Grounded visualization: integrating the analysis of qualitative and quantitative data through grounded theory and visualization

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Abstract. Our purpose in this paper is to conceptualize and demonstrate an integrated analytical method for using both qualitative and quantitative data through geographic information systems (GIS) and ethnography. We acknowledge that the use of both types of data has been possible in GIS for some time, particularly for representation purposes. However, a recursive integration of different forms of data at the *analysis* level has been less explored and minimally theorized. Drawing on recent work in critical GIS and feminist perspectives, we suggest that visualization offers a strong technique for this effort but we approach it from the analytical base of grounded theory. Thus, we present an example of how grounded theory and visualization might be used together to construct an integrated analysis strategy that is both iterative and reflexive, both contextual and conceptual. We use Knigge's work on community gardens in Buffalo, New York, to provide a substantive example of the proposed methods.

"Qualitative data are sexy."

Miles and Huberman (1994, page 1)

"In the context of data exploration, 'multiple representations' refers to the various methods of symbolizing the data. The postmodernist should be interested in this approach because it concurs with the notion that there is no single 'correct' way of visualizing data. Additionally, however, the postmodernist would be interested in the multiple meanings and potentially hidden agendas found in a particular thematic map"

Slocum (1999, page 15)

"[S]urely all research is concerned to some degree or other with exploring and scrutinizing an idea/presumption/hypothesis/question in an iterative process which moves back and forth between research questions and evidence, regardless of the eventual methods chosen to carry out the research."

Philip (1998, page 268)

The 'iterative process' that Philip refers to (above) is a recursive, reflexive set of research practices in which data gathering, analysis, and representation do not proceed along a linear course, but, rather, proceed through multiple iterations in what is often a messy and fluid manner. We were struck by the fact that this kind of purposeful recursive data exploration is a shared characteristic of both grounded theory and spatial data exploration and visualization and wondered if by engaging at the level of analysis we could further break down the boundaries between qualitative and quantitative research. Thus, in this paper, we are not merely advocating the use of multiple methods or sources of data, but proposing a research strategy at the *analysis* level, which will more fully integrate diverse forms of data toward building theories and coming to strong conclusions. Drawing on insights from feminists, critical geographic

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information systems (GIS), and reviews of grounded theory and visualization, we argue that the key to this development lies in a mindful yet open-minded progression through the research process. Four areas of commonality between grounded theory and visualization build the platform for the analytical approach we call 'grounded visualization': they are both *exploratory*, they are both *iterative and recursive*, both enable simultaneous consideration of *particular instances and general patterns*, and both encourage *multiple views* and perspectives for building knowledge.

Qualitative research and GIS: review and prospect

In recent years, qualitative research has been increasingly recognized as an important element in human geography, particularly in linking individual experiences and agency with understanding how social, economic, and political processes are constructed, maintained, legitimized, and resisted. In turn, the strength of qualitative research in geography has benefited greatly from the critically reflective perspectives of feminists, race theorists, postcolonialists, queer theorists, and many others as the methods of anthropology, sociology, and other disciplines have been adopted, adapted and debated. These critical perspectives have, in particular, raised methodological and epistemological issues of positionality, power relations between the researcher and researched, the varied construction of knowledge and 'truth', situatedness and context, multiple subjectivities, representation, and the politicized nature of all social research. Through these insights, a new set of discussions is taking place around insuring rigor in qualitative research without collapsing into awkward quantitative-based measures (Bailey et al, 1999; Baxter and Eyles, 1997), developing constructive methods of writing and representing our work and the (often marginalized) people who participate in our research (Browne, 2003; Moss, 1995; Pratt and The Philippine Women Centre, 1999), engaging with ethical issues (Kobayashi, 2001), and teaching a new generation of qualitative geographers (Hay, 2001; Limb and Dwyer, 2001).

Early critiques of GIS by social theorists raised significant issues concerning how technologies are used in ways that rigidify power structures while simultaneously *masking*—through the legitimizing strength of 'science' and gee-whiz displays—the possibility of multiple versions of reality or 'truth', socially constructed knowledges, and other sources of subjectivity that are inherent in all social research (Miller, 1995; Pickles, 1995). Critics called for greater accountability in the uses of GIS (at least within academia), suggested more open data trails, and challenged the underlying epistemologies of much GIS practice as adopting the 'God's-eye view' (Haraway, 1996 [1991]) of putatively objective research [for an excellent review of GIS and society debates and issues see Schuurman (2004)]. In the past ten years many of these challenges have been addressed, with fruitful outcomes such as the development of public participation GIS (PPGIS), forums on 'critical GIS', special issues of journals, recognition of fragmented and multiple realities in GIS textbooks (such as Longley et al, 2001), university courses and programs on 'geographic information and society' (for example, see http://www.geog.buffalo.edu/~mcope/courses/geo594), and many workshops and conference sessions. Recently, feminists and critical geographers, including some who use GIS in their own work, have engaged with issues of power, knowledge, and context (McLafferty, 2002) as well as issues of subjectivity, access, discourse, and meaning in major geography journals (see Kwan, 2002a; 2002b; Nightingale, 2003; Schuurman, 2002; Schuurman and Pratt, 2002). We take the recent developments in feminist perspectives on GIS as a launching point for our development of 'grounded visualization'.

