

Masters' Final Project

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Abstract

Gathering and analyzing geospatial information is critical for many decision makers, planners, and developers. This information is doubly necessary when there is a large divide between those making the decisions and those who will be affected by those decisions, as without it, those in power often end up making decisions that do not take the needs and wants of those most affected into account. The field of PGIS (Participatory Geographic Information Systems) emphasizes the necessity of listening to and actively including local communities in the planning process to ensure the ensuing plans benefit as many stakeholders as possible. Yet in many contexts, there are significant challenges to collecting this data, including cost constraints, the lack of availability and trained operators of hand-held GPS (global positioning system) devices, and the difficulty in finding staff who have the time or training to organize spatial data. Furthermore, community knowledge is frequently qualitative rather than quantitative and does not lend itself to precise latitudinal and longitudinal points. Local Ground combines the best of paper and pixels by using paper maps to capture rich qualitative data, creating digital versions of the hand-drawn annotations, then importing the annotations to a digital map. Using paper maps instead of GPS devices makes the data collection process cheap, portable, and, most importantly, easy to learn. Digitizing the data then allows planners and community members to collate and analyze the data with our user interface, and our visualization tools enable them to share their findings with key decision makers. We based our code on the Walking Papers open-source code that allows users to print out bar-coded maps that can later be geo-referenced. We have tested our proof-of-concept design in partnership with the Y-PLAN program, an award-winning initiative from the University of California in Berkeley's Center for Cities and Schools that works with UC Berkeley students and local middle-school and high-school youth to engage them as genuine collaborators in real-world development projects. As such, we worked with students in John F. Kennedy High School, Walter T. Helms Middle School, and Richmond High School, as well as various community organizations in the nearby city of Richmond. By working with these stakeholders—all of whom are involved in two re-development efforts in Contra Costa County—Local Ground has explored how digital tools can help collect qualitative geo-spatial data from community members, analyze that data, and then share redesign plans among community members and other stakeholders.

Introduction

The Problem Space

When planning and implementing public development projects—housing and infrastructure development, building parks and open spaces, economic development, etc.—it is critical that all parties involved come to the table to discuss their needs, expectations, and ideas. Each stakeholder brings a different set of perspectives to a project and having the proper tools and processes in place to share, synthesize, and document collective knowledge ensures that all viewpoints are taken into account. One of the predominant methods for creating a good public process is for federal, state, and local government agencies to sponsor or support neighborhood and community hearings, which is frequently mandated by law.¹ In these meetings, stakeholders come together to discuss issues and ideas. Working groups are sometimes formed to further research particular topics and or to flesh out ideas and suggestions for the larger plan. These meetings also provide forums for even occasional participants to voice their concerns. These community meetings are extremely important in providing a variety of perspectives for the public planning process. However, two key challenges in this type of dialogue are the difficulty in documenting the multitude of opinions and ideas expressed in meetings and the fact that not all stakeholders are able or willing to attend the public meetings for a variety of reasons.

With regard to the first challenge, there are a number of tools employed by meeting facilitators to document public meetings. Typically, the information sharing and collection is done on paper: large maps or architectural plans are displayed on walls, and handouts and spreadsheets are passed out to solicit comments from participants. Although these papers are frequently saved, they are often filed away instead of being made public, and their physicality makes it difficult to share the information documented. When working in Ethiopia to collect geospatial data about the local farm areas, Sarah found that even though local farmers had extensively mapped out knowledge, such as where they

¹ According to the Title VI of the 1964 Civil Rights Act, “each Federal agency is required to ensure that no person is excluded from participation in, denied the benefit of, or subjected to discrimination under any program or activity receiving Federal financial assistance on the basis of race, color, national origin, age, sex, disability, or religion.” The Civil Rights Restoration Act of 1987 extended this mandate to include “all program and activities of Federal-aid recipients, subrecipients and contractors whether those programs and activities are federally funded or not” (<http://www.fhwa.dot.gov/environment/ejustice/facts/index.htm>). The National Environmental Policy Act (NEPA) of 1970 also requires that the public is notified and has the opportunity to participate in the planning and scoping process for any federally funded project (<http://www.epa.gov/oecaerth/basics/nepa.html#publicrole>). Finally, President Clinton signed the “Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations” in 1994, to ensure that publicly funded projects did not have “disproportionately high and adverse” effects on minority and low-income populations (<http://www.fhwa.dot.gov/environment/ejustice/facts/index.htm>).

needed fertilizer or which areas would be negatively impacted by the creation of irrigation canals, the information on the maps was never saved to a more easily accessed format (Figure 1, Figure 2). Because of this, although valuable information was collected, the method of collection limited the reach of the information.

Figure 1: Photograph of farmer-drawn map of village crop areas in the Oromia region of Ethiopia



Figure 2: Participatory planning in the Jimma region of Ethiopia



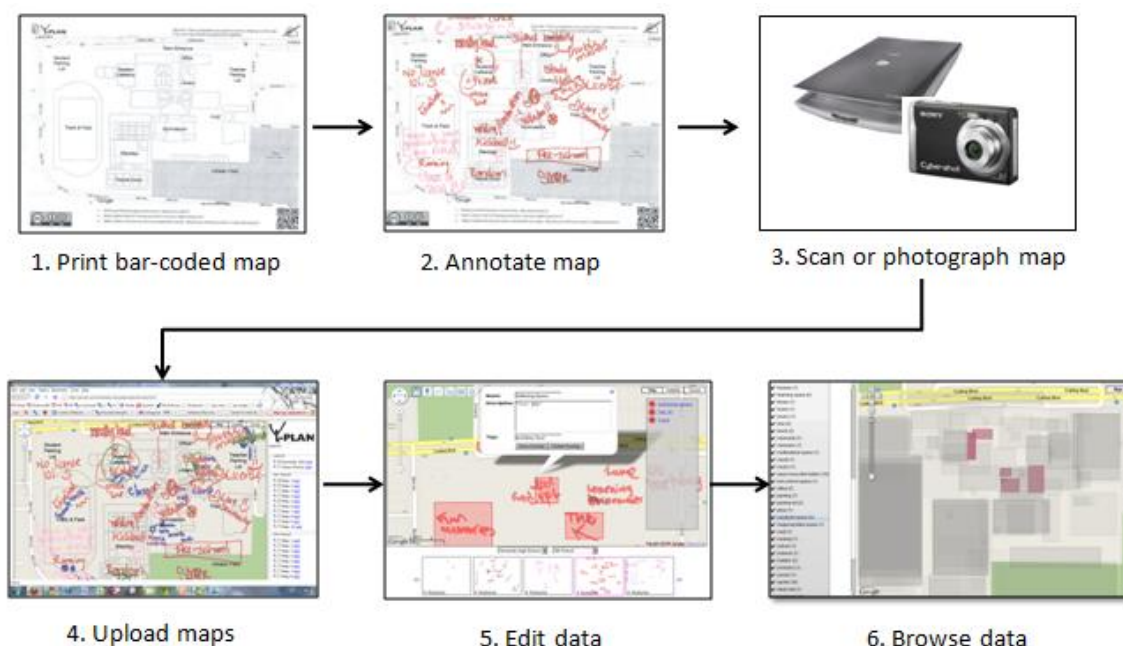
The second, even more daunting problem, is reaching out to the people who do not come to the meetings, but are in fact the local experts on a particular topic. For example, the City of Richmond is currently in the process of revitalizing the Nystrom neighborhood, which consists of mostly low-income families, schools performing below the national average, and unsafe and under-utilized community spaces. The Nystrom area also suffers from chronic violence, drug use, and gang activity (Suwalsky, 2009, p. 1). For the development effort, the city plans to renovate Nystrom Elementary School, the Historic Maritime Center, Martin Luther King Jr. Memorial Park and Community Center, and four public housing developments. With respect to the park renovation, the city wants to be sure to include new facilities and programs that community members will use, but without local knowledge of the neighborhood, it cannot make relevant, sound investment decisions. The city certainly has formal knowledge of the neighborhood surrounding the park—demographics, crime statistics, local businesses, schools, buildings, etc.—but it lacks knowledge of the day-to-day lived experience of the local residents.

On the other hand, local residents might not know statistical or budgetary details about their area, but they do understand the local context. For example, a mother living in the area knows precisely why she doesn't spend time in the park: the playground is located right next to a methadone clinic where patients often loiter, and she does not feel comfortable bringing her children there. A teenager might not want to spend time in the park because there are no barbecue pits and it is empty most of the time.

Documenting and synthesizing everyone's input makes all the difference in making wise investment choices rather than unnecessary ones, and it ensures that investment in public-oriented projects actually achieves the goals it sets out to accomplish. The most successful projects are not those that are designed unilaterally from the top down, but rather those in which all involved stakeholders discussed, negotiated, and worked together to design a plan that succeeds for everyone.

Local Ground focuses on users who do not have reliable Internet access and do not own smart phones by creating a bridge between paper-based data collection methods and high-tech geospatial data systems. As previously mentioned, many community meetings already rely on paper both as a means to facilitate interaction and as a means to document the results of the meeting. Hand-annotated paper maps take advantage of affordances that are absent from most handheld GPS devices and GIS software. On a map, important areas can be circled, directionality can be expressed, and multiple parties can collaborate to express a single idea. These qualitative, information-rich expressions of ideas are often lost in more formal GIS systems. Furthermore, using paper to gather data enables us to capture knowledge from a larger group of people, which in turns improves the planning process. However, limiting the data to paper alone also limits the benefits, as it is difficult to aggregate and analyze the data to discover meaningful patterns. As such, Local Ground takes data from the paper maps, digitizes it, then further transforms it by providing an easy way to browse both individual knowledge and knowledge from the aggregated whole. Finally, our system enables users to create visualizations from this data so that it can be effectively presented to different stakeholders in the decision-making process, thereby ensuring that the voices of as many people as possible are heard. Local Ground provides a cheaper, faster, and richer way to gather data, as well as a means to interrelate complex, qualitative ideas between parties. These features are significant, as time, budgetary, and technical constraints make more sophisticated information management tasks unfeasible for public planners.

Figure 3: Local Ground process



Field Partners

We were inspired by the Walking Papers project,² which allows users to print out paper maps from OpenStreetMap, an open-source online GIS system that calls itself the Wikipedia of online maps.³ These paper maps are bar coded, and after people annotate the paper versions, they can then re-upload the annotated maps to Walking Papers and add their data to the OpenStreetMap project. We similarly used the idea of using bar-coded paper maps to collect data and to display that data, although we used Google Maps⁴ instead OpenStreetMap and focused on using the paper maps to collect data for community planning.

