ARTICLE

Community Mapping for Community Health: GIS, ICT, and Citizen Engagement

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Community health refers to promoting healthy living and health outcomes at the community level (CDC, 2017). Community in this chapter refers to not only a particular geographic area but also to a specified group of people, such as tribal or homeless communities. Individual health condition is mainly determined by the individual genetic makeup. Nevertheless, environmental and external factors determined by where a person lives and works also significantly influence an individual's health. Therefore, it is important to understand a person's community health factors, such as socioeconomic factors, physical environment, health behaviors, and clinical care ability.

When it comes to community health the main focus often lies in providing preventive care. Its first step is to assess the community's health needs and create a plan to address those needs. Engaging and empowering community members to participate in this process is imperative to have a better understanding of the community and to make a sustainable community health initiative that fits the community's cultural background.

Promoting community health requires collaboration between multiple stakeholders from the community such as healthcare providers, public health officials, businesses, community developers, faith-based organizations, local and regional governments, social service providers, schools, and most importantly community members. Individuals from the community know more about their community than anyone else and can identify issues and provide innovative ways to improve their communities.

Community mapping is an innovative method to make community members involved in community health initiatives. It is a citizen engagement activity using geographic information systems (GIS) and information and communication technology (ICT). This chapter will present 1) the concept of community mapping with current geospatial technology and 2) case studies of community mapping.

What is Community Mapping?

It is difficult to present a clear, standard definition of community mapping because of its novelty. Community mapping is often seen as being

synonymous with the concept of community asset mapping. Community asset mapping was defined as a capacity-focused way of redeveloping devastated communities where an inventorying of the assets of individuals and organizations is taken. Physical mapping was not required in the early stages of community asset mapping, the concept of community asset mapping has also broadened to include physical assets of the community, not limited to just individuals and organizations.

Crowd-sourcing has become a frequently mentioned mapping solution for resource-limited organizations needing better information or data about their community or region. While community mapping can be viewed as crowd-sourcing or as citizen science, which focuses on the collective power of amassing community asset data, the unique characteristics of community mapping come from the process of mapping.

Drs. Im and Tullock (2013) defined "Community Mapping" as a process for generating geospatial data through collaborative group work, using mapping technology to identify, understand, analyze, resolve, and disseminate community issues. Community projects are identified by three clear intentions:

- education, with participants learning about an issue(s) important to their community;
- engagement, with participants becoming more actively engaged in at least one public or community process; and
- empowerment, with participants being newly equipped with information or data to apply to a community problem or issue.

To understand community mapping fully, public participatory geographic information systems (PPGIS) need to be addressed. PPGIS illustrates how Geographic Information Systems (GIS) can be used to help marginalized communities with location-based technology. The concept and definition of community mapping in this chapter were developed by Dr. Im while practicing in PPGIS with various communities.

Public Participatory Geographic Information Systems (PPGIS)

In the 1990s, the initial concept of PPGIS referred to making GIS accessible to citizens in order to effectively share information and to facilitate public participation in the planning process. In the past, utilizing GIS required significant hardware, software resources, and data access, as well as organizational staff support, which was often considered a barrier to utilizing PPGIS. In recent years, internet and mobile communication technology have evolved, and individuals now have access to these technologies at an affordable price (from the unpublished paper Im & Mercer, 2008).

PPGIS was first coined at a meeting of the National Center for Geographic Information and Analysis (NCGIS) at Orono, Maine, the USA in 1996 (Sieber, 2006). Since then, the term has been used to describe the various government and private actions to garner input and commentary on planned development projects by those who would be affected by the development. The spatial visualization aspect of PPGIS has made it an important tool for professional planners to gain information from under-represented groups that are otherwise unable to participate in the planning process (Craig et al. 2002; Seiber et al. 2002; IAPAD 2007).

The visual effect of maps gives community groups tremendous power in communicating their message. Maps are attractive, can provide clarification to community problems, and are more likely to draw the attention of important government officials to issues. Early PPGIS initiatives focused on projects with indigenous and/or impoverished communities. In most cases, PPGIS consisted of printed maps presented to local residents, who then had the opportunity to provide comments.