Feminist contributions

> "A more feminist cyborg will make GIS and geography a more equitable place not only for women but for many underrepresented and less powerful groups."
>
> Schuurman (2002, page 261)

Feminist engagements with GIS have been particularly apropos for qualitative researchers who are interested in GIS because of feminist concerns for subjectivity, positionality, difference, reflexivity, context, socially constructed or situated knowledge, power, everyday life, meaning, discourse, and the relationships between researchers and 'subjects'. For example, Kwan's (2002a; 2002b) work on identifying ontological and epistemological areas of commonality between feminist geography and GIS has provided a framework that is valuable to qualitative researchers. Kwan suggests that "the vision enabled by GIS can be reclaimed from the abstract, disembodying practice of masculinist technoscience through recorporealizing all visualizations as embodied and situated practices" (2002a, page 649). Drawing on Haraway's (1996 [1991]) concepts of 'feminist visualizations' and 'situated knowledge', Kwan argues that context, subjectivity, and multiple perspectives can and should be integrated into GIS practice. Similarly, in her example of a grass roots community GIS project, McLafferty (2002, page 265) identifies the key issues of knowledge, context, and power as areas of convergence for GIS and feminism, stating "the fields intersect in their concerns with the grounded contexts of everyday life and in dealing, either implicitly or explicitly, with conceptions of power and empowerment."

Through their own empirical work, Kwan (2000), McLafferty (2002), Nightingale (2003), Pavlovskaya (2002), and others have demonstrated the diverse potential for using GIS with feminist goals, epistemologies, and research topics. In addition to benefiting from increased attention to issues such as subjectivity, situated knowledge, and multiple meanings, qualitative researchers of all persuasions can make use of these projects by building on the insights of feminist authors in the task of breaking down the perceived divide between qualitative and quantitative work. Kwan states, "the representational possibilities of GIS can be used for enacting creative discursive tactics that disrupt the dualist understanding of geographical methods—where visual images, words, and numbers are used together to compose *contextualized cartographic narratives in geographical discourse*" (2002b, page 272, emphasis added).

From more of a human ecology approach (see also Heasley, 2003; Jiang, 2003; Robbins, 2003), Nightingale (2003) makes the argument that employing mixed methods strengthens research not only when the methods are complementary, but also when the findings are contradictory. She found in her study of community forests in Nepal that aerial photographic data suggested one interpretation of changes in the forest, whereas oral history interviews revealed a different story of these changes. She makes the point that, in fact, both 'stories' were correct: "It was only by analyzing the *incompatibilities* between the [air]photos (that showed minor change) and the [oral] histories (that insisted resources are much more accessible) that I was able to appreciate the inherent silences, and hence the *partiality*, of both methodologies (2003, page 85, emphasis added). In other words, multiple methods need to be considered not only in their potential for 'triangulation' (corroboration and confirmation), but also for their potential "silences and incompatibilities that become evident when datasets produced by diverse methodologies are brought together" (page 80).

Pavlovskaya (2002) presents another excellent example of integrating methodologies. In an attempt to "create alternate representations of urban transformation" (page 282), Pavlovskaya sought to reconcile fine-resolution quantitative spatial data with information from in-person interviews in post-Soviet Moscow. She used grounded

theory to analyze data from the interviews and to build a theoretical framework to construct a household-level perspective on changes in the economy and the city. Pavlovskaya also used GIS to "create dozens of maps depicting urban change in a relatively short time" and found that data exploration was straightforward because "digital databases can easily be remapped, rescaled, and regraphed, and thus analyzed in a variety of ways" (page 284). Her flexible, recursive, and reflexive strategy resulted in the discovery of patterns and explanations for their underlying processes in a way that would have been impossible if only one set of analyses had been used.

Thus, although the tools and techniques of quantitative and qualitative data collection (surveys, interviews, etc) may remain basically the same, there is great potential for reenvisioning their use, the surrounding epistemologies, and the resulting analyses of integrated research, whether through 'contextualized cartographic narratives' or by comparing inconsistencies. New analytical methods are emerging from the ground up; that is, feminist researchers—with their commitment to understanding difference, context, and power—who are using GIS are actively constructing new ways of bringing qualitative and quantitative work together. We hope that this paper will contribute to this endeavor.

Constructing a grounded visualization

"Combining ethnographic data and GIS methods helps researchers see both 'context' and 'content' in a spatial dimension. This alternative way of representing data may identify issues that would not be apparent otherwise."

Skinner et al (2005, page 230)

"Although most technical barriers to data integration have fallen, the analysis of mixed data types—quantitative and qualitative—in GIS remains a challenge. How can these diverse types of information be fused to generate new knowledge?"

McLafferty (2002, page 266)

To at least partially answer the challenge posed here by McLafferty, we propose adopting two analytical methods—grounded theory (based in qualitative research) and visualization (based on quantitative GIS)—to explore their potential areas of commonality with the goal of constructing an integrated analytical method we are calling 'grounded visualization'. Although thorough reviews of each of these approaches are not possible here, there exist excellent guides and handbooks for each.[1] Brief overviews of the two approaches are provided here as a way to focus on their areas of commonality.