To begin exploring the idea of using paper maps to collect community data, we selected a local partner, the Y-PLAN (Youth – Plan Learn Act Now!). The Y-PLAN, an award-winning initiative in the University of California Berkeley's Center for Cities and Schools, provides UC Berkeley undergraduates and graduate students the opportunity to work with local middle-school and high-school youth, engaging them as genuine, authentic collaborators in real-world development projects. In the spring of

² <http://walking-papers.org/about.php>

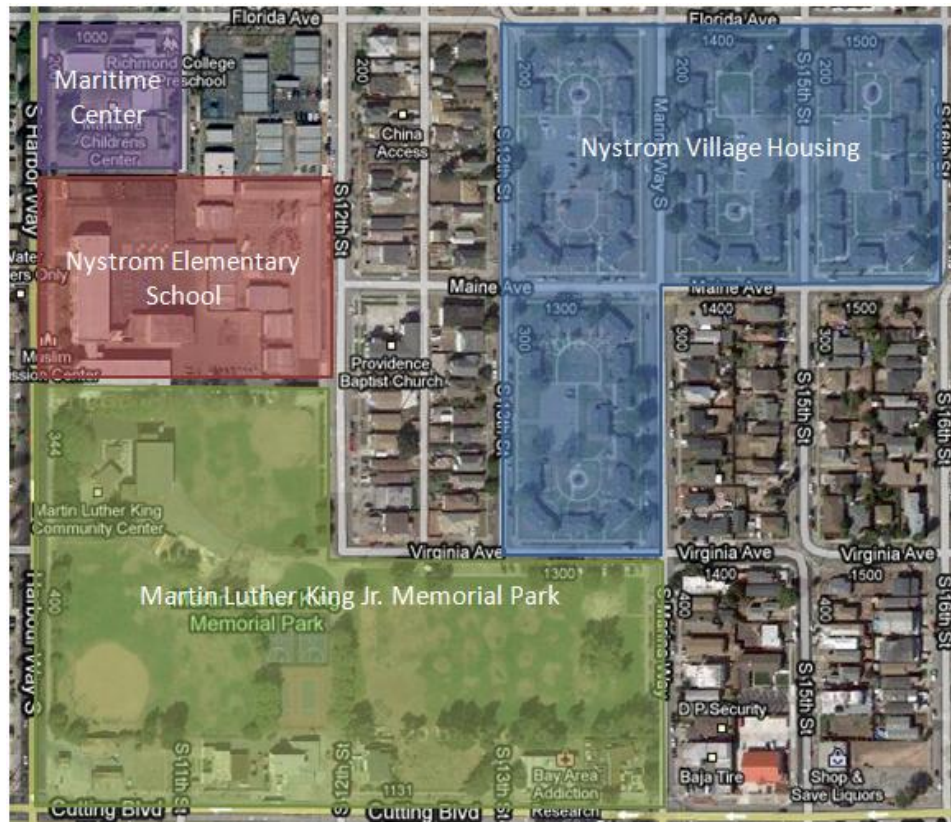
³ OpenStreetMap is a user-generated map of streets, landmarks, cities, and other features for which the underlying data is made publicly available, as opposed to Google, where the data is proprietary. <http://www.openstreetmap.org/>.

⁴ <http://maps.google.com>

2010, the Y-PLAN was tasked to analyze, from a youth perspective, two publicly funded projects in Contra Costa County: (1) the redevelopment of Nystrom Village and the surrounding area in Richmond as part of the larger Nystrom Urban ReVitalization Effort (NURVE) and (2) the building of the Helms Community School in San Pablo. For the NURVE project, our primary case study, Berkeley students worked with two 11th grade U.S. History classes at Kennedy High School twice a week for twelve weeks. During these twelve weeks, the students participated in various mapping exercises, brainstormed suggestions, and finally selected their best ideas to present to the City Manager, the Richmond Housing Authority, the Richmond Children's Foundation (RCF), and other key stakeholders at City Hall on May 5th, 2010. Unlike some youth-oriented projects, the Y-PLAN is not simply a simulation of community problem solving. Rather, the problems tackled by youth are carefully screened by the Center for Cities and Schools to ensure that the youth involved are treated as serious stakeholders in the planning process. We emphasize this because it was essential that our technology be explored in the context of a real development project, in order to get a real sense of how Local Ground might be applied in the real world.

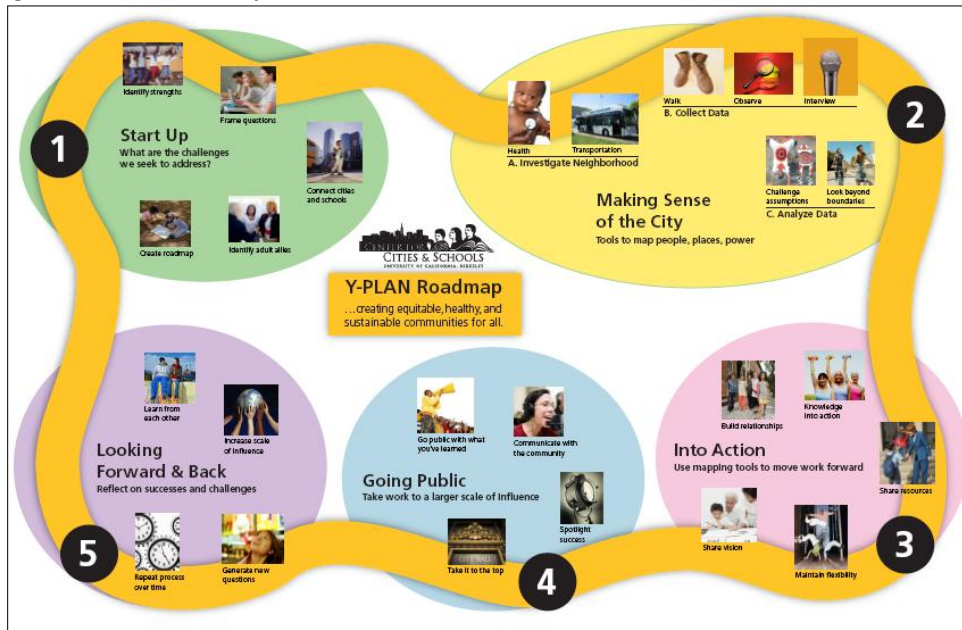
The Richmond Housing Authority, the client for the Kennedy students, specifically asked the Y-PLAN to focus on "pathways and connections" in order to create designs that would connect Nystrom Village Housing – four blocks of public housing slated for redevelopment – with the nearby park, school, and community center to make it feel like a connected, cohesive neighborhood (see Figure 4 for a map of the area under redevelopment). To guide the Kennedy students along, mentors and students followed the Y-PLAN curriculum, which broke the analysis into five key phases: (1) "Start Up," where students explicitly stated the challenges they sought to address; (2) "Making Sense of the City," where students gathered data about their communities in order to map people, places, and power; (3) "Into Action," where students translated their data and observations into visions and action items; (4) "Going Public," where students create a report, poster, and presentation to present to decision-makers, and (5) "Looking Forward & Back," where students reflect on successes and challenges, and think about next steps (Figure 5).

Figure 4: NURVE Area



Because a number of mapping exercises were included in the data collection and visioning phases of the curriculum to guide the students to think critically about spaces (phases 2 and 3), we were able to test several different technologies within the context of the students' community inquiry. The interventions tested are described in subsequent sections.

Figure 5: Y-PLAN Roadmap



Overview of the Paper

This paper will first examine work related to Local Ground, beginning with the theory behind community mapping and participatory design. We will then look at participatory GIS systems, along with paper-based computer interfaces. After this, we will describe the Local Ground toolkit and the technology behind the Local Ground system. We will then discuss our design process, from our first iterations to how the Local Ground system has developed with each mapping exercise we have conducted. Finally, we will evaluate our work and map out future ground to cover.

Related Work

The bulk of pre-existing work related to Local Ground can be separated into four categories: (1) the theory of participatory and community mapping, (2) interfaces developed for participatory and community mapping, (3) online map interfaces, and (4) paper-based computer interfaces.

Participatory and Community Planning

Involving community in the planning process in meaningful and authentic ways helps to foster participation and makes it more likely that sound development decisions are made. The literature is thick with descriptions of policies that were enacted in the United States to limit certain groups' access to space and resources, from the marginalization of women to the post-World-War-II Urban Renewal policies in the U.S. where African-American communities were destroyed to push forward the building of a national highway infrastructure (Wacquant, 1995, p. 428). Since the Y-PLAN is analyzing a public housing revitalization effort in a predominantly minority community, it is relevant to note that during Urban Renewal, the poorest members of displaced African-American communities were moved in to public housing (Nespor, 1997, p. 88).

Delores Hayden also writes in her account of the history of spaces in the U.S. that “one of the consistent ways to limit the economic and political rights of groups has been to constrain social reproduction by limiting access to space” (Hayden, 1997, pp. 23-24). Like Hayden, the Y-PLAN and a number of other participatory mapping activities also explore access to space. In participatory mapping for design, participants are asked, “Where are you allowed to go?” or “Which areas are off limits to you?” because access to space is tightly entwined with issues of social justice and community voice. Participatory mapping and design processes explicitly explore these issues.

In addition to spatial access, a lack of voice can also lead to bad design choices. Jane Jacobs writes in *The Death and Life of Great American Cities* that “[i]n NY’s East Harlem, there is a conspicuous rectangular lawn – object of hatred to the project tenants” (1992, p. 15). When one of the community members was asked why the lawn was so despised, he responded by saying, “Nobody cared what we wanted when we built this place. We don’t have a place to get a cup of coffee or a newspaper, but the big men come and look at that grass and say ‘Isn’t it wonderful. Now the poor have everything.’” (Jacobs, 1992, p. 15). Jacobs demonstrates that by imposing something on a place that isn’t wanted, “The real order that was struggling to exist and be served was ignored or suppressed” (1992, p. 15).

To avoid marginalization and bad decision-making, participatory design has become a standard, both in the U.S. and internationally, for ensuring that public projects meet the needs of the citizens they are meant to serve, and that equity concerns are appropriately addressed.

Participatory GIS

Participatory GIS emerged to address concerns that GIS, when used in a planning context, could further exacerbate social injustice by emphasizing quantitative, formal data sets over local knowledge (Elwood, 2006, p. 695). By bridging participatory methods, quantitative data, and technology, PGIS attempts to ensure that community knowledge and local politics are sufficiently taken into account in planning projects (Abbot et al., 1998, pp. 27-29; Sieber, 2006, p. 495). In addition to the geospatial layers (point, lines, and polygons) that are found in traditional GIS systems, PGIS frequently incorporates visual and multimedia information such as photographs, video, and sketches (Elwood, 2006, p. 696). Examples of such approaches include Fagerholm and Käyhkö's participatory mapping study in Zanzibar, Tanzania, where they collected information by interviewing participants and having them map out social landscape values with pen or marker on aerial photographs of the area (2009, pp. 47-48). Al-Kodmany's study of using GIS for neighborhood planning in three Chicago neighborhoods found that "traditional activities and tools, such as sketching with pen and paper, are very powerful and are irreplaceable in the early stages of planning" (2000, p. 19); and concluded that GIS alone was not sufficient to meet the communities' needs. There are countless other examples of PGIS projects throughout the world, but most still rely, in some form, on paper and pen:

Despite the powerful features of GIS, electronic sketchboards, and digital 3-D modeling, some community participants commented that the high-tech set up hampered the social function of these meetings. To address this and to further foster participation, we resorted to the use of traditional tools: pens and large printouts of GIS maps. (Al-Kodmany, 2000, p. 32)

Online Map Interfaces

There are a number of web-based geo-spatial data collection and dissemination initiatives. Regarding open, web-based platforms that accept user-generated geo-spatial content, Google Map Maker and OpenStreetMap are two of the most prominent, both of which have specific initiatives geared toward digitizing maps in the developing world. For example, in November 2009, residents of Kibera, Kenya's largest slum, used OpenStreetMap and GPS units to annotate what had previously been

a blank spot on a map. There are also a number of open-source mapping tools, such as ModestMaps and Open Layers, and publicly accessible APIs, such as the Google Maps API and the W3C Geolocation API, that allow users to consume, display, and query existing geographic data. Even so, an online medium can still exclude, as many underserved populations are also underserved in terms of Internet connectivity and computer access (Kyem & Saku, 2009, pp. 5-7). Furthermore, systems that are solely online run the risk of participation inequality, in which a small percentage of the user base comprises the largest percentage of the voices, and an online medium can also strip away important non-verbal cues that enrich face-to-face communication (Kyem & Saku, 2009, pp. 8-9).