PPGIS grew to be used in mainstream planning and decision-making processes to assist with quality of life and social justice issues. Those initiated by the government related to development tended to be reactive, allowing community members and grassroots alliances to pick from a number of design alternatives (Seiber et al 2002). On the other hand, preservation-minded individuals, community groups, non-government organizations, and universities have used GIS to find solutions related to their missions and to communicate that information to authorities (Ghose 2000; Laituri and Ramasubramanian 2006).

The number of PPGIS applications is growing. It is commonly accepted that PPGIS is an interdisciplinary approach that can and should be used as a tool to help communities analyze and find solutions to their problems (Craig et al. 2002; Laituri and Ramasubramanian 2006; Seiber 2006). Owing to its origins in GIS, PPGIS provides a medium to coordinate, view and share knowledge and information.

Benefits of Community Mapping (Im & Tulloch, 2013)

Record and archive community information: When community information is recorded by community members, the information is archived from the community member's perspective. The information reflects the community's needs and the data quality is improved from the community's perspective.

Encourage community engagement & collaboration: By using community mapping, community members are more engaged and collaborate with mapping.

To raise awareness on community issues: By participating in community mapping events, communities become more aware of the issues that they may have not deemed significant. While collecting data, they can begin to see a pattern of the item they are interested in, and they can even add community asset data overlaid on the map to dig deeper into community needs.

Promoting a sense of connection to the community, and give a sense of identity: While doing community mapping, participants feel a sense of attachment to the community and feel bond with other members.

Empower communities to advocate for change: Community members are empowered to be involved in planning and actions taken. The data can be used to present information to state officials that may need evidence in order to change laws or allocate more resources to specific communities.

Innovative solution (collective intelligence): By mapping community assets, you also can look at the information using other data layers which can help solve community issues that you may have missed. You can use the input from community members' dialogue and discussion to then find innovative ways of solving community problems.

Help local governments be more effective and equitable: Citizens participate more, the local government's work can be more effective and equitable.

The Process of the Community Mapping
When community mapping is considered, what do you need to think about?

- What is the purpose of the community mapping project?
- What issues do we need to solve?
- What kind of outcomes are expected?
- What kind of data is going to be collected?
- How do we solve the issues using community mapping?
- Who are the community members/entities who will be engaging in the process?
- What community will get benefits?
- What kind of methods/technology will be used?
- What kind of data do we need to collect?
- What are the available/existing data and limitations of such data?
- What types of data need to be updated?
- Once data is collected, how can it be visualized and how can it be analyzed?
- How to get feedback from the community people?
- How can we evaluate the project?
- How can the process be improved?

Common Questions

Dr. Im has put together hundreds of community mapping workshops in both South Korea and the United States. During these events, there are common questions that he is often asked which include the following topics, the reliability of the data collected, how to motivate and engage community members, and digital divides for a population that can not afford mobile technology

Reliability of the Data Collected

The reliability of the data collected by community members is a valid concern, which is why there are many checkpoints implemented that safeguard the reliability of the information. To control the data quality, rigorous pre-training is needed before community members can participate in collecting data. During the process of collecting data, teams include at least two members which serve as a way to increase the reliability of the data collected. Oftentimes, community mapping projects have a website gatekeeper that approves and controls data sets. Since the site is only open to community members with the secured password, the community asset data can only be entered by participants assuring that false data is not added by others in the community. If the community mapping site is open to the public, a more cautious approach is needed. This approach is possible if the public is only viewing data or the project is for emergency needs such as natural disaster management.

How to Engage Community Members

It is often difficult to get community members to participate in the community mapping processes. Working with existing community groups is the most effective way to get the rest of the community involved. Community members are more engaged if the project directly addresses their concerns in the community, so working collaboratively with the community is essential to be successful since they will be more motivated by the process. Sometimes, due to the nature of the project, the community mapping project may be open to the public which requires the public's input and participation. An example would be during disaster management, which has many benefits to the community being affected and therefore garners increased participation.

