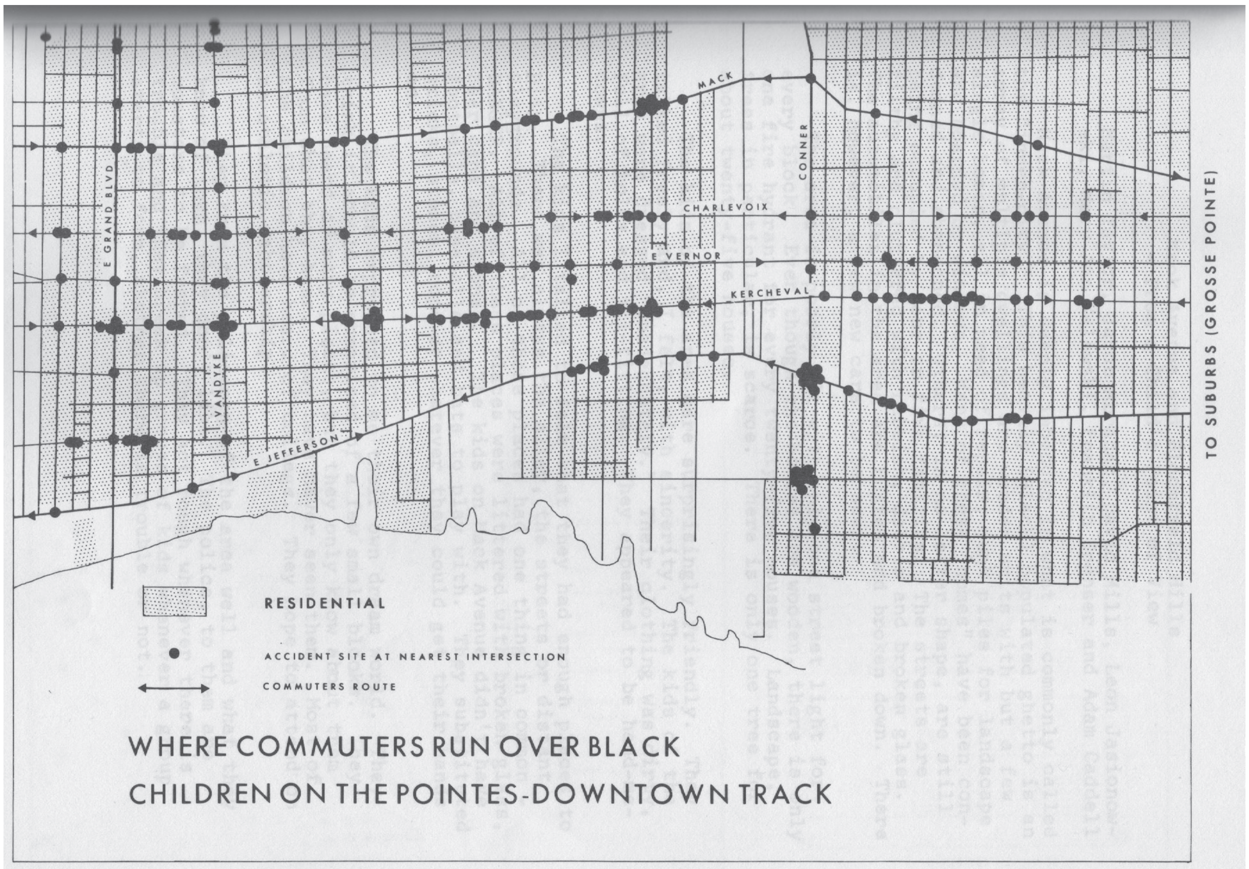


Figure 8.1: Map from Warren et al (1971) depicting locations where black pedestrians are hit by cars

8.2 Limitations

Ultimately, this dissertation focused predominantly on the technical implementation of a qualitative spatial inquiry application. The theoretical framework underpinning GeoInquiry is still nascent and offers opportunities for further exploration. Further development to more completely establish the theoretical context is a logical next step for GeoInquiry.