Grounded theory

Grounded theory involves the collection, coding, and categorization of qualitative data (transcribed text from interviews, focus groups, and researchers' notes, photographs, and other images, etc) toward enabling themes to emerge through iterations of 'constant comparison'. Geographers have recently begun to pay more attention to grounded theory as a qualitative methodology, adopting it from its roots in sociology (for a review see Strauss and Corbin, 1998).

The purpose of grounded theory is to build theories from data about the social world such that theories are 'grounded' in people's everyday experiences and actions. The methods of grounded theory are iterative, reflexive, and inductive; that is, they involve multiple stages of collecting data, coding and analyzing them, reflecting on

[1] For grounded theory see Creswell (1997), Dey (1999), Miles and Huberman (1994), Silverman (2000), and Strauss and Corbin (1998). For visualization, see MacEachren and Taylor (1994), Slocum et al (2005), and Slocum (1999).

emerging themes, collecting more data targeted to initial theories, and constantly comparing the insights that evolve. Grounded theory operates at both concrete and abstract levels as it "seeks both to represent concrete situations in their complexity and to produce abstract theory" (Hammersly, 1992, page 21; quoted in Bailey et al, 1999, page 174). Researchers using grounded theory are concerned with people's subjective experiences of everyday life as they are influenced by broader historical, geographical, and structural contexts, which makes grounded theory a useful tool for incorporating both human agency and social structures, both small-scale and large-scale social phenomena, and both specific instances and broader trends. Thus, grounded theory has a basic compatibility with GIS in that it enables or demands attention to both the particular and the general. Further, grounded theory provides strong potential for much of the current work in critical geography through its central focus on subjectivity, difference, meanings, discourse, partial or situated knowledges, and power, as well as being open to geographical concerns of scale, place, context, and flows:

> "Grounded theory demands critical inquiry: it starts from the premise that the world is in a constant state of flux, and that individuals are not all equally placed; it seeks not only to uncover conditions that are relevant to the research question, but also to build in process and change by exploring how individuals respond to changing conditions and to the consequences of their actions" (Bailey et al, 1999, page 173).

One of the most important elements of grounded theory is the practice of *coding*, which is a way of evaluating and organizing data in an effort to understand meanings in the text (or images) and helps the researcher to identify categories and patterns, which can in turn be investigated through additional data collection and/or analysis.[2] Coding is a process of both data reduction (for example, making hundreds of pages of notes easier to grasp) and data analysis (that is, by evaluating data, looking for internal consistencies or inconsistencies, and identifying patterns, the researcher is *analyzing* her or his findings). In this way, coding qualitative data is similar to processes in GIS; both involve dealing with data-rich environments and making sense of patterns and processes.

Grounded theory is not, however, strictly limited to the practice of qualitative research. Rather, it is an approach to data gathering, analysis, and theorizing that encourages a deep level of flexibility on the part of the researcher, part of which involves openness to using multiple methods. So, although grounded theory is used primarily in qualitative work, the goal is actually a simultaneous commitment by the researcher to creativity and a systematic approach, which uses appropriate techniques as needed. Grounded theorists are, therefore, more concerned with the reflexive process that creates a 'flow of data' toward emerging theories than with whether the data are numerical or text and images: "[qualitative] researchers must think of quantitative procedures as representing not the enemy but rather a potential ally to theory building when its use seems appropriate" (Strauss and Corbin, 1998, page 32).

Finally, grounded theory is deeply concerned with enabling *rigorous* qualitative research in which theory is held accountable to empirical data (Dwyer and Limb, 2001). Recent insights and debates on the evaluation of qualitative research in geography have called for more and better practices of bringing transparency to scholarly work by including open discussions of method in papers, presentations, and reports (Baxter and Eyles, 1997). Grounded theory is a robust method of insuring rigorous research for several reasons. First, grounded theory requires evaluation of findings and theories and reflection on the role of the researcher throughout data collection,

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[2] For further reviews of coding see Miles and Huberman (1994) and Strauss (1987), and for examples from geography see Cope (2003) and Jackson (2001).

analysis, and representation processes. Second, grounded theory "requires the researcher to be clear and open in reporting research procedures so that overall findings may be judged in terms of the validity and credibility of the data, the plausibility and value of the findings, the theoretical formulations, the adequacy of the research process generated, and the empirical grounding of the research findings" (Bailey et al, 1999, page 174). Third, the methods of analysis themselves are becoming better known in geography, which enables researchers to reference their approaches more concisely (for example, "I used axial coding to follow the theme of attachment to place"), and not to use excessive amounts of space in a journal article to describe the step-by-step minutiae of a particular analytical process. Fourth, there is an increased recognition that the standards of rigorous quantitative work cannot and should not apply to qualitative work; however, there is still an imperative to insure robust work: "We need methods that are credible, dependable, and replicable in *qualitative* terms" (Miles and Huberman, 1994, page 2, emphasis in original; see also Baxter and Eyles, 1997). In summary, then, grounded theory is an attempt to acknowledge analysis to be a social practice with all its attendant subjectivities, partial knowledges, and positionalities, but it is one that seeks to find rigorous, verifiable, and explicit ways to draw conclusions.