Digital Divide

A digital divide is an uneven distribution in the access to, use of, or impact of ICT for certain groups of the populations. Seniors, disabled people, and the homeless population often do not have similar access to smartphones which are needed for the community mapping process and if they do have smartphones they may not have knowledge or familiarity with using the device. To combat the digital divide, teams are often used during community mapping events. Teams are divided such that each team has at least one person that has access to a smartphone and can input data, for example, a team may consist of a senior and younger individual.

Geographic Information Systems

Geographic Information Systems is defined as "a computer system for capturing, storing, querying, analyzing, and displaying location-based data". In other words, it is an information system that can handle location-related data. An information system makes it easy to do the following: Add/update location-based data

- Display data on various visualizing methods on the map based on the author's intention with the user's perspective
- Store and copy/transfer data in digital format (the storage capacity has become much larger, the size is smaller, and the cost becomes affordable)
- Automate analysis (especially for repetitive tasks)

When identifying GIS history, the story of Dr. John Snow is a well-known historical case showing how mapping diseases played a crucial role in solving public health issues. He traced the source of a cholera outbreak in Soho, London in 1854. To do so he observed and collected information from residents, and used a dot map to identify public water pumps on streets, and illustrated the clusters of cholera cases. Based on the findings, he contributed to understanding the circumstantial features for the cholera outbreak and made London and other cities change the water system.

GIS can also help identify at-risk or minority populations within a community because the visualization by GIS can differentiate data in multiple ways such as color, and space differences, and lighten understanding of data intuitively.

Despite the potential of GIS in community health, GIS has not been widely used at the community level due to its

resource requirement. These resources include the cost of the hardware and software, data availability and accessibility, and the lack of knowledgeable GIS professionals since it wasn't until 2000 when GIS professionals started emerging. Prior to 2000, only large corporations, governments, and universities, and colleges were able to use geospatial technologies. In 2005, internet maps became available, especially Google Maps and Google Earths, so there was a huge increase in GIS usages.

Components of GIS

The following will describe the five components of GIS. However, with the evolution of technology including the internet and cloud service technology, there are now combinations of data and hardware, or software and process combined as services for consumers or users of GIS. Often this combination is customized based on the needs of the user.

Technology (Hardware and Software)

Initially, community mapping applications produced paper maps to support community engagement. The high cost and technological specialization associated early on with GIS can be traced to its initial users—the private sector, researchers, and governmental agencies (Sheppard 1995). At the same time, most non-profit organizations and individuals lacked the financial and personnel resources to utilize GIS.

There have been significant changes in computer hardware, GIS data accessibility, and the process of creating and accessing GIS. The speed of computing power has increased, while the price has decreased the basic required hardware costs are now low. Moreover, most internet portals allow people to access free and secure data storage spaces. We also now have mobile phones, which are more powerful, accessible, and affordable and can be used for GIS.

GIS software was expensive and not user-friendly until the 1990s. Some of the GIS software, such as ESRI's ArcGIS or QGIS (open source) require knowledge of the software. Now, there are tools that can be used relatively easily for data visualization and some of those applications provide the basic mapping services for free. An example of an application that is user-friendly is Google My Maps, this application can be used by beginners as it is easy to navigate.

Access to Data

In earlier years, obtaining GIS-related base data for community mapping was a major obstacle. Some agencies and websites provided data for free, but the available information may not have been relevant to a specific group's cause. Moreover, many community organizations did not have the necessary hardware and software to analyze the available GIS data. When groups were able to acquire data, hardware, and software, they still had the barriers of technical expertise and personnel development needed to use GIS (Craig et al. 2002). With the significant advances in internet technology that we now have, most federal, state, and local government data is now available via web portals.

These advances in data accessibility enable PPGIS communities the following benefits:

- Access to the latest roadmaps and aerial photos (where available)
- Ability to geocode and add other geographic features

- Ability to associate text, photos, and movies to geographic locations
- A greater awareness in the general public regarding geospatial technology, thus more comfort with this technology
- Many applications are developed by user communities, and these applications trigger other ideas as to how PPGIS communities can use the mapping

Open Data

"Data.gov is the federal government's open data site and aims to make the government more open and accountable. Opening government data increases citizen participation in government, creates opportunities for economic development, and informs decision making in both the private and public sectors" - from data.gov site.