Because of this, we believe that Local Ground's combination of traditional and digital media is its key strength. Although a component of our system is online, leaving the data collection to a paper interface means users do not have to have computer access in order to contribute their local knowledge. Furthermore, PGIS systems that gather information via paper or other non-digital media still must transfer that data from paper to a digital system. Using bar-coded paper maps will make this process easier and less labor-intensive, allowing more data to be collected and analyzed.

Paper-Based Computer Interfaces

Paper-based computer interfaces have been in existence since the beginning of modern computing. Paper is portable, relatively inexpensive, and extremely easy to annotate; however, the content on paper is also static and cannot easily be stored in a database for querying and organization. Electronic interfaces, on the other hand, have the opposite set of benefits and drawbacks. They can be updated, edited, and searched, but they frequently are more expensive and require more training to use. Most paper-based computer interfaces are designed to combine the best of both worlds. However, even though the affordances of paper make it a good fit for ICTD (information and communication technologies and development), many of the paper-based interfaces we surveyed were either for office use or for the use of people who already have access to advanced computer technology (Arai, Aust, & Hudson, 1997; Dymetman & Copperman, 1998; Heiner, Hudson, & Tanaka, 1999; Holman, Vertegaal, Altosaar, Troje, & Johns, 2005; Liao, Guimbretière, & Hinckley, 2005; Nelson, Ichimura, Pedersen, & Adams, 1999). Often, special equipment – such as “intelligent paper” or a custom pen fitted with a camera – is required by these interfaces, which is not practical for resource-constrained communities with limited computer access.

Marked-Up Maps, a paper-based map system, has many of the same limitations. The Marked-Up Maps system relies on RFID chips embedded in paper maps; the user can scan the map with a handheld

computer or smartphone to activate the RFID chip and retrieve additional information about a specific location from the Internet (Reilly, Rodgers, Argue, Nunes, & Inkpen, 2006). However, because the maps must be marked ahead of time with RFID chips, this interface is more suited toward uses in which the user's information needs are known ahead of time, rather than a data-collection application such as Local Ground.

CAM, on the other hand, is a paper-based user interface designed for ICTD applications. With the CAM system, users can use their mobile phones to navigate through a bar-coded paper form to input information without having to access a computer or a website (Parikh, Javid, K, Ghosh, & Toyama, 2006). Local Ground similarly uses bar codes to connect paper with backend electronic systems; however, the Local Ground interface for data collection is entirely paper based. Another difference is the unstructured nature of the data we are gathering. With Local Ground, although a user may be tasked with answering specific questions or collecting specific data, the user is also able to record other noteworthy observations on the map. The free-form nature of Local Ground allows users to include features that may have been overlooked by the planners structuring the mapping exercise.

Finally, the paper-based interface that has the most influence on the Local Ground system is the Walking Papers system. Walking Papers was created by Stamen Design's Michal Migurski to address the needs of users who either did not own a GPS device or found it inconvenient to use one for certain mapping tasks. By using bar-coded paper maps, Walking Papers makes it simple for the casual mapper to travel about and note down points of interest, in turn enabling more people to contribute to OpenStreetMap's ever-changing inventory of crowd-sourced map data. Local Ground has extended the Walking Papers idea and applied it to the realm of community planning and mapping. The same strengths that makes Walking Papers a good match for local points of interest also make it ideal for gathering even more qualitative data such as "safe areas" or "places that need improvement." Furthermore, Local Ground applies the use of bar-coded paper maps not only to data collection, but also to visualizing future plans for an area. Users can use the paper maps to gather data about an area and plot out features such as where they would like benches or pieces of art to be on the maps and then share these plans with others.

The Local Ground Toolkit

Though the Local Ground system evolved as we tested ideas with our partners, this section describes the basic technologies in the toolkit for context. At a high level, the Local Ground system

consists of two components: (1) data input tools and (2) data analysis and visualization tools. Our primary data input toolkit leverages maps printed out on paper, QR codes,⁵ image recognition scripts, and geospatial tools to gather quantitative and qualitative geo-spatial information. For data analysis and visualization, Local Ground provides an application programming interface (API) to interact with our data store; a web-based map editor to summarize and tag points, lines, and polygons of interest; and a several web-based map viewers to present different views of the data. In combination, this toolkit allows users to:

1. Print a map of a location of interest from a web browser using map data from Google Maps. The map can be copied and disseminated to many users.
2. Annotate the map with ideas, issues, plans, or data, using pens or markers.
3. Scan and upload the resulting map into our system.
4. Process the uploaded map image using a script to straighten the image; geo-reference it so that it can be accurately placed on a map; extract the hand-drawn annotations from the underlying print; and view these hand-drawn annotations on a web-based map.
5. Draw polygons and place markers on annotated areas; tag and describe the uploaded annotations; and associate photographs, video, or audio with specific areas.
6. Summarize and discover patterns in the data so that hand-drawn annotations can be overlaid and compared with other GIS data layers, such crime zones, demographic information, facility locations, and even other hand-annotated maps. Users can also browse through multiple annotations of a single area, as well as view any photographs, videos, or audio captured of the area.

Data Input

The Local Ground data input tool utilizes code and ideas from the Walking Papers open source project. Walking Papers combines a number of technologies so that paper maps can be incorporated in a digital system. For map generation, Walking Papers uses OpenStreetMap data and ModestMaps⁶ to display, print, and interact with geospatial data. It also utilizes the Google Chart API⁷ to generate and read QR codes containing information about the printed map's extent and zoom level by encoding the

⁵ QR or "Quick Response" codes are two-dimensional bar codes.

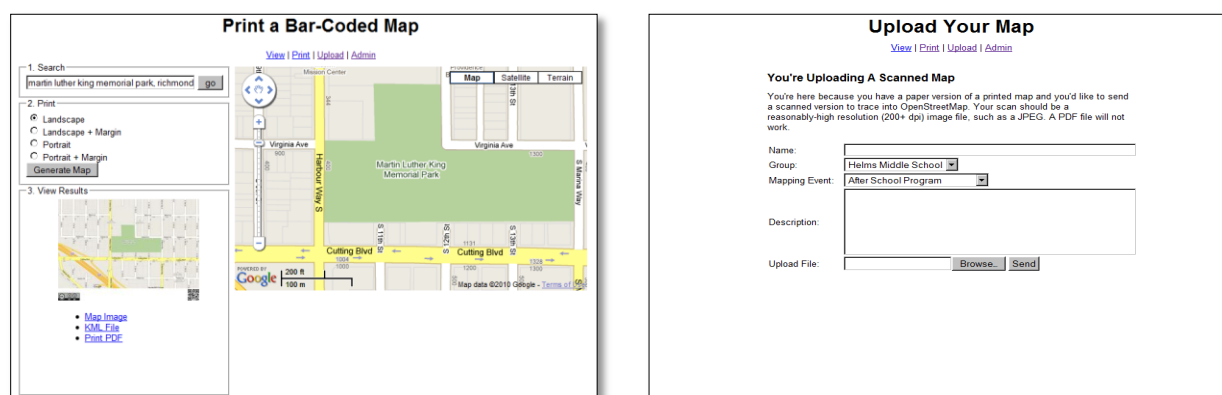
⁶ ModestMaps is a library designed for displaying and interacting with tile-based maps in both Flash and Python. <http://modestmaps.com/>.

⁷ The Google Charts API provides an interface for creating quick charts and graphics. http://code.google.com/apis/chart/docs/making_charts.html.

map's unique identifier. It also uses a Python script to process the scanned map image by: (1) calling a Java library, which implements the SIFT algorithm⁸ to rotate and scale the scanned image and extract the QR code; (2) reading the code and matching it with a corresponding print record in the database; and (3) tiling the image so that it can be digitized and stored in OpenStreetMap.

To meet the needs of our users, Local Ground made several modifications to the Walking Papers codebase. First, since there was more data regarding the churches, schools, parks, and facilities in Richmond and Contra Costa County in Google Maps than there was in OpenStreetMap, we modified the code to use Google Map products.⁹ Second, so that we could use the map scans with the Google Map API, we removed the tiling code and instead generated a KML¹⁰ file for each scan so that it could be easily imported into our map editor and viewer. Third, because we wanted to support overlaying many scanned maps at once, we utilized some of the image processing features available through the Python Imaging Library (PIL)¹¹ – specifically image subtraction and color subtraction. This allowed us to extract the map annotations from the map background so that the maps would not occlude one another. A screenshot of the QR-coded map generator and map importer is shown in Figure 6.¹²

Figure 6: Screenshots of Local Ground's data import tool



⁸ SIFT (Scale Invariant Feature Transform): A patented algorithm that can be used to detect features in an image, regardless of variations in scale or rotation.

⁹ An alternative would have been to help OSM collect more data for Contra Costa County. In the long run, it this strategy would probably be beneficial, as OSM allows users to have access to the underlying data store, unlike Google.

¹⁰ KML is an XML-based file format for expressing spatial information developed by Google. However, it was made an open format.

¹¹ <http://www.pythonware.com/products/pil/>

¹² <http://localground.org/print>

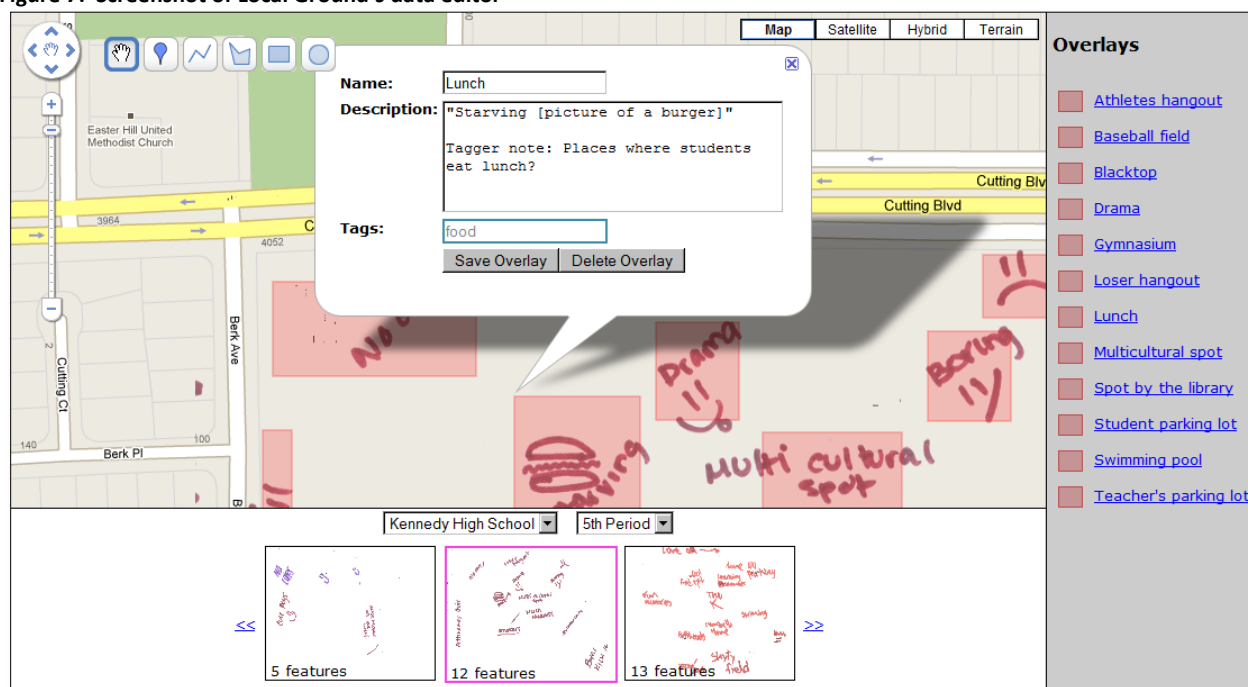
Data Analysis and Visualization

In order to making the scanned maps useable, we developed a map editor, a simple API to interact with the Local Ground data store, and several different map viewers.