Despite the simplicity of options in the data capture module, the complexity of providing spatial information through an internet map is a limiting factor to both the

wider adoption of the method as well as the widespread distribution of the technology.
While a growing percent of the population has had contact with internet maps like Google Maps, users in this study repeatedly showed hesitation when contributing spatial data. The reasons for this trepidation are not clear. Speculative reasons for this hesitancy with the online map include the flagging geographic literacy in the United States or simply lack of experience in the use of internet technology to contribute to a map—the ultimate reason is not clear and is beyond the scope of this study. Reducing the digital data capture to highly mediated or technologically savvy project groups is not damaging to the overall method of GeoInquiry. The potential of linking the GeoInquiry analysis modules with a paper-based data capture methodology such as LocalGround offers a robust work-around for the technology barrier. Coupling multiple means of data capture with training and education can help to prepare participants using GeoInquiry to approach the data input with confidence. In a truly open implementation there are potentially more challenges, for example support would be limited to help menus only and participants would have to be motivated to contribute without a researcher prompting their participation. As Internet maps continue to grow in number, the comfort with this type of data submission should increase.

The technological requirements to implement a GeoInquiry system with customized questions can limit the methods adoption. However, the GeoInquiry analysis tools could be offered through a central server with a project-based database table implementation. By centralizing the GeoInquiry modules, while providing remote database access, the technological barrier to implementation can be alleviated. The analysis modules will continue to be refined, per the changes found from the user study, with the hope that those change will allow the system to be deployed widely in the near term.

8.3 Future Work

One of the first pathways for future research is implementing the Local Ground collection device and constructing a vectorization algorithm to enable data captured from this device to load properly into GeoInquiry. Once these technical barriers are solved, it will be critical to implement the modified method in a field trial. Preferably this new field effort would demonstrate the utility of the GeoInquiry methodology in a new domain outside of health to highlight the extensibility of the system.

The growth of social media like Twitter, Facebook, Google+, Foursquare, Gowalla and others is a component that needs to be added to this work. From a standpoint of user contribution, these sites possess a wealth of data—more and more commonly with a spatial footprint. Consumption of these datasets is becoming easier all the time, with packages appearing in software like R to capture and consume Twitter data based on specific keywords and the presence of geographic coordinates. Removing the focus from the data capture side of GeoInquiry by consuming Twitter and other social media would be valuable. Work by MacEachren and colleagues (MacEachren et al. 2011), illustrates the potential of these data as a means of understanding content specific questions such as the emergence of disease like flu in a small geographic area. Incorporating remotely collected data from Twitter would enable the analysis proposed in GeoInquiry to extend into new domains—essentially any domain where spatial information could yield new insights—without requiring deployment of the input module. Data from sources like Twitter could be used to populate the qualitative analysis components of GeoInquiry, either in conjunction with survey data or in isolation.

Along with the qualitative analysis, one important area to expand in the near term are the theoretical underpinnings of this work. New Spatial Media is a powerful, but nebulous concept and GeoInquiry could benefit by expanding the theoretical links with not only Geoweb and New Spatial Media, but also through an intensive inquiry into the linkages back to Bunge's work in Detroit. The landscape around this area of research is changing rapidly. It is short-sighted to believe that the conceptualization of GeoInquiry has reached a conclusion with this work. Embarking on a pathway of exploration about not only the theoretical underpinnings of GeoInquiry, but also potential futures, in terms of research and practice applications, is a critical next step—one that demands to be initiated immediately following the conclusion of this work. This dissertation has set a stage for wider development of the theoretical connection of GeoInquiry while simultaneously leaving the pathway open for other conceptualizations of GeoInquiry to develop. In the near future it is important to extend the practical work further into the theoretical and provide a clear path of theory and research that effectively links to the legacy of Bunge, Elwood and others.