The US federal government made an open data website called Open Government based on citizen participation in government. The site provides various mapping data about the economy, public safety, finance, etc. The initiatives of open data by the government are significant to increase the potential benefits and data innovation. Agencies' dependence on external innovators influences their actions to share data (Zhenbin et al., 2020).

People/Users

Another innovation in recent years is the Google Maps application programming interface (API) which allows user communities to customize Google Maps for their own needs. Many other web portals followed suit providing their own API. In addition, 3D visualization tools like Google Earth and Microsoft Virtual Earth have captured the public's attention. These mapping tools have raised awareness of GIS technology, and shed light on the endless potential for using GIS. There are now many public and commercial tools available that allow community users to customize internet mapping applications for their own needs at low or no cost (Miller 2006).

Prior to 2000, using GIS software required training and taking GIS classes, and the fields using GIS were somewhat limited (in the fields of environment and city and regional planning). Now, GIS has become more widely used, especially in public health, and more people are aware of its benefits to society. Some of the consumers/users of GIS include:

- GIS Professionals- those who use GIS modeling and analysis and create sophisticated GIS
- Application Developers- those who use location-based data
- Professionals (in other domains who use mapping as a tool)- those people who use Google Maps API, ArcGIS Online, Carto.com, Mappler
- Users or Participants of GIS- volunteers who leave their smartphone to be used as an information collector or provide information via their smartphone and people who use GIS outcomes.

Process

To be able to use GIS, users need to know how to use different processes of GIS. Most of the widely used processes become a module (as an object), the user does not need to know a detailed process other than using the functions.

Other Key Technologies

Interoperability

Another recent phenomenon important to GIS is "Interoperability", or the "Open GIS" concept. Interoperability refers to the capability to communicate, execute programs, or transfer data among various applications and operating platforms. In addition, users do not need to have extensive knowledge to use or share the data. Open GIS provides users the ability to exchange data freely over a range of GIS software systems and networks. Interoperability enables GIS users to integrate various GIS data via the internet, without having in-depth knowledge of how to manipulate the data. The development of Open GIS can be summarized as an "effort to enhance user-friendly interfaces, interoperability between data repositories, web GIS services, and affordability". Google Maps is allowing communities to have access to relevant maps without significant resources and technical expertise, which has tremendous implications for PPGIS. Web-based mapping expands the possibilities beyond the simple printed map, allowing for the re-purposing of the location-based data for multiple communications campaigns, projects, and planning efforts.

Web Services/API

Technology has made locational data available to the public through applications, and therefore people/consumers are more aware of GIS technology. In the 1990s, using locational data required existing knowledge in GIS to locate addresses on the map using latitude and longitude. During the mid-2000s, several web-based internet mapping services were available, and they provided a free service of geocoding and routing locations on the map. With smartphones becoming popular, more people have used mapping functions in navigating locations. With available data, mapping services provided by internet service providers, a few web or applications have been developed to provide services such as restaurant locators, public transit service locators, and so on. In the increase of data availability, the trend of open data has been pervasive, and governments provide public mapping data to make citizens use and observe their communities allowing more people access to public data.

While the platform of mapping data is provided publicly by the government, there are some online mapping services that affect the use of GIS. For example, Google Maps provides various map-based data such as satellite imagery, street view, public transportation, etc. Additionally, they provide an API that makes the maps visualize and analyze more graphically. One practical way of using GIS was demonstrated through the online New York restroom map, based on public participatory mapping, in 2015 made by Dr. Im. This map was created using Google Maps at reasonable prices, which is a clear example of the community mapping possibilities using low-cost user-friendly platforms.

It is apparent that the development of the internet and the concept of PPGIS initiated a change in GIS. There has been a significant transition in GIS since Google Maps was launched in February 2005. Google Maps offered an API that allows maps to be embedded on third-party websites and offers a locator for businesses and other organizations. API is a computing interface which defines

interactions between multiple software intermediaries. This implies a huge change in how GIS application is created and delivered. For example, GIS application developers can develop location-based applications without having their own GIS database and GIS software on the web servers. By using Google Maps API, Dr. Im was able to create an interactive mapping application for the New York Restroom site, where people can add and update publicly accessible restrooms.