Map Editor

Though there is value in simply looking at hand-drawn maps overlaid on top of one another, as the number of overlays increases, it becomes more and more difficult to make sense of the information being displayed. Thus, we built an editing tool for users to digitally annotate areas with summaries, names, and tags so that the maps could later be searched. The editor allows users to specify and label points and polygons on a map, and uses suggestive tagging to encourage tag convergence as seen in Figure 7.¹³ The “description” field of the editor also lets users embed multimedia hosted online such as photographs, video, or audio.

Figure 7: Screenshot of Local Ground’s data editor



API

To allow easy access to the digitally annotated images and corresponding annotations, we also developed a RESTful API so that developers can query the map data using a variety of different

¹³ <http://localground.org/map-editor>

technologies, such as HTML and Flash. The API returns JSON-encoded strings for any combination of queries that are supported. We have documented the API on the Local Ground website (Figure 8)¹⁴ and are continually developing the functionality as needs to arise. Having an API is critical to our work: since there are many ways in which the qualitative data might best be presented, having maximum flexibility to re-mix the data makes it more likely that user needs can be met.

Figure 8: Screenshot of the API documentation



Map Viewers

Since this project was exploratory, we experimented with a variety of ways to present the data, using both HTML/JavaScript technologies and Flash/ActionScript technologies. For example, the viewer pictured in Figure 9¹⁵ is centered on the individual maps created. This way, students can see each others' maps, as well as have the satisfaction of seeing their own map online. On the other hand, the viewer pictured in Figure 10 presents a summary-level view of the data so that decision-makers can quickly browse tags to determine which areas are labeled as "dark" or "important" or "under-utilized."

¹⁴ <http://localground.org/api.html>

¹⁵ <http://localground.org/map-viewer>

Figure 9: Screenshot of Local Ground's JavaScript-based map viewer

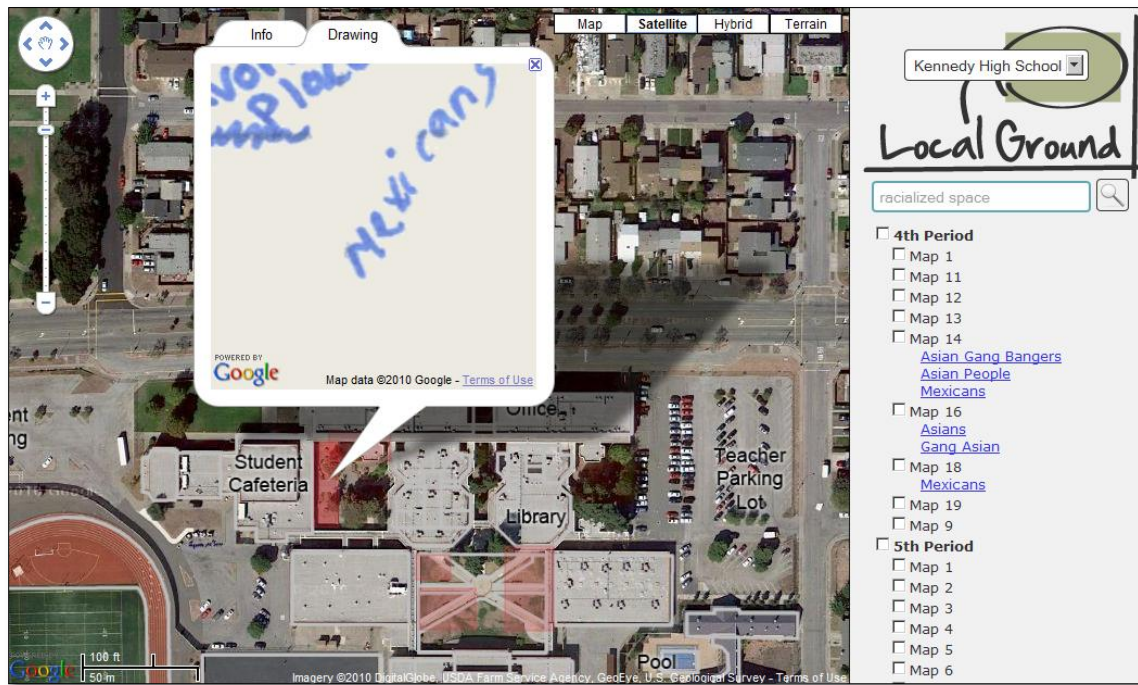
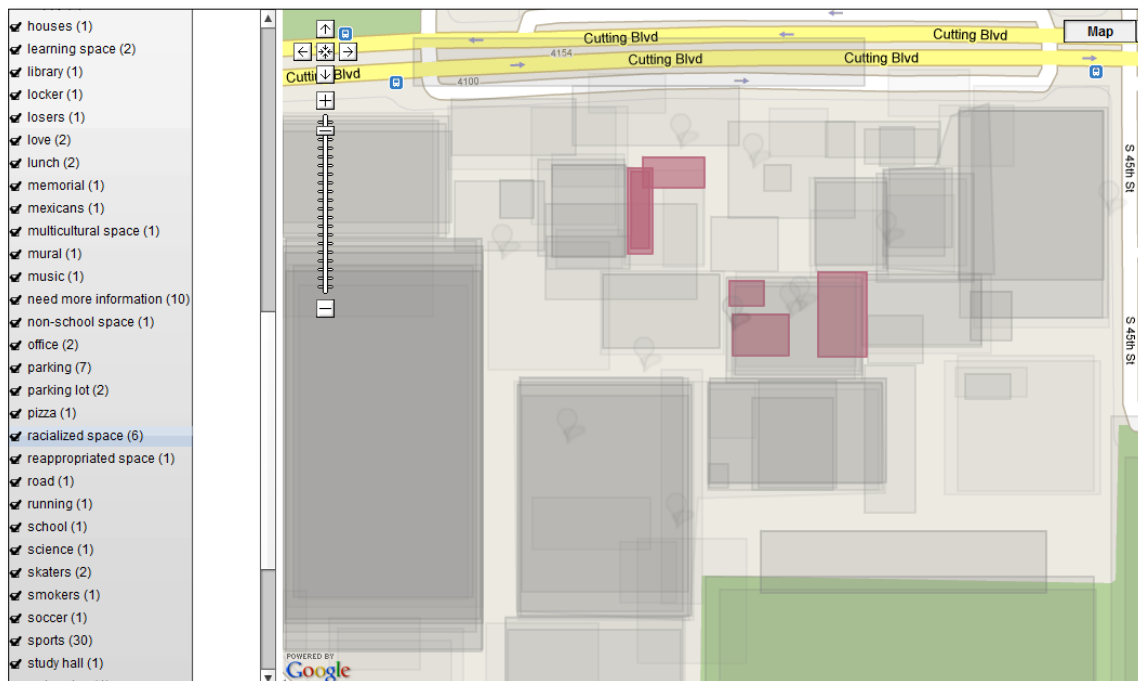


Figure 10: Screenshot of Local Ground's Flash-based map viewer



In addition to allowing for the display of paper map imagery, we also support the display of other elements, such as additional KML files and photographs. By supporting other forms of qualitative spatial data, it was possible to paint an even richer description of the spaces being explored by students.

Design Process

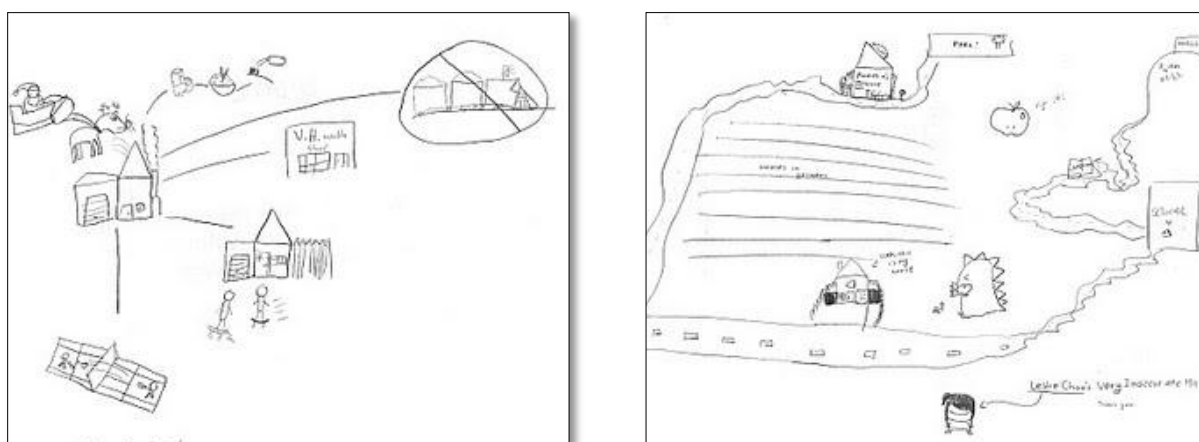
Now that we have introduced the Y-PLAN and given a general background of the technologies used to streamline paper-based data collection and integrate it into digital systems, we will explain our design process.

Cognitive Mapping

The Y-PLAN framework introduces students to the concept of “thinking about spaces” by first asking them to think about the places they experience in a given day. After a few ice breakers and a basic introduction to the NURVE project, the Berkeley mentors began the “Making Sense of the City” module by facilitating a cognitive mapping¹⁶ exercise. For the Kennedy students, cognitive mapping involved asking the students to close their eyes, imagine their day, and draw the places they either spent much time in or avoided. It is only later that students delve into the world of latitudes, longitudes, and spaces that can be represented in Cartesian coordinates. After giving students ten minutes to create their own cognitive map, it was clear that some students had put more effort into their maps more than others, and each student interpreted the assignment differently. Some students drew cartoons or comics; others drew more of a picture timeline, drawing arrows from one place to the next. A few students drew maps which included parks, friends’ houses, and boyfriends’/girlfriends’ houses in their maps (Figure 11). Regardless of individual effort, the cognitive mapping exercise gave students a first glimpse into how one might think about space and one’s experience of space.

¹⁶ “A process composed of a series of psychological transformations by which an individual acquires, codes, stores, recalls, and decodes information about the relative locations and attributes of phenomena in their everyday spatial environment” (Downs & Stea, 1973).