8.4 Conclusions

The Geoweb offers an exciting framework in which to implement a web based qualitative spatial analysis methodology such as GeoInquiry. Earlier implementations of qualitative spatial analysis have remained rooted in the literature of both CAQDAS and GIS software paradigms (Jung 2009; Jung and Elwood 2010; Knigge and Cope 2006; Kwan and Ding 2008). Working only in the highly technical software paradigms of both CAQDAS and GIS has consistently proved both limiting in terms of wider adoption, and in terms of expansion and modification. My research shows that not only can the Geoweb model of producer-consumer dichotomy can be integrated to include an analytical component, but the idea of qualitative spatial analysis can be expanded into the Geoweb to offer the potential for wider access and adoption.

The research reported here shows that qualitative spatial data analysis and the Geoweb are complicated subareas of GIScience with limited overlap. Both domains, however, have the potential to be connected to provide a rich environment for qualitative spatial data analysis and capture. Support for other forms of qualitative inquiry, like narrative analysis or ethnography, will only enhance the system. Incorporating and expanding the foundation of both participatory geography and the Geoweb, may offer the most effective path to continuing to connect qualitative spatial inquiry and the Geoweb.

The potential breadth of applications of this methodology, coupled with GeoInquiry's technical requirements make this not only an exciting development, but also a challenge to balance usability with the multitude of analysis options that an individual may desire. But technology alone will not make GeoInquiry a useful and deployed method. Developing the theoretical underpinnings along with the technical improvement and continuing to demonstrate the potential of this method in multiple domains is the best pathway forward. This study has contributed a novel method for the analysis of qualitative spatial data. This new path can help to expand adoption of qualitative GIS.

This research has demonstrated the potential for GeoInquiry as a method for qualitative spatial data capture and analysis. GeoInquiry builds off of numerous bodies of literature including new media, geoweb, social epidemiology, health geography, PPGIS and geovisualization. This broad foundation provides a number of connections to the literature upon which GeoInquiry can be situated. The simple, web-based structure designed in this dissertation for GeoInquiry showed both in formal user testing, and in basic SUS scoring that it was usable and had future potential. This dissertation demonstrated that combining the Geoweb with GIScience areas such as qualitative GIS and visualization could yield a new framework for qualitative spatial research. The interdisciplinary nature of this work enhanced the resulting GeoInquiry system. Without the input of experts in qualitative research, usability studies, public health and participatory research, GeoInquiry would have been deficient. Ultimately, GeoInquiry demonstrates that capturing qualitative spatial data and analyzing and visualizing these data is not only possible in a web-based environment, but has potential for both research and, most importantly, further use in many settings.

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“userLabelsFeatures” : true,

“columnType” : “GEOMETRYCOLLECTION”

}

]

},

{

“questionID” : 10,

“questionType” : “multiplechoice”,

“answerField” : “field11”,

"questionText" : "Are there things about your neighborhood that worry you or create stress?",

"questionOptions" : [

"Yes", "No"

],

"columnType" : "character(15)",

"subquestions" : [

{

"questionType" : "drawing",

"geometryType" : "point",

"answerField" : "field11sub1",

"questionText" : "If these stressful things are in a certain place and you haven't noted it already, please mark this on the map.",

"userLabelsFeatures" : true,

"columnType" : "GEOMETRYCOLLECTION"

}

]

}

]

Field Name	*Data Type*	*Description*
FID	Object ID	Auto Generated Object ID from ArcGIS
Shape	Geometry	Point Geometry Generated in ArcGIS
SITE	Text	ID of the site where the interview occurred
F501	Text	Radio Button Response
F502	Text	Contributed Text
F5011	Text	Yes/No Response
CODE1	Short Integer	Code Generated during Analysis: Values 0-Absent, 1-Present
CODE2	Short Integer	Code Generated during Analysis: Values 0-Absent, 1-Present
CODE3	Short Integer	Code Generated during Analysis: Values 0-Absent, 1-Present
CODE4	Short Integer	Code Generated during Analysis: Values 0-Absent, 1-Present
CODE5	Short Integer	Code Generated during Analysis: Values 0-Absent, 1-Present
CODE6	Short Integer	Code Generated during Analysis: Values 0-Absent, 1-Present

System Usability Scale

	Strongly disagree				Strongly agree
	1	2	3	4	5
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very cumbersome to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

Script:

Introduction:

Thank you for agreeing to participate in my study of a geoinquiry tool suite. During this session you will be asked to contribute data based on a series of questions. You will be asked to contribute information both on a map as well as in text about healthy and unhealthy places and situations where you live. There is no time limit so feel free to work through the questions at your own pace.