New applications like Uber and Lyft, the common ride-sharing applications, have been popular in terms of using geospatial technology. The data is used to show where consumers and drivers are and helps find the fastest routes to travel or even how to avoid expensive tolls.

Use (Functions) of GIS

Data Visualization (Location or Thematic)

Data visualization is one of the main utilization of GIS. One way this can be used is for community resources mapping to see the distribution compared with population distribution by race and ethnicity. Non-physical boundaries can be mapped such as health service areas, watershed boundaries, or political boundaries. By looking at the map, certain visual patterns can be found, and a new hypothesis can be developed.

Proximity

Proximity is about measuring distance on the map. For example, users can view or query accessibility to health care providers.

Overlay

Overlay enables researchers to make a relationship with multiple different layers. For example, a homeless shelter location map and bus stop map layer can be overlaid to assess the transit accessibility for homeless shelters.

Connectivity

Connectivity is often used for line data, such as road networks or water/sewer pipes. The function enables you to see how different line segments are connected. In community health, the connectivity of bike lanes or pedestrian roads can be assessed.

Mapping and Monitoring Change Detection

Detecting a change is important to evaluate what is happening in the community. Land use or vegetation change, air pollution change, or any pattern can be viewed with different time intervals.

Modeling

Complicated spatial modeling can be done with various data like disease spread which can be modeled and predicted. This can also be used for air pollution or water pollution impact modeling.

Fig: Images of nyrestroom.com application created by Dr. Wansoo Im using Google Maps API

Effective Data/Information Dissemination via Web/App

Effective map visualization can make citizens understand better. Interactive maps and mobile applications are more user-friendly and informative.

Case Studies

IMSOCIO Community Mapping Event

Background

IMSOCIO is an organization that was borne out of the partnership between Scholars Organizing Culturally Innovative Opportunities (SOCIO) and Dr. Wansoo Im. SOCIO began as a branch of the Franklin Township Spanish Club but has undertaken many projects that have been beneficial to both the students and the local community since the students started working with Dr. Im in 2010.

The goal of IMSOCIO is to provide high school students with the skills and resources necessary to succeed in their future endeavors. Although filled with potential, many students lack the means through which they can direct their talents. By involving these students in local initiatives, IMSOCIO demonstrates the value of cooperative focus. The local initiatives undertaken by IMSOCIO include:

- College Access for Teens: focusing on providing information about the college application process and emphasizing the benefits of having a college degree
- Recycling and Garbage Disposal: focusing on cleaning up the community and encouraging others to do so
- Oral History of Senior Citizens: recognizing the value of recording the stories of the elderly in order to reconnect with the past
- Sidewalk Inventory: mapping sidewalks and crosswalks that are unsafe in order to persuade township officials to repair these areas

Safe Routes to School

Dr. Im in conjunction with Franklin High School students in New Jersey partook in a community mapping event through the IMSOCIO Sidewalk Inventory initiative.

Goals of the Sidewalk Audit:

- Provide an accessible and easily understood visual depiction of safety hazards
- Empower community members and demonstrate the power of collaboration
- Ensure the safety of pedestrians, cyclists, and motorists
- Cultivate community advocacy skills in high school students
- Provide another tool for residents to voice their concerns in an organized and efficient way

Description of Project

On September 10, 2011, Dr. Im and Franklin High School students surveyed the areas around Pine Grove Elementary to assess the cleanliness and walkability of the routes to school. The students documented the quality and safety of the sidewalks and crosswalks with notes and photographs. The students made sure to record the presence of litter and the locations of garbage/recycling bins using smartphones. The information that was collected was added to interactive maps generated by Vertices, LLC, a geospatial technology company.