Figure 11: Cognitive mapping samples: where students go during a typical day



Introduction to Maps: Mapping in the Computer Lab

In the week following the cognitive mapping exercise, our project design team gave a guest lecture about mapping¹⁷ in the Kennedy High School computer lab, where we (1) introduced the concept of mapping, (2) showed students a map of the NURVE site using a custom map view that we created using the Google API (Figure 13), and (3) asked them to add a marker to a class Google Map using Google's "My Maps" tool¹⁸ (

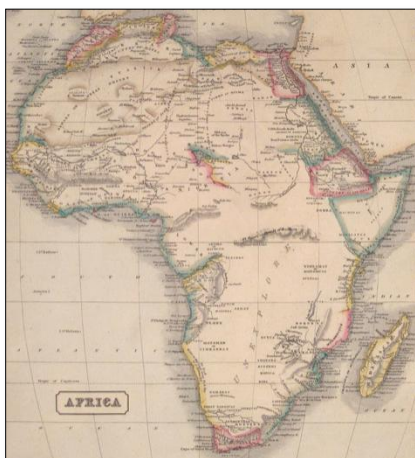
Figure 14). To start off the session, we briefly asked students how they used maps in their own lives. Students said they often used maps for directions and "in school," but not for much else. We also tried to facilitate discussion around the types of information that can be represented using maps, such as boundaries, landmarks, or commercial centers. We did this by showing the students a map of Africa, drawn in the 1850s, where the center of the map was blank because it had not been explored by Western cartographers, and an upside-down map of the world to challenge their concept of the standard "North is up" map (Figure 12). We asked the students why they thought the center of the African map was blank, and several answered that it was because "no one" knew what was there. We also asked them which continents were more or less noticeable when the map was upside down,

¹⁷ Online lesson can be viewed at <http://groups.ischool.berkeley.edu/papermaps/maps.html>.

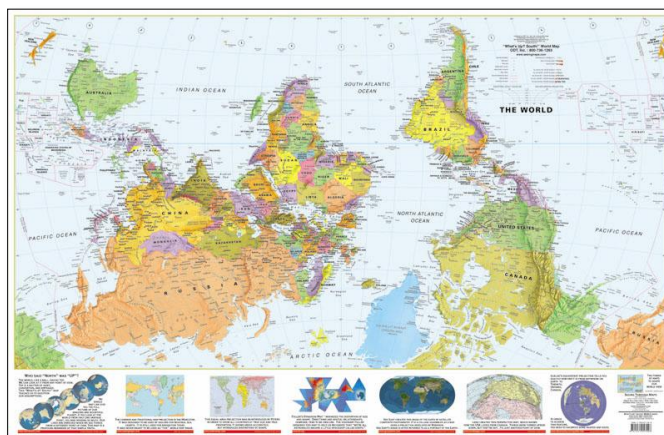
¹⁸ A web-based Google tool for adding markers to a Google Map and saving them to one's user profile to access again at a later point in time, or share with others

although this question received less feedback than the questions about the African map. Overall, we attempted to give the students an introduction to how space is documented on map and how maps often reflect not just the reality of space, but also the biases and knowledge of those who created the maps.

Figure 12: Exploring the information portrayed in different kinds of maps



Source: <http://www.philaprintshop.com>



Source: <http://flourish.org/upsidedownmap/diversophy-large.jpg>

For the second part of the lesson, we asked students to open a web browser and type in a URL to a Google Map that we created using the Google Maps API.¹⁹ The map had 4 layers: (1) an annotated map of each feature of the NURVE site (MLK Park, the elementary school, Nystrom Village, etc.), (2) a historic map from the 1950s taken from the fire insurance map collection, (3) a hand-drawn annotated layer named “Sarah,” and (4) another hand-drawn annotated layer named “Michael” (Figure 13).²⁰ The purpose of the lesson was to acquaint the students with online maps, particularly Google Maps, and note that there were many different types of information that could be overlaid onto a map – labels and borders, historical information, and even drawings. We asked students to turn on the satellite imagery, observe MLK Park and then zoom to Dolores Park in San Francisco to compare the two parks. Finally, we

¹⁹ Google’s Application Programming Interface (API) for its map tools, which allow programmers to customize and interact with Google’s map data, as well as overlay custom data sets and imagery. Please see <http://localground.org/nurve.html> for a working demonstration of the map that students explored in the computer lab.

²⁰ <http://localground.org/nurve.html>

asked them to simply explore the map. Some students installed Flash by themselves and turned on Street View,²¹ while others looked for their houses from the satellite view.

Figure 13: Introduction to online mapping, map overlays, and the NURVE site

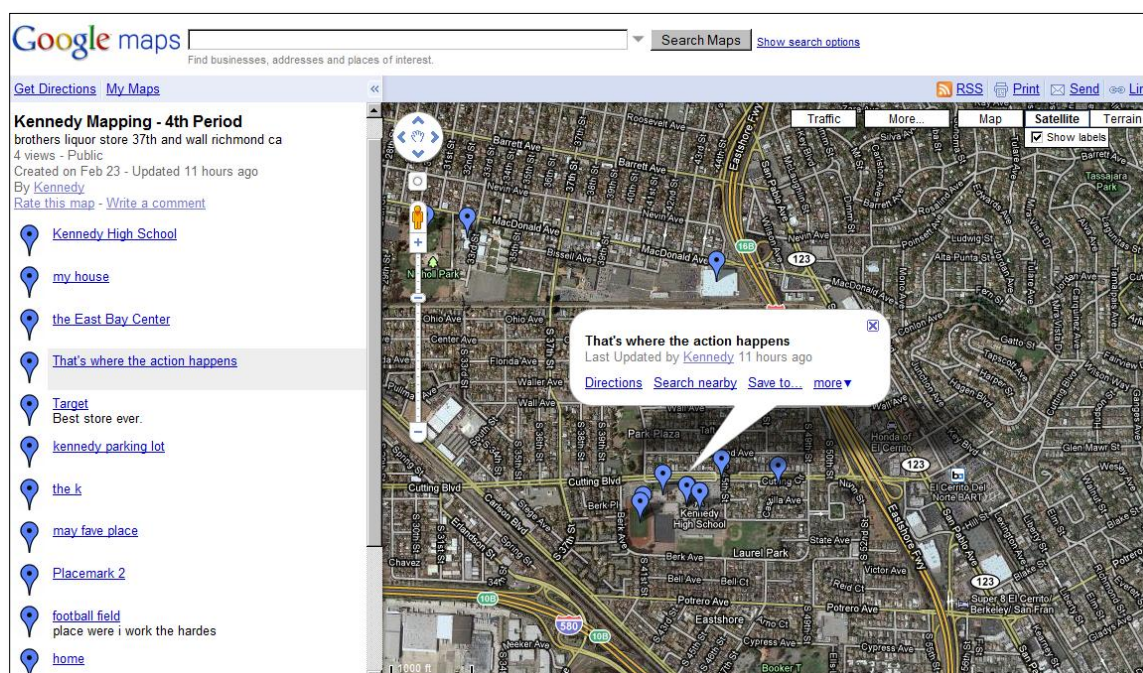


For the final ten minutes of the lesson, we asked students to create a class map using Google My Maps. Prior to the lesson, the design team had created a class Google account with two blank "My Maps"—one for fourth period and one for fifth period—that were pre-zoomed in on and centered on Kennedy High School. We asked the students to add two markers to the map: one to mark a place they enjoyed visiting, and one to mark a place that they didn't particularly like. During the hands-on portions of the lesson, we walked around and answered individual questions. The students varied in their familiarity with Google Maps, web browsers, and computers in general. However, most students

²¹ A view in which users can see panoramic, street-level photography of a particular location, including cars, houses, and whatever features were present at the time the photograph was taken.

eventually were able to add their own markers to the map after approximately five minutes of instruction and a supplementary handout.

Figure 14: Fourth-period class map in Google's "My Maps"



Discussion

During the computer lab session, the design team's ultimate goal was to communicate to Kennedy students that maps could be given additional meaning based on annotations and supplementary information and that anyone could make a map, not just "experts." At this point in the Y-PLAN process, students hadn't developed relationships with any of the mentors and frequently expressed how little any of the mapping we demonstrated mattered to them. Given the proliferation of complaints from students about getting stuck, we were surprised that so many students were able to eventually add data

to the map. We also noticed that students refused to put a marker just anywhere. Rather, they insisted on putting the marker some place meaningful to them.

Even students who were stuck or had a hard time typing in the URLs to the links we gave them seemed to be trying. Their frustration and requests for help indicated to us that they genuinely wanted to succeed in opening the links, in contrast with the small number of students who simply refused to interact with their computer. There was also a great deal of collaboration and discussion about the maps themselves, some relevant, and some somewhat off-topic— one student browsed to the Great Wall of China and then bragged to another student that he had climbed it. Many students also found their house on the map. We discovered after the session that one of the students had even changed the style of the class Gmail account and made the map publicly available. Another student found the custom marker symbols in My Maps and opted to use a dollar sign to mark her house. The descriptions and titles the students chose for their markers were interesting as well. Some samples titles include: “That’s where the action happens,” “This is where people be starving,” and “Target – the best store ever.” There were about 20 or so markers per map, which meant that for the most part, everyone seemed to have contributed content.

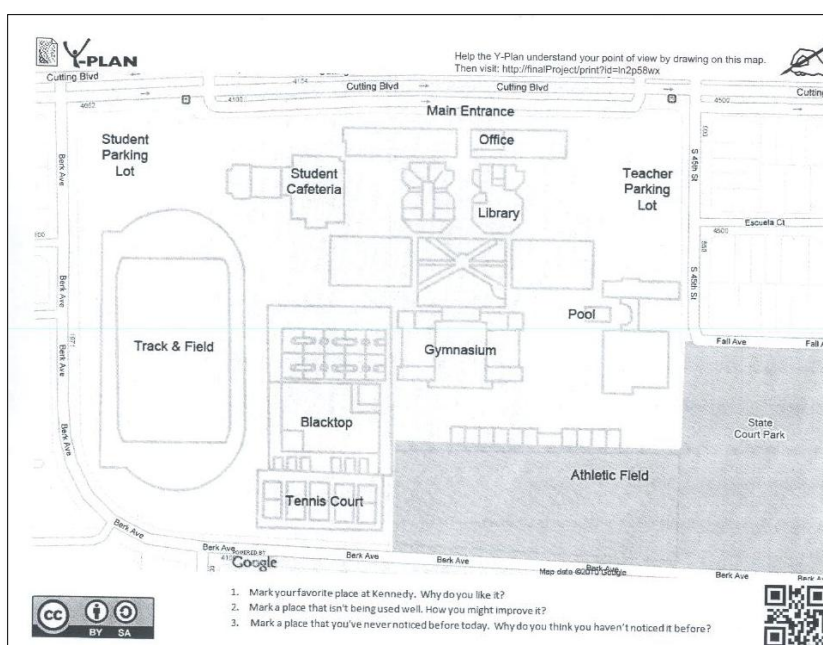
Mapping the School and the Neighborhood

For the next phase of the Y-PLAN, Kennedy students and mentors planned to collect data about the NURVE site to identify both assets and areas that could be improved upon. There was a class trip to the NURVE site planned for the coming week, but as practice the class decided to walk around the Kennedy campus to fine tune their observational skills. This was the design team’s first opportunity to test our paper-to-pixel process for collecting qualitative geo-spatial information.

Preparation

In preparation for the campus walk, the team digitized the outlines of all of the buildings, classrooms, fields, courts, and courtyards at Kennedy High since this level of detail is not available in the Google map tiles and printed out paper maps marked with QR codes (Figure 15).