Visualization

'Visualization' is a broad term that refers to an array of methods that are used to provide insight into data through visual representations and includes the areas of geographic, information, and scientific visualization, which refer to the visual representation and exploration of geographic data, of nonnumeric datasets, and of large, multivariate datasets that use high-end computing, respectively. While maps have been used in understanding, visualizing, and communicating spatial data for centuries by cartographies and geographers who relied on the power of the human eye to detect patterns and concepts, GIS and other technological developments in data exploration have changed the way that we store, analyze, and display spatial data and have generated new methods for exploring and visualizing data that were never before possible.

The term 'visualization' has been informally "used to describe any recently developed novel method for displaying data" (Slocum et al, 2005, page 12) and ranges from the use of paper maps to the use of GIS and other highly interactive tools for exploring data. MacEachren's (1994) 'cartography-cubed' representation of how maps are used [3] is widely accepted by cartographers, spatial scientists, and the geographic community. He defines geographic visualization as a private activity that facilitates exploring unknowns in a highly interactive environment, as opposed to the use of maps as a tool to communicate 'knowns' to a public audience. Further, he notes that 'interactive' computer tools "expand the possibilities of 'interaction' with maps and thus the possibilities to facilitate visual thinking, perhaps in *qualitative* as well as quantitative ways" (MacEachren, 1994, page 8, emphasis added). New technological developments that allow the interactive exploration and manipulation of data, multiple views of the same data, and "the mixing of maps with other graphics, texts, and sound", among other things, are "not only a technological difference in tools for representation, but a 'fundamental' difference in the nature of how analysts interact with those representations" (1994, page 5). We suggest that data exploration, exploratory spatial data analysis (ESDA), and visualization using GIS and other visualization software, can be employed to facilitate an 'iterative process' in the analysis of data whereby researchers can recursively explore data in order to identify themes and processes, raise new questions, and begin to build theories.

[3] MacEachren refers to this as: '(cartography)³'.

Exploratory data analysis (EDA) employs statistical techniques to reveal hidden characteristics and facilitate seeing what the data 'tell' us in order to develop new questions or hypotheses (Slocum et al, 2005, page 45). ESDA extends the use of EDA to spatial and temporal data by using GIS and visualization techniques that invite researchers to explore and gain insight into spatial data (page 14). For example, the 'zoom and pan' function of GIS and mapping software allows some consideration of both the general and the specific, thus facilitating an awareness of particular features, trends, and phenomena within their broader contexts in ways that might be missed with coarser resolution and data aggregation. Additionally, 'focusing' and 'brushing' can highlight a subrange of numeric data (for example, census tracts with a high percentage of Hispanic population living in poverty) or an arbitrary set of spatial entities (such as parcels of land that are vacant). Further, dynamic visualizations and multiple images representing change over time aid in the representation of temporal data, facilitating the understanding of *process* (Harrower and MacEachren, 1998); this is of particular interest for grounded theory approaches.

Other techniques such as linking of maps with other forms or sources of data such as charts, graphs, or ethnographic data including digital photographs, text, or sounds can provide rich, contextual data for consideration in analysis. Additional features, including interactive legends, data-exploration tools, user-controlled animation, virtual environments, real-time 3D modeling, wearable computing devices, semi-immersible environments, and 3D flybys greatly enhance the visual, iterative exploration of data, allow simultaneous attention to both the particular and the general, the concrete and the abstract, at multiple scales, and accommodate multiple interpretations of the world and diverse views of reality.

A second form of visualization takes a quite different approach, but again has common ground with qualitative analysis techniques. Information visualization is concerned with the visual representation, exploration, and analysis of qualitative data that is nonnumeric and nongeographic. The technique of 'spatialization', an emerging research field within information visualization, involves the process of converting abstract text-based information, such as keywords from conference abstracts, bibliographic entries, or newspaper headline topics, into 'information spaces'. These maplike visualizations (3D topographic maps, tree maps, neural networks, or spatially bounded regions of information) use spatial or geographic metaphors to visualize data by using cartographic techniques and geographic principles (Skupin and Fabrikant, 2003; Slocum et al, 2005). Like the coding of qualitative data, an important step in the process of spatialization of free-form text involves content analysis of 'unstructured' data to create order and extract meaning from the text (Skupin and Fabrikant, 2003). This interdisciplinary research area provides a clear intersection between qualitative research and visualization. Qualitative research software packages, such as Atlas.ti, use information visualization techniques to code, organize, and query qualitative data and to visually represent complex properties and relations through text-based networks. Further research into the integration of qualitative data information visualization software and GIS will facilitate exploration of data for patterns, relationships, and trends, and serve to build the connections between qualitative research and geographic visualization.

Overall, visualization techniques allow users to explore, interpret, and integrate data to provide a rich and flexible medium for data exploration. This suggests that visualization, indeed, has some commonality with grounded theory in its paths toward building themes inductively and in exploratory ways.