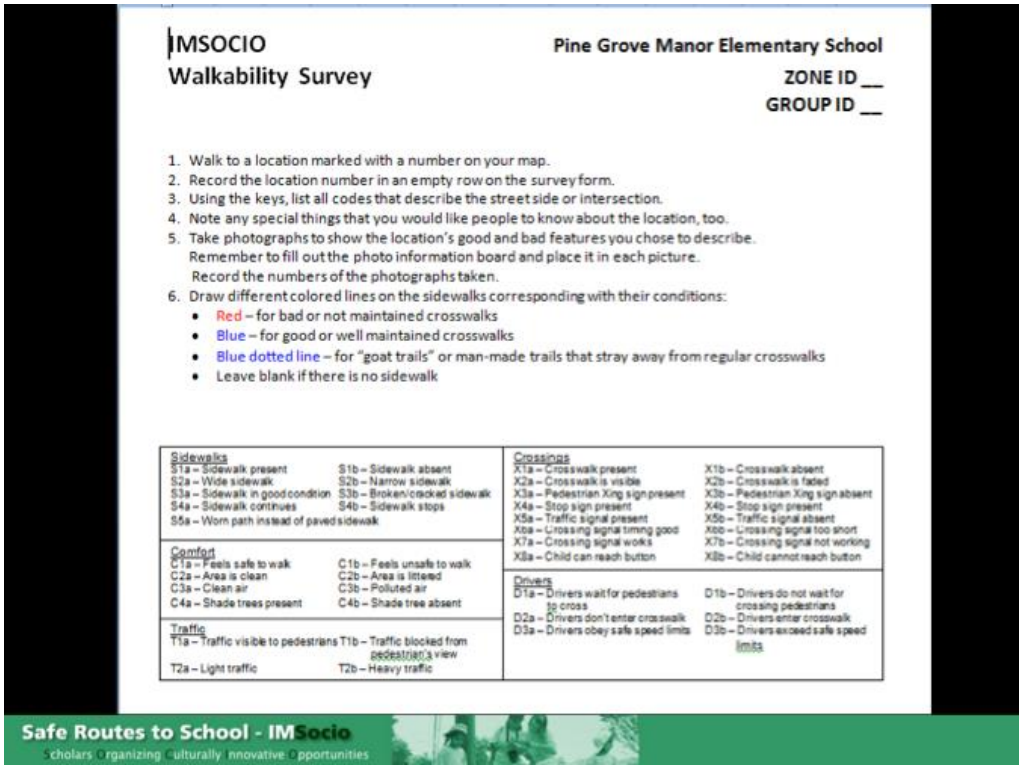


Photo: Walkability survey instructions and input codes.