Figure 15: Paper map used for Kennedy High School mapping exercise



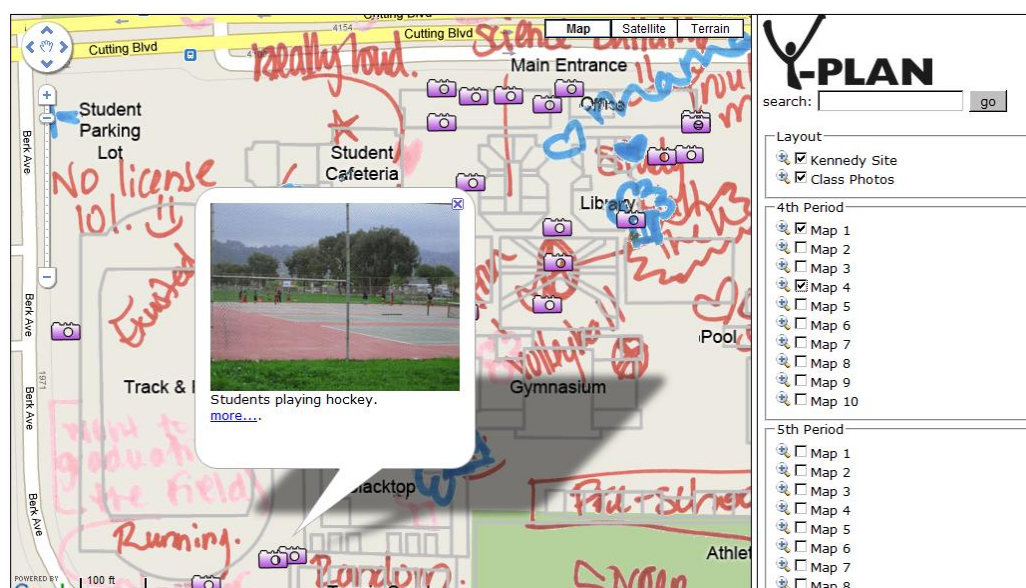
Since we anticipated overlaying many maps on top of each other to aggregate each class' observations, we also spent some time prior to the mapping exercise testing methods to remove the map background from hand-drawn annotations. Though we initially tried to perform an image subtraction, where pixels common to both the original image and the final image are removed, this was ultimately unsuccessful due to the variations in the scan and print quality and distortions to the image that occurred during the image rotation and scaling process. We finally came up with the idea to only preserve sections of the map in color, which required that the actual maps be printed in grayscale and that students had to write on the maps using colored pens and markers. By imposing this constraint, we would be able to subtract all pixels where the R, G, and B values were roughly equivalent, leaving only the colored portions of the map – the student-generated content – visible.

Data Collection

These paper maps were handed out to students, who were asked to record their observations of Kennedy using colored markers. Two students were also given digital cameras to take photographs of their observations. One of the design team also followed a group of students to video tape the process. The students led their Y-PLAN mentors around the school grounds and recorded their spatial observations, annotating their maps based on their own ideas and a few prompts from the Y-PLAN

mentors, such as "Where do people hang out?" or "What do you think of this space?" The design team then collected the annotated maps and scanned them into the Local Ground system, where they were automatically processed, geo-referenced, and displayed in a rough, first-generation map viewer (Figure 16).²² The photos that students took were also processed and manually geo-referenced according to the places they were taken. The design team also provided paper maps to Helms Middle School and Richmond High School students to map the immediate neighborhood around the site of the new Helms Community School. In the case of Helms, since the design team wasn't able to anticipate the students' trajectories ahead of time, the maps that we provided did not sufficiently cover the area walked. Consequently, the students could not map their observations for places that went beyond the extent of the map boundaries.

Figure 16: First generation hand-drawn map viewer



²² <http://localground.org/kennedy.html>

Discussion

The design team had no idea what to expect and was uncertain if the students would even write on the maps and participate in the exercise. At this point in the semester, student participation was marginal, as they did not understand the point of the Y-PLAN and were not emotionally invested in the program. Surprisingly, despite slow beginnings where no one wrote anything on their maps, many of the students eventually covered their maps with descriptions of spaces from their perspectives and collectively created a rich tapestry of observations. In contrast to the computer lab, where four or five mentors took about ten minutes to make sure twenty-some students had marked a single place on the map, the students needed no hands-on instruction to draw on the paper maps, although prompts from the mentors helped to stimulate their imagination in both exercises. Although some students only marked a few areas on the paper maps, others covered their maps with images of cupcakes to mark popular make-out spots, smiling or frowning faces to indicate likes or dislikes, and other such notes. Many students mapped where they perceived certain cliques gathered, while others wrote in their impressions of different areas of the school, such as a happy face and a heart accompanied with the note "Love swimming" by the school swimming pool.²³ Although at that point in the process, Local Ground had no means to display data trends, we discovered several hot spots of activity around the school—from the popular area to socialize at to a spot behind the library identified as “where emo people r”²⁴—by simply layering all the annotations from the students on top of each other.

Mapping Nystrom Village

After the high school mapping exercise, we conducted a similar mapping exercise at the Nystrom Village site, as part of a school field trip. We printed paper maps of the area, using the same methods described above, and gave the maps and two cameras to the Kennedy High students. The design team, mentors, and students walked around the neighborhood, with the students again taking notes of their observations on the map and snapping photos. Though several of the students lived in the area, the neighborhood was new to most students. Rather than mapping a space they knew well, like their high school, the students tried to observe their surroundings, probably for the first time. In contrast to the more light-hearted notes that had been scribbled on the map from the previous mapping exercise, some of the maps from the Nystrom exercise read “looks like a crack house” (referring to the Nystrom Community Center) or “robbery type area.” The students also took some interesting photos – some of

²³ Student-annotated map created in a mapping session at Kennedy High School on March 1, 2010.

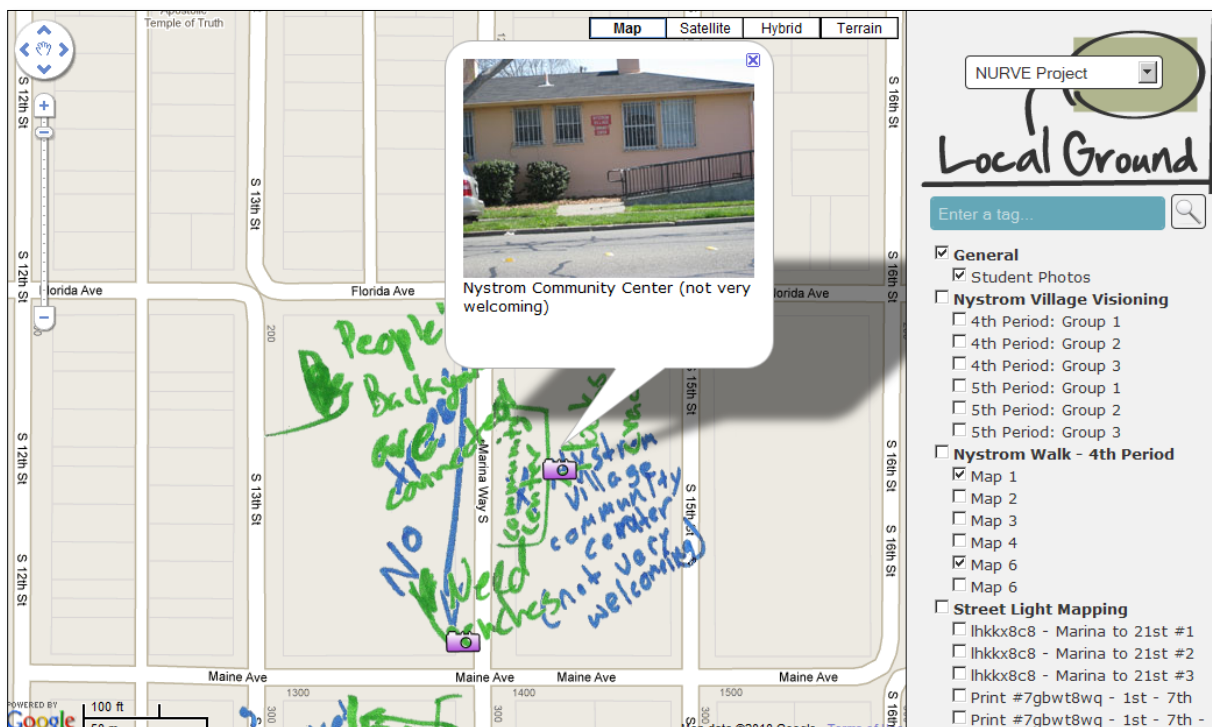
²⁴ Student-annotated map created in a mapping session at Kennedy High School on March 1, 2010.

the houses, streetscapes, and construction workers, and others of broken glass, litter, potholes, and loiterers (Figure 17). Like the first exercise, we scanned in and used the Local Ground system to geo-reference their annotations and manually geo-referenced their photographs (Figure 18).

Figure 17: Left: Kennedy High students annotate maps of their observations of the neighborhood. Right: A photo taken next to the entrance to the park



Figure 18: Collecting data about Nystrom Village



Mapping Street Lights

The design team also wanted to test how QR-coded paper maps would work for more quantitative data collection. Thus, we worked with the NURVE “Safety Committee” – a committee formed by the Coronado Neighborhood Association – and the Martin Luther King Jr. Youth Council—a group of youth consisting primarily of former Y-PLAN students—to survey street light outages in the Nystrom Village area.²⁵

Preparation

After speaking with the City of Richmond’s Public Works department, we learned that when reporting a broken street light, we needed to submit the following information: (1) whether the pole was wood (belonging to PG&E) or metal (belonging to the city), (2) its serial number (two different numbers for each pole), and (3) the location. Since we anticipated recording multiple street lights per page, we created a new map template with whitespace at the bottom, to allow the mappers to record detailed data. We then printed out a series of 4 maps that spanned 1st St. to 20th St., and again brought along colored pens to record the outages.

Data Collection

We handed out the map packet to the mappers—two Youth Council members, a volunteer, and the both of us—and slowly drove around each block to find broken streetlights. The mappers exhibited varying degrees of difficulty following along on the map: one of the Youth Council members was frequently on the wrong page, other members were on the right page but on the wrong street or the wrong side of the street, while yet others had no problem with navigation. We decided as a group to record metal poles with a red marker and wooden poles with a green marker and wrote observations and serial numbers in the margins. Most of the mappers also colored in a small legend in the margins of their maps. As we neared to the park and more towards the “single digits,”²⁶ the mappers noticed that some areas felt particularly dark or uncomfortable. Although this was not a part of their initial mapping plan, they also wrote down their observations.

After the data collection was over, the maps were scanned in and annotated using the map editor (Figure 19).