The session will follow a planned script. You will begin by choosing a username and password. Any combination is fine. These are only used in the event you have to log back into the system--at which time you will be able to skip directly back to the last question you saw. Please fill this section out now.

Next you will see some basic demographic questions. Please take a moment to fill these three questions out.

Now you can begin the survey. One thing to mention though is that the system will reset if you use the ENTER key, so please avoid using enter when answering the questions.

If you have any questions during the survey please ask.

Completion:

Thank you for completing the computer portion of this test. Here is a Usability form. Please take a moment to answer the 10 questions here.

Thank you for completing the usability form. In order to receive payment I need you to fill out the following form for records required by the University. Here is your payment and thank you for participating!

UNIVERSITY OF WISCONSIN-MADISON
Research Participant Information and Consent Form

Title of the Study: Volunteered Geographic Information for Qualitative Spatial Research in Health and Place

Principal Investigator: Samuel F Dennis Jr (phone: 608-262-9156) (email: sfdennisjr@wisc.edu)

Student Researcher: William R Buckingham (phone: 608-262-9156)

DESCRIPTION OF THE RESEARCH

You are invited to participate in a research study about the potential of geographic data or information provided by the public. You will be asked to answer questions about your neighborhood and health. You will also be invited to evaluate the software you will use and provide suggestions for improvement. At the conclusion of the study you will continue to have access to the mapping software to continue to contribute information and learn about your community.

You have been asked to participate because you have an interest in your health and your community. Your expertise about your neighborhood and your willingness to contribute your information to a map is appreciated.

The purpose of the research is to evaluate internet mapping as a potential research and collaboration tool. Additionally, this research hopes to gain insights into the health of the community.

This study will include adults who live in Dane County, WI.

This research will be conducted in settings with computer and internet access. Ideally, this research will be conducted at a location near the neighborhood in which you live.

WHAT WILL MY PARTICIPATION INVOLVE?

If you decide to participate in this research you will be asked to use the internet to answer questions about both your neighborhood and your health. You will both draw on a digital (Google) map, and answer questions about your drawing. You will also be asked to describe any problems you had while using the map.

You will be asked to complete 2 surveys.

Your participation will last approximately 45 minutes within 1 session.

ARE THERE ANY RISKS TO ME?

We don't anticipate any risks to you from participation in this study.

ARE THERE ANY BENEFITS TO ME?

There will be no direct benefit to you for participating in this study.

HOW WILL MY CONFIDENTIALITY BE PROTECTED?

While there will probably be publications as a result of this study, your name will not be used. Only group characteristics will be published. Your responses will only be available as a part of the group.

If you participate in this study, we would like to be able to quote you directly without using your name. If you agree to allow us to quote you in publications, please initial the statement at the bottom of this form.

WHOM SHOULD I CONTACT IF I HAVE QUESTIONS?

You may ask any questions about the research at any time. If you have questions about the research after you leave today you should contact the Principal Investigator Samuel F Dennis Jr at 608-262-9156. You may also call the student researcher, William R Buckingham at 608-262-9156.

If you are not satisfied with response of research team, have more questions, or want to talk with someone about your rights as a research participant, you should contact the Education Research and Social & Behavioral Science IRB Office at 608-263-2320.

Your participation is completely voluntary. If you decide not to participate or to withdraw from the study it will have no effect on any services or treatment you are currently receiving.

Your signature indicates that you have read this consent form, had an opportunity to ask any questions about your participation in this research and voluntarily consent to participate. You will receive a copy of this form for your records.