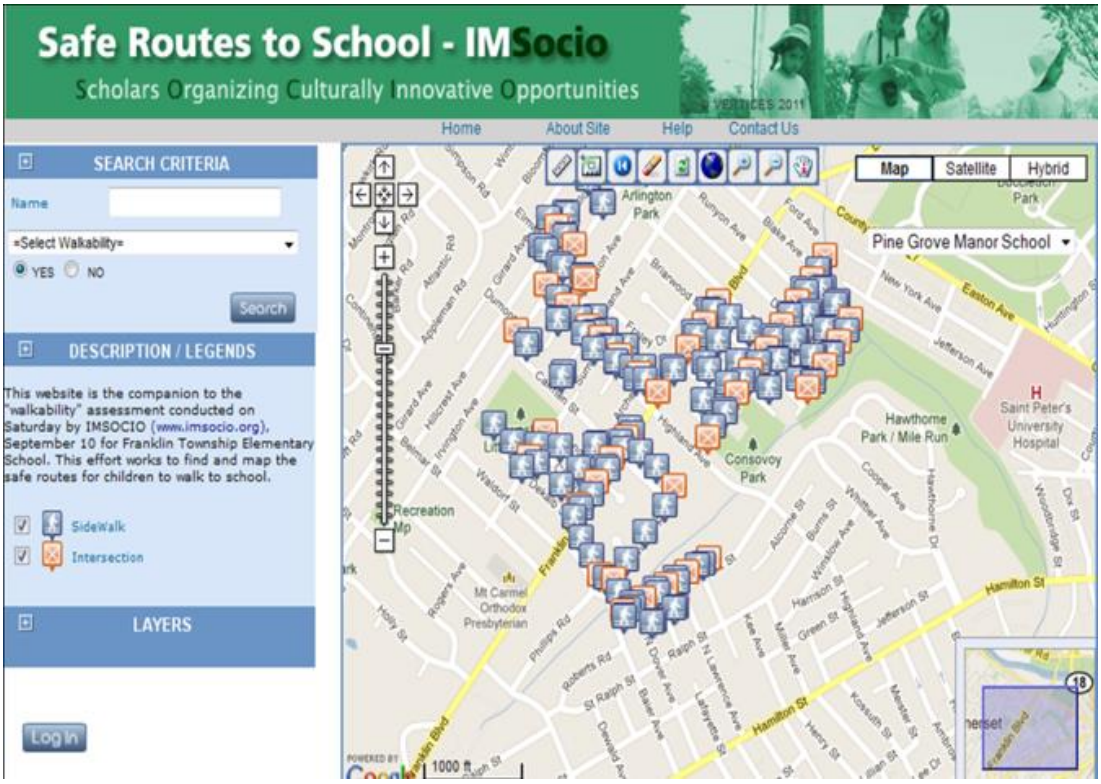


Photo: Neighborhood map illustrating points where students recorded data for that location.

Photo: Franklin High School students taking photos and recording crosswalk data.

Photo: Dr. Im and Franklin High School students and Rutgers University student volunteers at the Safe Routes to School event.

Post-Event Survey

Following the Safe Routes to School event, a survey was distributed to students that took part in the audit. There was an overwhelmingly positive response to the event. Students enjoyed the event and learned about safety in their community. Below is a sample of responses to questions in the survey.

Please explain your response to the event (student):

- *"My response to this event was definitely a positive one due to the hard work and determination shown by myself and my peers. I enjoyed helping the community and making a difference."*
- *"It will benefit the students who walk to school."*

What were the greatest lessons you took from this event?

- *"It takes teamwork and cooperation to produce an understanding of the concepts and how to approach the tasks at hand."*
- *"The areas not only discourage people from walking around town but also pose a safety hazard to pedestrians and motorists."*

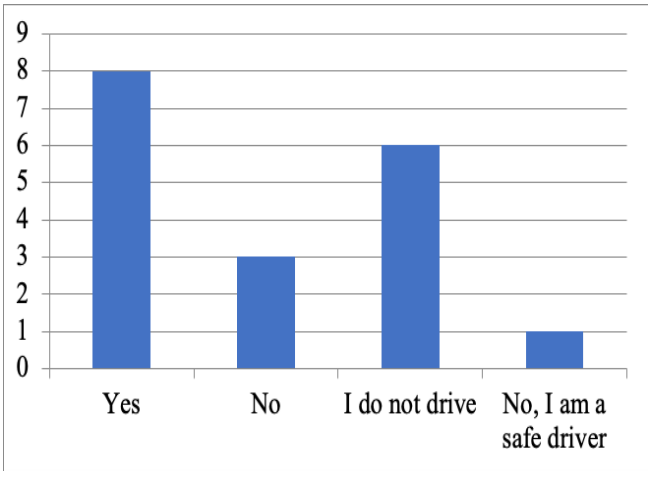
How did the event change your perception of your neighborhood?

- *"Even though the streets and sidewalks were clean, they are not all pedestrian-friendly."*
- *"There could be better walking opportunities in neighborhoods if there were more sidewalks in residential areas."*

What did you learn about sidewalks, crosswalks, etc?