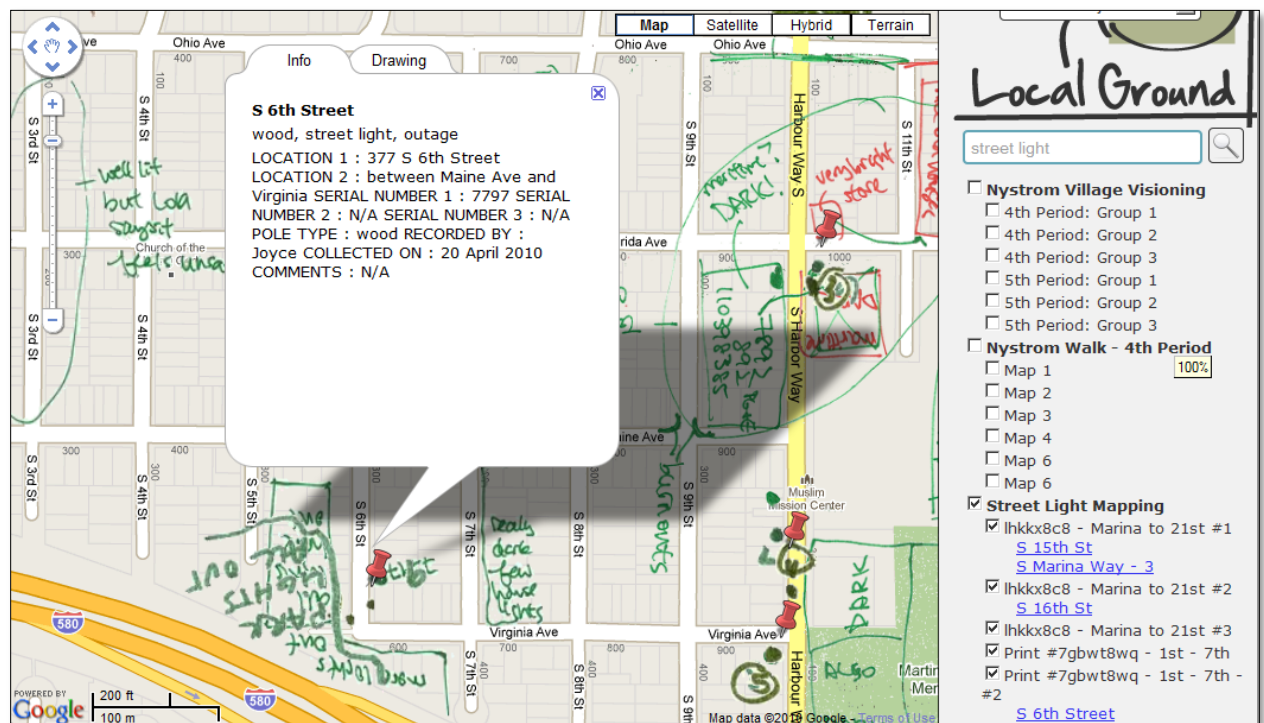
²⁵ Bounded by Ohio Ave. and Cutting Blvd. (north/south) from 20th St. to 1st St. (east/west).

²⁶ How the council members described 1st through 9th streets. They explained that the “single digits” are particularly known for crime, though they remarked it was a “quiet night” on the night we did our street light mapping.

Discussion

Most of the mappers noted that it was difficult to stay oriented while driving as opposed to walking. We also found that it was helpful to have more than one person recording the data, for quality purposes. For example, once the scans had been processed, if one of the street light locations had been marked incorrectly, there were two other scans to compare against. Having the Google satellite imagery underneath the maps was also extremely helpful, as it was possible to see the actual streetlight shadows and the markers for purposes of comparison. Finally, the maps allowed us to document information that we had not expected to find, such as how dark an area felt. Had we used a more form-based approach with predetermined legends, we would not have been able to accommodate further qualitative documentation, and we would have lost the additional information gathered on the trip. Furthermore, paper proved to be a very forgiving medium for mistakes, as the mapper could simply cross out errors and annotate the map with comments such as “oops, wrong place.”

Figure 19: Map of scanned and annotated street light and lighting information (Nystrom neighborhood)



Documenting Student Visioning and the Inquiry Process

We have now described all of the paper-map-based data collection exercises that were carried out during the semester-long Y-PLAN program. We would now like to briefly discuss a few other features of

the mapping toolkit that we developed in response to other types of spatial information generated by the students.

Incorporating Supplemental KMLs

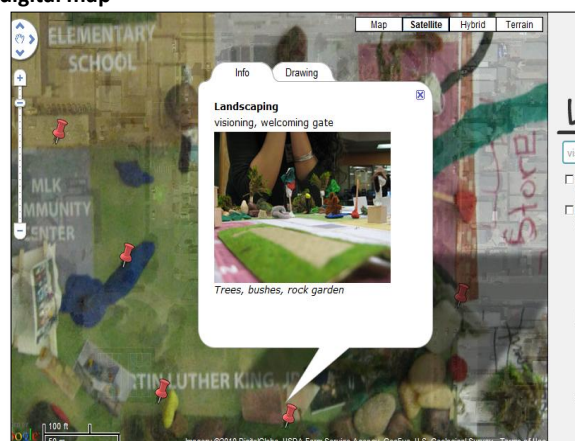
After the data collection phase of the Y-PLAN ended, students launched into their planning phase, where they participated in a charrette²⁷ to envision designs for the future of Nystrom. The students were asked to build 3-D models out of cardboard, clay, twigs, rocks, and pipe cleaners, to communicate their ideas visually, which they ultimately presented to each other (Figure 20).

Since the models were build on top of real maps, thereby preserving real-world dimensions, the design team decided to create custom aerial imagery by geo-referencing photographs of each map model and importing them into our viewer using KML files. We also asked students to take photos of the key ideas from their models and added map markers to the interactive viewers to tie each photograph to its corresponding location. The team was curious to find out if overlaying the *current* Nystrom neighborhood information with the *future vision* of the neighborhood would be understood by users, and whether or not users would find this information valuable.

Figure 20: Students build 3-D models of their vision of the Nystrom neighborhood



Figure 21: Students' models displayed in a Local Ground digital map



Y-PLAN Website

Finally, to put all of the data collected about the students into chronological context, the design team also decided to make a WordPress²⁸ website for the spring 2010 Y-PLAN inquiry process (Figure

²⁷ Any collaborative session in which a group of designers drafts a solution to a design problem.

²⁸ WordPress: A web publishing platform for content management (<http://wordpress.org/>)

22).²⁹ In addition to supporting the students' ability to describe their inquiry process to City Hall, the website was also a way for the design team to point Y-PLAN participants to the map viewers that we had developed to see what they thought. We hoped to be able to allow students to have a chance to browse through their data in a way that was straight-forward to them. The website content consisted of links to the map viewers, photographs the students had taken throughout the process, videos of students' classroom presentations and debates, and photographs that the mentors had taken to capture student work. All of their work was displayed chronologically, following the structure of the Y-PLAN Roadmap.

Figure 22: Y-PLAN website to document the students' community inquiry process



Discussion

A week before the City Hall exhibition, where students would present their data, models, findings, and recommendations, the design team gave the mentors and Center for Cities and Schools (CCS) staff a preview of the website and the maps – complete with the digitized paper maps, photography, and models – during one of the regularly scheduled Y-PLAN seminar classes. Though the mentors were aware that the design team was using the Y-PLAN as a case study to explore digital mapping tools, few of them understood precisely what we had been building. When we unveiled the digital maps and the websites to them, mentors were all very enthusiastic about the idea of publicly showcasing the process that the students had undergone, the data that they had collected, and the models that they had

²⁹ Y-PLAN Spring 2010 website link: <http://youthplan.org>

created. The digitized models were particularly popular among the class: when Deb McKoy and Ariel Bierbaum, CCS's founder and director (respectively), saw the students' 3-D models in the interactive map viewer, they remarked that last year's models were in a closet down the hall how great it was that the students' work could be displayed online, especially since the planning process for NURVE is expected to go on for years to come. This in particular confirmed our theory that the online aspect of Local Ground would mitigate how physical artifacts were frequently lost or filed away. The mentors were amazed that something could be extracted from a poster and be put onto a live online map. One of the mentors said that she found it particularly powerful that the students' 3-D models could be overlaid on top of satellite imagery and made to look like they should be "taken seriously" on the web. At the end of seminar, several mentors volunteered to contribute content in the form of photos and videos and were enthusiastic about using the website and the map viewers to showcase student work.

At City Hall, the design team brought in two laptops to show the students the website and the interactive maps for the first time. Students took over the keyboard and turned other students' maps on and off, guessing which students in the class drew which map. One student asked if she could post the map on Facebook to show her friends. Although our focus was on analyzing the maps as a useful planning tool, the students brought an emotional dimension to the maps. They had fun looking at the maps: as they panned around and looked at other students' notes about "EMO people" or "cupcake spots," they would burst into laughter and joke with each other. The team then asked two of the students to operate the "computer booth" (alongside other booths displaying posters and models). For about an hour, guests circulated from booth to booth. Guests included the City Manager; academics from UC Berkeley and San Francisco State; members of the Richmond City Council, Bay Area LISC, and the Richmond Children's Foundation; the Kennedy High School Principal and Assistant Principal; teachers; parents; and friends. As guests approached the computer booth, the students pulled up the maps and began describing their mapping process. One of the students opened the Nystrom Village map and began turning on students' data layers. One of the guests remarked, "Wow, it gives you a sense of the complexity of the space." The students agreed.

At the end of the night, after the students had presented, Deb asked that we demonstrate the website and the maps to the City Manager, LISC, the Housing Authority, and the rest of the panel, in front of the entire auditorium. The audience smiled as we were able to show simultaneously, through the interactive map viewer, a student model overlaid with a paper-map description of the area overlaid with a photograph taken by one of the students at Nystrom Village. Without interfering with the Y-

As we were working on preparing for the Y-PLAN presentations, the design team also focused on creating and evaluating different map viewing tools. Although we had a first-generation interface to view the students' annotations, the interface was optimized for viewing each student's map separately. Turning on all the layers meant annotations and drawings were obscured by other annotations and drawings, and although we could find hot spots where many students had written over the same area, it was difficult to tell what they had written and if there was a consensus in the comments (Figure 23).

4052

Student Parking Lot

Student Cafeteria

Main Entrance

Library

Teacher Parking Lot

Gymnasium

Blacktop

Athletic Field

Running Track

Berk Ave

S. Glen St

4100

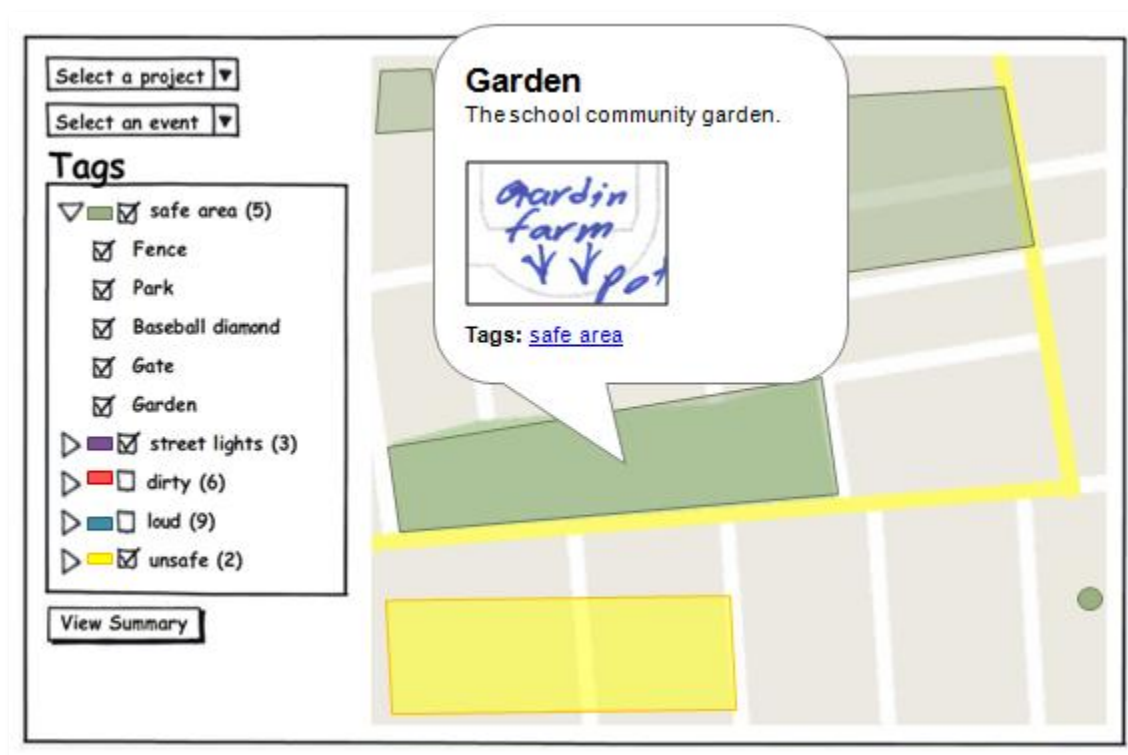
As a result, we built prototypes of two different types of viewers. One was a Flash-based viewer optimized for a high-level summary of the data (Figure 10), and one was another iteration of our original JavaScript-based viewer (Figure 9), with the addition of a tag search function. We showed a low-fidelity

prototype (Figure 24) of the Flash-based viewer to April Suwalsky, a previous Y-PLAN mentor who is now working at the RCF on the NURVE project. April noted that the summary view was extremely helpful, but that she would also want to be able to drill down to find out who had created an annotation. She stated that she would weight a local resident's opinion differently from the opinion of a city planner. She also wanted a way to not only view a summary of selected tags, but to also be able to print them out so that she could pass them out at meetings.