Integrating analytical methods: finding meaning through grounded visualization

> "A major concern in this context is how to practice reflexivity with respect to the visualization process and the images created in GIS, in addition to being attentive to one's positionality with respect to research participants, the research project, and the knowledge produced."
>
> Kwan (2002a, page 649)

How, then, can we identify areas of common ground at the conceptual level of grounded theory and visualization? If we take Kwan's quote as an entry point, the practice of reflexivity in visualization could be enhanced by opening the scope of data to include qualitative sources. Displaying quantitative spatial data in a variety of ways may reveal patterns, and statistical analysis may reveal correlations, but it is often the case that explanation (and thus theory building) is grounded in the experiences of real people living through specific conditions and they are in many ways the 'experts', even if their explanations seem to be at odds with other sources of data.

There are several areas in which we believe the connections between grounded theory and visualization are most important. First, both approaches are *exploratory*. They enable, and, in fact, demand, researchers to query the data from multiple angles, ponder emerging consistencies or disjunctures, make new or revised connections, and entertain rival explanations. Within this, they both frequently make use of visual techniques (such as relational networks, scatter plots) to perform these explorations, a point at which the two methodologies could be further integrated with better software compatibility (such as between qualitative packages like Atlas.ti or NVivo and ArcGIS). And, significantly, the visual techniques for exploration in both involve the combination of display or representation of data with its substantive analysis.

Second, as part of their exploratory nature, both approaches involve *iterative*, recursive processes; that is, grounded theory and visualization both involve multiple rounds of data collection, display, and analysis, with critical reflection embedded at each stage, which combine to form results strengthened by the recursive process. This nonlinear approach enables researchers to be freed from the dictates of 'hypothesis testing' by allowing for more robust inductive research, as part of the "reconfiguration of science" (Schuurman, 2002, page 258). This leads to the third commonality between grounded theory and visualization: the simultaneous attention paid to both *the particular and the general*, the concrete and the abstract, and the small and large scale. Indeed, both approaches can be used to seek the connections between these dualisms through their basis in real-world phenomena or human experiences of the everyday and their attention to broader processes.

Fourth, and in some ways the sum of the above commonalities, both grounded theory and visualization can accommodate and represent *multiple interpretations* of the world and diverse views of reality. Sometimes multiple interpretations are complementary, with different perspectives filling gaps left by other data, as Pavlovskaya (2002) found. In other instances, as in the example from Nightingale (2003), these multiple interpretations can be simultaneously contradictory and yet both 'true'—the discrepancies themselves represent new areas for explorations. These are possible because in both visualization and grounded theory there is an acceptance of *partial* knowledge. Thus, it is well understood in both approaches that one set of data (whether qualitative or quantitative) is going to tell one particular 'story' (or piece of a story) only, which is inherently shaped by the strengths and limitations of the data-collection methods, the position of the researcher(s), and the ways research questions were formed.

Similarly, both grounded theory and visualization allow researchers to acknowledge uncertainty in their data, whether a result of gaps in data collection or of the accommodation of the 'unknowable' (such as in historical research when there are inherent silences).

And both approaches can be used in ways that honor the concept of 'situated knowledge' by incorporating the historical, geographical, and cultural context; recognizing the immanent roles of the researcher and the researched in constructing knowledge; and maintaining critical awareness of the research process as embedded in particular political, social, and historical moments.

Once again, however, we arrive at epistemology and the social practices of research. It is not sufficient for either grounded theory or visualization to be *open* to these common practices or to the *possibility* of using them in progressive ways. The recognition of methodological approaches as socially and politically laden means that they can be used in diverse ways, ranging from (un)consciously oppressive to critically engaged and potentially empowering. As feminists, we certainly hope for the latter.

But how can we put these areas of commonality between grounded theory and visualization into practice? Nightingale (2003) and Pavlovskaya (2002) provide inspiration, but their projects are presented as fait accomplis; few advances have been made in the more concrete and practical realm of combining GIS with qualitative research (but see Matthews et al, 2005). In the following section, we present a brief demonstration of grounded visualization, drawing on Knigge's work in progress on community gardens in Buffalo, New York. Although this demonstration is primarily for illustrative purposes where, we believe it can serve to both concretize our discussion of integrated analyses and spur new questions, both methodological and substantive.

Case example: community gardens in Buffalo, New York

The Lower West Side (LWS) of the city of Buffalo, New York, is known locally for its ethnic and social diversity. Area residents are aware that this neighborhood has high crime rates, numerous housing vacancies, urban blight, and a struggling commercial sector; however, the neighborhood also has numerous social and cultural amenities. The LWS has historically served as a landing point for new immigrant groups, which in recent years has meant Puerto Ricans, Vietnamese, and Eastern Europeans. The socioeconomic diversity of the neighborhood is evident from the different types of structures that vary from well-kept, owner-occupied housing in the northeast corner at Symphony Circle (part of Buffalo's Olmstead Park system) to the dilapidated Lakeview Housing Projects that are scheduled for demolition and the newly constructed Hope VI Housing Projects, located in the southwest corner of the neighborhood.

The diversity of this neighbourhood led Knigge to consider how various residential groups form attachments to place and shape the neighborhood to reflect their identity, social practices, and sense of community. What follows is a partial account of her path through an inductive research project that employs both qualitative and quantitative analyses, and uses grounded theory and visualization recursively. The actual research process is often messy, nonlinear, and opportunistic, and changes direction with new information or new developments in the community; although such diverse flows are difficult to represent textually, we attempt to take the reader through several iterations of these analyses to illustrate *grounded visualization* in order to demonstrate its use.