Name of Participant (please print):______________________________

_______________________________________ _______________

Signature Date

_________ I give my permission to be quoted directly in publications without using my name.

University of Wisconsin-Madison
FWA00005399

Protocol: SE-2010-0843
Approved: 1/21/2011
Expires: 1/20/2012

NIGHT	ASSIST
ASSAULT	JOBHELP
STABBING	TECH
FIGHTS	BADFOOD
DRUGS	NO JOBS
PEOPLE	NO REC
CRIME	LACKACCESS
POLICE	INSURANCE
GANGS	RIDE
BUSYROAD	BIKE
GUNS	BUS
EVERYTHING	CAR
NATURE	TAXI
PEOPLE	WALK
INCLUSION	WHO OPEN
COMMUNITY	WHO CLOSED
RECREATION	STUDENTS
STORES	FRIENDS
TRANSPORT	NEIGHBORS
QUIET	EXERCISE
SAFE	GOOD FOOD
QUALITY	PROXIMITY
CLOSE	LIBRARY
FREE	LEISURE
CONVIENENT	SPORTS
GOOD DOCTOR	

Script:

Introduction:

Thank you for agreeing to participate in my study of a geoinquiry tool suite. During this session you will be asked to contribute data based on a series of questions. These questions will ask you about your perceptions

The session will follow a planned script. First, I will ask you some questions about your use of both the internet and GIS and online maps specifically. I will also ask some general demographic questions. Next, I will ask you to answer a series of questions using the interface to interact with the data and solve the posed problem while talking aloud as you work. Again, your use of the computer will be recorded and you will be prompted to continue talking periodically.

If you don't have any questions we will begin:

1. Type: Researcher General Public
2. Years Using the Web: ______________
3. Age Group: 18-24 25-34 35-44 45-55 over 55
4. Gender: Female Male
5. How often do you use the internet?

   Daily Weekly Monthly Occasionally Never
6. What percent of your time online is spent on email? __________
7. What percent of your time online is spent surfing the web? __________
8. How often do you use maps on the web?

   Daily Weekly Monthly Occasionally Never
9. How often do you use a Geographic Information System?

   Daily Weekly Monthly Occasionally Never
10. Describe your level of experience with GIS and mapping technologies.

    GIS Expert Some Use of GIS I have used GIS before Never Used GIS

11. What do you usually do on the internet? *(e.g., email, use reference materials such as encyclopedias and dictionaries, read news, curriculum activities, games, entertainment etc.)*

____

____

____

____

As an introduction to the study I am going to ask you to perform a simple multiplication task. I want you to talk out loud and describe each step as you complete this problem to practice describing your actions step by step.

Multiply 63x25 and talk through your steps.

Specific Tasks

In this portion of the session, I will ask you to complete a series of tasks on the computer screen. While you complete the task I want you to talk aloud and tell me what you are doing and thinking.

1. Adding your neighborhood – **Please use the interface to construct a neighborhood shape. Follow the directions on the screen to complete the task.**

[**Facilitator** asks this question out loud. Try to use the wording listed here. Do not lead the user to the answer. Do not help the user answer the question. Remind the user we are testing that software, not them. Encourage them to think out loud. ("what words are going thru your mind?", "what are you looking for?")

Observe known click stream: **[Facilitator checks each step user clicks]**

___ Switch to Drawing

___ Click to Create Nodes

___ Double Click to Complete Drawing

___ Click Next to Complete the Task

If user does not follow the known path, what did s/he click on?
[Facilitator notes different paths/dead-ends]

User's Verbal comments: [Facilitator notes user's verbal comments]

Any suggestions for making this (task) easier? [Facilitator asks user]

0 1 2 3

[Facilitator indicates difficulty rate of this task for this user based on Facilitator's opinion]

0 = User completed task with zero difficulty. (Zero Frustration)

1 = User completed task with only minor problem(s). (Little Frustration)

2 = User completed task, but it required more effort/time/dead-ends than the user expected. (Medium/High Frustration)

3 = User did not complete task. (Point of Failure)

2. Adding a Point: **Follow the screen prompts to answer the Question on the Screen and complete the subquestions.**

Observe known click stream:

___ Radio Button Choice

___ Choose Draw and create point

___ Label Point

___ Input Text in Text Block

___ Click Next to Complete Task

If user does not follow the known path, what did s/he click on?