The design team then showed a Y-PLAN mentor and Deb a version of the Flash-based viewer before we had tagged and annotated the data. Although both of them enjoyed being able to see the students' work on the maps, since we had not yet tagged or summarized the student-annotated maps, the lack of summary data made it difficult for them to imagine what the interface would potentially look like. Both also noted that having a framing device or narration to set the map data in context would be helpful. Now that the student data has been tagged and annotated, we would like to revisit the viewers to see how actual data would make the experience different.

As noted previously, the students were delighted with the layer-based viewer. Several students could identify which of their fellow classmates had created a particular layer based on the handwriting and the annotations, and many of them enjoyed seeing their own annotations online and on a Google Map. Being able to have a creator-based view as well as a summary-based view allowed for a more personal connection with the data, which directly contributed to the students feeling as though their voices had truly been heard.

Figure 24: Low-fidelity prototype of Flash viewer



Outcomes

We have described the Y-PLAN inquiry process and the ways in which the design team experimented with technology to support the collection and analysis of place-based information. We were able to achieve our initial objective of being able to collect qualitative geo-spatial data using QR-Coded maps. We were also able to develop information architecture to support browse, search, and data visualization of the information. Finally, we were able to publicly present students' hand drawn map data, integrated with other data sources – photos, schematics, and other qualitative maps –by showcasing our map viewers to city officials and community members. Not only were the information tools enthusiastically received at the City Hall event, but mentors, students and CCI staff all took ownership of the maps and used them to showcase their community mapping process, describing them as “our mapping tool” and “our website.” Though further research is still needed to do a true evaluation, we have highlighted several of our preliminary findings:

Paper Keeps Things Fun

The design team found that community collaborations are both serious and lighthearted at the same time. Though community members and paid employees all come together to carry out important work and solve common problems, since community participation is largely dependent on volunteer efforts, the process must be fun. The free-form and flexible nature of paper allowed data collectors to express their ideas in their own way, using their own language. As the students walked around campus and their community, the flexibility of paper allowed them to be themselves, rather than having to fit their responses into a pre-defined data entry form. Later, when students were actually able to view their own maps on a Google Map, they thought it was hilarious to see their own Kennedy High slang written on top of satellite imagery. Given that participatory mapping and charrettes are also designed with fun in mind, the QR-Coded maps honor the spirit of community collaborations.

A Computer Makes Paper Seem More Legitimate

Many of the mentors and CCI staff mentioned that having the student data available online was another way to honor student work, and they found it very powerful. Throughout the semester, there was much discussion about the lack of “good news” in Richmond, due to Richmond’s national reputation for high-crime. However, having a way for student ideas and voices to be heard by a wider audience had universal appeal to Y-PLAN mentors and staff. Students also indicated that they valued having representations of themselves online by exclaiming that they wanted to share the website with their friends and put it on Facebook.

Good Data Collection Requires Planning

Since paper maps have no real data validation or required fields, it requires that mapping facilitators plan their data collection sessions carefully. There are a number of things that must be anticipated in advance, such as:

1. What is it that is being mapped?
2. What is the appropriate zoom level for the mapping activity? Furthermore, if the map is zoomed in very close, should there be a way to provide some additional contextual information (such as the building outlines at Kennedy High)?
3. Where will the data collection activity be taking place, and what are the boundaries?
4. How familiar is the mapper with the place that is to be mapped?

The flexibility of the map means that a mapper can write anything, so being clear about what is to be mapped will determine what information will be recorded. For the Kennedy High School mapping, the instructions were loose and flexible. For the street light mapping, there were specific data attributes that needed to be collected for each street light. Being able to anticipate the area of inquiry ahead of time also ensures that the printed maps are printed at the right scale. At Helms middle school, the mentors didn't know in advance where they would be walking, and as a result, they printed a map that spanned several miles. At this zoom level, Helms and Richmond students did not have the opportunity to take detailed notes. On the other hand, at Kennedy the students worked with a map that only spanned 1,000 meters and hence were able to give accounts of space at the building level. Higher zoom levels tended to encourage rich descriptions.

A Flexible Architecture Means That Many Perspectives Can Be Supported

As expressed in multiple sections of this paper, paper allowed for flexible expressions of space, and could be adapted, on-the-fly, to fit a number of different scenarios. It was only in the car, as we started driving around to look for broken streetlights, did we determine a key:

- red = “City of Richmond”
- green = “PG&E”

We were also able to switch from collecting data simply about street lights to collecting data about the way spaces felt. This would not have been possible using many hand-held, forms-based, GPS-enabled input tools.

In addition to the flexibility of the paper, the flexibility of our information architecture also allows end-users to view the aggregated data from multiple perspectives. Whereas April, a local NGO worker, wanted to see a summary of what community members had said about a place, Kennedy students were more interested in seeing what their friends and classmates wrote about the school.

Importance of Integrating Technology into Existing Processes and Social Structures

Paper maps also succeeded as a data collection tool because they were familiar, required no training or special devices, and fit well with existing processes. In the case of the Y-PLAN, students in 2010 collected spatial data in the same familiar way that they did in 2009, but in 2010, QR-Codes, some image processing tools, and a database had enabled students' information to be extracted and displayed in an online map, where their observations could be preserved and analyzed more easily. Similarly, the Martin Luther King Youth Council had participated in other hand-drawn mapping activities in the past, so

the format was familiar. Finally, Kennedy students were all familiar with doodling, drawing, and note-taking. Whereas teaching students to add a marker took around 20 minutes and scheduled computer lab time, mapping with colored markers was understood immediately.

Benefits and Limitations in Working with the Y-PLAN

Finally, as we reflect on the design process and collaborating with the Y-PLAN, the design team could not have discovered a better test case for the potential for QR-Coded maps in qualitative geo-spatial data collection. We had weekly access to students in their classroom for twelve weeks; the students were working on a genuine community development project; and community mapping was central to their inquiry process. In addition, the fact that we were able to work with teenagers, though challenging at times, meant that there was a fun-loving spirit to the entire data collection process that made spatial information gathering fun, and full of surprises. As an added bonus, the design team was able to observe the students' perspectives on community engagement truly transform as they went through the Y-PLAN process. The team watched skeptical, seemingly apathetic students transform into students that truly applied themselves and believed in their own power to change their community.

From a purely logistical perspective, our main challenge was time: since mentors had less than an hour a week to spend with students, and have a very full itinerary of goals to accomplish during each class, it was not possible for the design team to conduct the kind of structured evaluation we might have liked. Had there been the time and the opportunity, we would have asked students to do a number of things:

1. Use Local Ground's map editor and tag their own paper maps
2. Browse around the map viewers and talk about their reactions to various spaces
3. Complete a technology survey, to assess their level of computer literacy
4. Post the map links on their Facebook and MySpace pages to see what would happen

The design team would have also liked to interview the City Manager and the head of the Richmond Housing Authority, to see what they thought about the maps and the website. Fortunately, over the course of the semester, the design team has been able to build personal relationships with students and with the various collaborators within NURVE, so for future efforts, it will be possible to meet students and other NURVE participants outside of the classroom environment.

Future Work

The majority of our work for this masters' project involved field testing data collection with the bar-coded paper maps. Although we have also created an editor to tag and describe the annotations, two different viewers to summarize the data collected, and an API to access the data collected, all these software artifacts are still in the prototype phase. Our short term goals involve improving on our current scripts and software, whereas our long term goals involve forging more partnerships with local organizations to test Local Ground with a wider range of users and use cases.

Data Collection and Image Processing

1. The SIFT algorithm we used to straighten and scale the scanned map images failed to process the image correctly if (1) students wrote on the embedded images added to each corner of the map for the algorithm to use as a point of reference for straightening or (2) images were scanned in using a low-resolution scanner or camera. We would like to experiment with other image processing libraries in order to make the image processing more robust, and not dependent on high-resolution map scans.
2. We would like to incorporate the ability for users to add their own data and create their own layouts before printing a QR-coded map. For example, the map view of Google Maps does not include the Kennedy High School schematic and the satellite view was too graphically busy for students to annotate. As such, we had to add the school plan manually, along with the Y-PLAN logo. Giving the map-printer the ability to add supplementary details to the printed maps will ensure that mappers have sufficient context to carry out the given mapping activity.
3. We would like to create a way to print a book or package of maps. Since a mapping activity, such as our "Streetlight Mapping Exercise," often spans a larger area than can be rendered on a single page at a suitable scale, the map-printer should simply be able to specify (1) the boundaries of the area to be mapped, and (2) the appropriate scale in order to generate all of the maps required.
4. While teaching the students to place markers on Google Maps, we noticed that students spontaneously changed their markers to icons or images personally significant to them. Furthermore, paper maps generated in community meetings also use icon-based legends to denote items such as surveillance cameras, fences, or trees. We would like to explore using

stickers as a physical representation of the Google Maps icons, as well as a pre-made legend for planners to pass out.

Data Summarization and Visualization

1. Several people we talked to expressed an interest in printing out versions of the annotated maps to bring to planning meetings. Currently, the Google Static Maps API used for printing does not accommodate image overlays, so users cannot print their maps with the annotations they made. Creating a service to do this may violate the Google terms of service agreement, which necessitate a return to OpenStreetMap.
2. Users of our map viewers noted that they would like to save a particular view of the data, such as particular overlays turned on, or a search on several tags. They would particularly like to email a link to a saved view so if they found a particularly engaging or important view, such as a playground built next to a busy street corner, they would be able to share the data with other decision makers.
3. Finally, we would like a wizard that let users geo-reference images from non-bar-coded maps. We found that placing images of the 3-D models the students built on the maps made the models feel more life-like and realistic, and we also discovered that users might have previously existing maps that they would like to convert into digital versions.

Further Evaluation and User Testing

To date, we have only extensively tested the data collection portion of the Local Ground system. Although we both used the map editor and viewers to edit, tag, annotate, and explore the data gathered by the students, we need to further test our interfaces to optimize them both for community members and for public planners. We discovered it was often difficult to decipher handwriting or determine what an annotation meant while tagging the students' maps, despite having been there in person during the mapping exercise. As such, the ideal case would be a map editor easy enough for community members to use so that their annotations would not be subject to misinterpretations. Furthermore, we have only been able to show low-fidelity prototypes of our map viewers to city planners. Although their initial feedback has been extremely positive, further testing of the prototypes is still necessary. This way, our system will provide a way for information gathered from the local community to reach public planners.

We would also like to test the data collection portion of the Local Ground system with other groups. Although we believe the flexibility and cost-effectiveness of paper maps will make them suitable for a range of applications, we would like to verify this in the field.

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