The integration of qualitative data (photographs, text, etc) into GIS at the level of *representation* has a brief but rich history. Although we are proposing a substantial integration at the analysis level, using representations to let different data sources rub up against each other can be helpful at the beginning of analysis to spur new questions. Figure 1 (over) shows one possible rendition of combining qualitative and quantitative data at the representation level in a web-based multimedia environment. The main map of the LWS of Buffalo shows community resources and facilities while the peripheral boxes allow a user to explore the characteristics of the neighborhood in
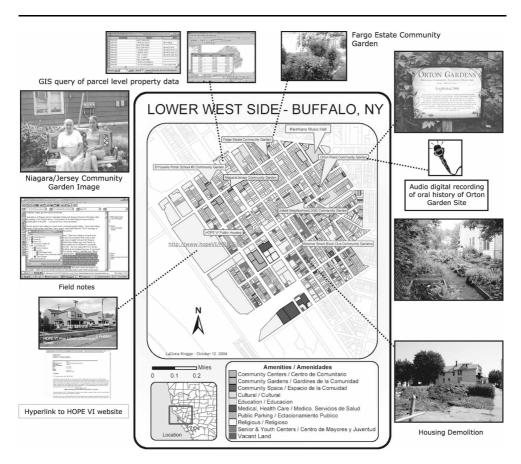
Figure 1. Multiple representations of the Lower West Side.

much more depth with racial composition data charts, parcel-level attributes, maps showing different subareas or characteristics, photographs of neighborhood spaces, text descriptions of local features, and quotes from neighborhood residents in both text and audio form. Additional links could be made in the form of websites, databases, video clips, music, or user-interfaced information sources. At the level of combining qualitative and quantitative data there is great potential for new representations, particularly if multimedia, user-interface aspects are employed. However, figure 1 is still a representation that merely shows both qualitative and quantitative data without substantively enabling the data from different sources to inform each other, raise new questions, or be otherwise integrated in analysis.

Step 1: neighborhood overview—exploring the data

As part of Knigge's internship with a local planning organization,[4] housing and demographic data were collected that demonstrate that the LWS has experienced considerable changes over the past decades in population composition in terms of race, ethnicity, age, and family structure. For example, the white population of the LWS has declined by 44% since 1970s but the Hispanic population has increased by 27%, the percentage of vacant housing has nearly quadrupled since 1970, and a relatively

[4] Knigge became familiar with this part of Buffalo through an internship with Lovejoy District Neighborhood Revitalization Services, a community-based neighborhood planning organization that was contracted by Hispanics United of Buffalo, a community-service organization, to prepare a redevelopment plan for the LWS.

low percentage of the homes are owner-occupied (18% in LWS compared with 43% for the city overall), according to the 2000 Census. The planning interns conducted sidewalk inspections and rated the condition of all structures. From this quantitative summary of the neighborhood housing and demographic data, Knigge noted several patterns in housing conditions, characteristics of population change, and economic factors, and began to identify possible emerging themes for her own research.

Also as part of the community-planning process, housing, demographic, and other neighborhood data were analyzed and mapped using GIS. The first public meeting was dominated by residents who had found that their homes were *not* included within the boundaries of the LWS planning area. This strong reaction by participants resulted in the planners enlarging the planning area along the eastern boundary, collecting more data, redrawing all maps and altering prior conceptions, representations, and conclusions about the neighborhood. The public expression of the community members' obvious identification with the neighborhood sparked Knigge's interest in pursuing her own research within this neighborhood, which is the focus of the remainder of this example.

Step 2: participant observation—exploring the neighborhood
Knigge found the emerging themes of neighborhood transition and the strong expression of the residents' identification with the LWS at the public meeting intriguing and they increased her interest in this neighborhood. Theoretically, these sparked her interest in pursuing issues of attachment to place, the active role of residents in (re)shaping their neighborhood, and issues of marginalization of both people and places. As a way of understanding more about the neighborhood, she began conducting participant observation at the supermarket on Niagara Street, which provided further data about the area and its residents. Some of the activities that were observed included:
(1) A Hispanic male selling chains and watches outside the store.
(2) An African-American male with a minivan, who hired himself out to give shoppers with groceries a ride home.
(3) Recycling bottles and cans for cash.
(4) Spanish language spoken and in signs, newspapers, and magazines.
(5) Range of items for sale that catered to the Hispanic population.
(6) A security guard located at the door.
(7) Spatial configuration of the store that constrained movement in and out of the store.

Using entry-level code categories for coding and theme-building (conditions, interactions, strategies and tactics, and consequences) from Strauss's discussion of grounded theory (1987), we can begin to see some important connections. This fieldwork reinforced the themes of poverty and ethnic diversity (*conditions*), revealed some of the *interactions* among residents, and demonstrated some survival strategies (*strategies and tactics*) of the lower income people who live in the neighborhood, including some illegal behaviors. Through coding data from both the qualitative and quantitative research, patterns and categories were emerging into themes of diversity, poverty, survival strategies and (potentially) community identity. These kinds of initial categories are the foundations of an important stage of all types of research: that is, grouping 'like' things together to explore their commonality. This principle of grounded theory has obvious applications for visualization as well.