User’s Verbal comments:

Any suggestions for making this (task) easier?

0 1 2 3

3. Adding campus – **Please use the interface to construct a campus shape. Follow the directions on the screen to complete the task.**

Observe known click stream: **[Facilitator checks each step user clicks]**

___ Switch to Drawing

___ Click to Create Nodes

___ Double Click to Complete Drawing

___ Click Next to Complete the Task

If user does not follow the known path, what did s/he click on?
[Facilitator notes different paths/dead-ends]

User’s Verbal comments: [Facilitator notes user’s verbal comments]

Any suggestions for making this (task) easier? [Facilitator asks user]

0 1 2 3

0 = User completed task with zero difficulty. (Zero Frustration)

1 = User completed task with only minor problem(s). (Little Frustration)

2 = User completed task, but it required more effort/time/dead-ends than the user expected. (Medium/High Frustration)

3 = User did not complete task. (Point of Failure)

4. Adding a Point: **Follow the screen prompts to answer the Question on the Screen and complete the subquestions.**

Observe known click stream:

___ Radio Button Choice

___ Choose Draw and create point

___ Label Point

___ Input Text in Text Block

___ Click Next to Complete Task

If user does not follow the known path, what did s/he click on?

User's Verbal comments:

Any suggestions for making this (task) easier?

0 1 2 3

5. Coding: **The next screen presents the data that were contributed from a prior test. Please use the buttons and your judgment to create qualitative "codes" to summarize the data points**

Observe known click stream:

___ Click Next Button

___ Type Code in text box and Click Add

___ Check Code

If user does not follow the known path, what did s/he click on?

User's Verbal comments:

Any suggestions for making this (task) easier?

0 1 2 3

6. Second Coding: **The next screen presents the data that were contributed from a prior test and previously coded. Please use the buttons and your judgment to further the qualitative "coding" to summarize the data points**

Observe known click stream:

___ Click Next Button

___ Type Code in text box and Click Add

___ Check Code

If user does not follow the known path, what did s/he click on?

User's Verbal comments:

Any suggestions for making this (task) easier?

0 1 2 3

7. Visualization 1: **You are interested in where the code "dark" occurs. Use the interface to evaluate how prevalent the code fear is and where it is located geographically**

Observe known click stream:

___ click on "Fear" in word cloud

___ Verbally describe the prevalence

___ Verbally describe the location

If user does not follow the known path, what did s/he click on?

User's Verbal comments:

Prevalence:

Location:

Any suggestions for making this (task) easier?

0 1 2 3

8. Visualization 1: **You are interested in where the codes "nature" and "people" overlap. Use the interface to evaluate how prevalent the code Nature is when the code People is also present and how these codes are related geographically**

Observe known click stream:

___ click on "Nature" in word cloud

___ Verbally describe the prevalence

___ Verbally describe the location

If user does not follow the known path, what did s/he click on?

User's Verbal comments:

Prevalence:

Location:

Any suggestions for making this (task) easier?

0 1 2 3

Post Task Steps

Great! Now that we have completed the online testing, please take a moment

and tell me what you liked or disliked. Also please mention any ideas for improvement that you may have.

Finally I have a series of 7 questions I would like to ask you:

GeoInquiry web site Feedback

What features of the **GeoInquiry** web site were vague or confusing to you, if any?

____

What is your impression about navigating the site? Does it seem easy or difficult?

What makes it that way? ____

What else should be included on the **GeoInquiry** web site? ___________________________

What did you like best about the site? ____

What did you like the least? ____

Do you think some people would have problems using the **GeoInquiry** web site?

What kinds of people? What kinds of problems? __________________________________

Would you like to make any other comments about **GeoInquiry**?______________

Thanks for participating! This concludes the test.