In the initial stages of the research, the issue of the boundaries of the neighborhood was the most apparent link to community identity. As a result of the reaction of the residents who were excluded from the original LWS plan, Knigge walked and bicycled the boundary in order to answer some of the questions that were developing. For example: how homogeneous or heterogeneous was the built environment of the neighborhood?

Were there other survival strategies that could be observed? Was there more evidence of the ethnic and economic diversity? What were the visible effects of rapid demographic changes? Table 1 contains a coded excerpt from the detailed field notes of the boundary-field survey.

Other trends that were observed were the high number of vacant lots, abandoned homes, and empty storefronts, differences in the ways that residents used the space of their porches and front gardens, and the presence of community gardens in the neighborhood, which seemed to be more common in some areas than in others. These patterns and conditions that were observed in 'the field' reinforced the theme of diversity in the housing stock but also raised more issues about vacancies: a binary categorization between vacant – not vacant seemed overly simplistic after the neighborhood fieldwork where empty houses, boarded up or condemned houses, recent demolitions, truly empty lots, and community gardens were observed, possibly suggesting a spectrum rather than a binary. Additionally, poverty and ethnic diversity were certainly evident in the neighborhood, but there appeared to be more economic

Table 1. Example of coded field notes with themes.

Field notes	Codes	Themes
I turned the corner and headed south on Niagara Street, which intersects the LWS neighborhood. There is a *community garden* located at *the intersection of Niagara and Jersey* with large pots of flowers and raised beds with both ornamental plants and vegetables growing in them. Many of the people that I encounter on the street are *speaking Spanish*.	community garden location language, ethnicity	conditions— ethnic diversity
I note that the *character of the houses appears to change* dramatically at Jersey Street. They are much smaller, closer to the street and show more signs of *deferred maintenance, such as peeling paint, boarded up windows and porches in need of repair*. Many of the houses have open windows with no screens and porches are generally void of plants, furniture, wind chimes and other personal items. The yards consist mainly of mowed weeds, with no landscaping or decorative plantings. Many of the homes have *boarded up windows* and for-sale signs.	housing housing vacancies	conditions— poverty
There are a variety of small *commercial businesses and vacant store fronts* along Niagara Street. Many have *Hispanic names* or signs that indicate that they serve the *Hispanic community*.	commercial activity ethnic diversity	conditions— ethnicity and poverty
As I turn the corner and head north along Cottage Street, the *type of housing changes to small, one and two story, single family dwellings, with small, well-kept gardens in front and larger back yards*. Once again the *porches are furnished and decorated with plants, wind chimes and other items*. [It seems that the porches are an extension of the living room and seem to be transitional space between the public space of the street and the private space inside the home, where the private and public merge or meld into a third space that is neither public nor private.]	housing changes stuff on porches	strategies—uses and construction of public space

diversity (judging from housing conditions) and economic activity (judging from signs of informal economic exchanges) than was originally expected. These led to more questions about the neighborhood that could potentially be answered by returning to the quantitative data, and specifically to GIS-enabled visualization.

Step 3: visualization—mapping connections and context
At this point, the Erie County cadastral parcel-level data were explored with a GIS to visualize land use, including classifications for vacant lots, housing values, types of structures, and other information at the level of the parcel. Whereas standard census-tract mapping is useful in understanding *general* housing and demographic patterns at the census-tract level, more *particular* information at the parcel level provided a more detailed view of the neighborhood. It was determined that 265 parcels of land were vacant. Mapping land use, the assessed valuation of housing, and other attributes of the neighborhood at the scale of individual parcels revealed places with higher concentrations or clusters of vacant lots from housing demolitions, the locations of community services, parks, and public spaces, and the distribution of housing by assessed valuation. There was little information, however, about the existence of community gardens, about which Knigge was increasingly curious.

During this same time period, while attending various public and neighborhood meetings in the area to continue along the simultaneous path of ethnographic fieldwork, Knigge attended a meeting of the Coalition of the Buffalo Community Gardeners and Vacant Lot Task Force. This provided a wealth of information about the City of Buffalo's policy regarding the creation of community gardens, vacant lots, and the aggressive housing demolition policies in which an estimated 31 000 housing units will be demolished between 1990 and 2010 (City of Buffalo, 2000). Knigge was able to obtain a database of Buffalo's community gardens prepared by the Buffalo Community Gardeners, in collaboration with the Massachusetts Avenue Project, information regarding the process of creating a community garden within the City of Buffalo, and information regarding Buffalo's aggressive housing demolition policy. The database, which Knigge geocoded for use in the GIS, listed seven community gardens located within the LWS. This development began to enable analysis of the individual contexts and surrounding conditions of the gardens, as well as providing some historical data, but did not touch the issue of the *meanings* of the gardens or different people's perceptions of them.

Step 4: further iterations of analysis and data collection
Subsequent participant observation included site visits to the community gardens to make observations and to photograph their contents and surroundings (which varied from beautiful ornamental gardens to a grassy lot that was mowed only occasionally), and conversations with community members encountered incidentally during the note-taking and photograph-taking processes. This round of fieldwork revealed certain aspects of gardens that were coded into the database (for example, were the garden plantings ornamental, for food, or both, was there bed preparation, or no garden at all, were there fences, gates, or locks, etc?) By this point, qualitative data-analysis software (Atlas.ti) had been adopted to facilitate coding of the field notes, meeting transcripts, and other text-based documentation, as well as aiding in the identification of themes. Based on Knigge's long-standing interests in marginalized groups and 'public' spaces, the possibility that community gardens were potential sources for political and economic empowerment and were an emerging form of public space deepened her focus on the gardens, their construction, and use, and their meanings for local residents.

An integrated analysis and multiple views of reality

After several months of collecting and mapping quantitative data, attending public meetings, inspecting and documenting community gardens, and engaging in participant observation in the LWS, Knigge had performed several rounds of recursive analyses using visualization and grounded theory. She realized that by solely looking at published quantitative data she may have missed the existence of community gardens, and a wholly ethnographic study might have missed potential correlations and clusters that were best analyzed through GIS. For example, on the qualitative side, grounded-theory practices revealed various economic and political survival strategies that are used by low-income people and by the community, such as activities in the informal economic sector, the creation of community gardens as a potential means for empowerment, and the production of food in the community gardens. On the visualization side the location and spatial distribution of community gardens in the neighborhood seem to relate to the economic and ethnic patterns within the neighborhood.

The data collection and analysis of this project consisted of the use of a range of research methodologies from interpretation of census data, GIS analysis, and mapping or visualization to participant observation, field research, and text analysis using grounded theory coding structures and theme building. Without this combination the connections between community gardens, a strong community identity, and the survival strategies of community residents that emerged from the coding of data and building of themes through grounded visualization would not have been made. Although participant observation, fieldwork, and attendance of public meetings would have provided information about processes associated with creating community gardens, these methods alone would not have provided a complete picture of the neighborhood without the inclusion of quantitative data, and, conversely, an analysis solely consisting of census data, GIS and visualization, and other quantitative methods would not have revealed trends in community-based activities such as the creation of community gardens. Although the study on community-based survival strategies and tactics of empowerment through community gardens in the City of Buffalo is still in progress, the community gardens have now become the central focus of the research, and newly emerging issues surrounding their creation, use, and meaning for different groups in the LWS, as well as in other neighborhoods in Buffalo will be addressed from a multifaceted set of data and analyses. We hope that this short example is illustrative of the potential value of iterative, reflexive research that purposefully takes the insights of grounded theory and visualization as central to the dynamic processes of inquiry into the complexities of the social world.

Continued iterations

As mentioned, this research is in progress. So what next? The qualitative and quantitative research trajectories will continue, and will continue to intersect throughout the analysis. On one hand, Knigge is beginning in-person interviews with local residents to ask about the meanings, uses, and presence of the gardens in their neighborhoods, as well as with city officials and community organization leaders to establish their perspectives. At the same time, Knigge is conducting spatial analysis of the location of the gardens in the LWS and in other areas of Buffalo and of how these relate to local characteristics such as household income levels, commercial activity, ethnic background of populations, and historical tracings of the relevant lots. The integrated data collection, analysis, and representations for this project have already raised new issues that will be reflected in the next stages: issues about public space, community identity, food security, and issues for youth, women, and immigrants with regard to the community gardens.

Thus the iterative process continues, embedded with the recognition that there will never be *one* story of the community gardens, but, rather, that the analytical integration of diverse interpretations of the roles and effects of the gardens will contribute toward a set of multiple (but partial) understandings, views of 'reality' that are both complementary and contradictory, and—ultimately—an account that weaves knowledge, context, and power together in a rich empirical setting.

Conclusion

When faced with the complexities of the real social world, researchers are charged with a delicate task. Maintaining a commitment and sensitivity to multiple subjectivities, meanings, and discourses, and to the relationships between context, power, and knowledge, is neither simple nor predictable. We need strong analytical methods that build on the robust capacities of ethnographic and GIS techniques to navigate the research process; in turn, these will allow us to produce rigorous results and present them in ways that are not oppressive or overly exploitive. The power of grounded theory and visualization, particularly when used together in an integrated qualitative–quantitative research report, offers one route. The combination of qualitative and quantitative data, together with a commitment to iterative, reflexive rounds of analysis, enables research to be attuned to multiple subjectivities, truths, and meanings. By building on areas of commonality between grounded theory and visualization—being exploratory, iterative—recursive, considering both the particular and the general, and allowing multiple versions of reality to emerge—grounded visualization carries great potential for building theory that is both 'grounded' in everyday life and real experiences, and 'situated' by context and broader trends and patterns.

Grounded visualization is also a particularly *geographical* set of analyses that could be used broadly outside of the discipline, thereby expanding the relevance and capabilities of spatial perspectives to other researchers. Specifically, grounded visualization is sensitive to *scale* issues, from local to global and back again; can integrate mobility and *flows* over both time and space; greatly depends on both qualitative and quantitative measures of *context* (historical and geographical); and, finally (as shown in our case example), enables rich explorations of *place*.

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