- *"I learned that there are barely any sidewalks. Some streets have potholes and uneven sidewalks."*
- *"Crosswalks have to be improved/repainted. Stop signs have to be a consistent distance from the curb."*

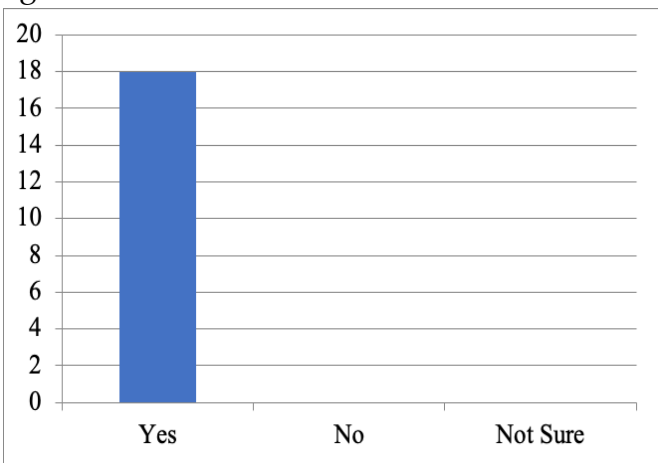
As a driver, will your attitude/behavior change towards pedestrians because of this event?



If yes, please explain:

- *"I'm going to be extra careful and I will be on the lookout for locations with crosswalks and locations where crosswalks need to be present."*
- *"I would put myself in their position."*

Would you participate in this type of event again?



Do you have any suggestions for improving the walkability audit?

- *"Advertise more!"*
- *"More preparation, including communication with police departments so more community members are aware of the event.*

Conclusion

Through Community mapping events like Safe Routes to School, students have the opportunity to learn the importance of community advocacy while integrating Geographic Information Systems (GIS). Franklin High School students were at the forefront of identifying possibly hazardous conditions in their neighborhood. Through the post-event survey, it is clear that many of the students learned collaborative skills and some even agreed that they would change their own driving behaviors to ensure a safer community. The IMSOCIO partnership and its many initiatives that integrate GIS have exposed students to public participatory information gathering which is a skill that

can be used by these students in their everyday life.

Project Title: Mosquito Breeding and Zika Virus Mapping
Name of Organization: The Health Disparities Research Center at Meharry Medical College
Duration: One Year
Dates: September 2016 to August 2017

Description of Project

Dr. Paul Juarez and Dr. Wansoo Im, The Health Disparities Research Center at Meharry Medical College, along with Meharry Public Health graduate students, organized community mapping projects with both Creswell Middle School and Haynes Middle School in Nashville.

The purpose of the Community Participatory Mapping Project is to engage the community in a coordinated effort to identify and eradicate mosquito breeding sites to control the spread of the Zika Virus in North Nashville/Davidson County.

These 6th-8th grade students were trained to map possible mosquito breeding areas around their respective schools using a mobile application called Mappler. This portion of the project was intended to teach students about data gathering and data analysis, focusing on how the Zika virus is transmitted. During the technical training, the students were instructed how to use the mobile application besides taking an actual photo of the suspected mosquito breeding site, the students were taught to record information related to the site (i.e. approximate amount of water, physical attribute of container: cup, stump, flowerpot, bold, stream, etc.). Pictures of possible breeding sites were placed on the overhead projector and students were asked to identify in the picture where those mosquito breeding sites might be in the pictures. The students caught on very quickly identifying the majority of potential sites.

Photo: Mapping data uploaded to the Mappler website by Creswell Middle School Students

While doing community mapping, students were divided into groups that were supervised by either a Meharry Public Health graduate student or school staff.

Students and their chaperones went into the neighborhood near their middle school to identify and map mosquito breeding sites as they participated in the Community Mapping Project. The students were given one hour to map the assigned sites and were very diligent in doing so. After the time allotted, students had identified over 150 sites where potential mosquito breeding locations existed.

To continue the learning experience, each middle school held a Zika Virus poster contest where the information used was primarily taken from the CDC website. During the time set aside in the class, the students worked together to create a unique poster for their classroom focused on the Nashville community. In each classroom, they focused on how to engage the community to respond to the information presented on the poster, and how to make sure that the poster would draw attention to the topic. To further impart the importance of community advocacy, the final element of the project was for middle school administration to schedule time for the classes to attend (a) meeting(s) of the Nashville City Metro Council, and/or Nashville School Board, and/or the Advisory Council of the Department of Public Health for Nashville to present their class posters and describe their learning experience. Instead, a letter was created by the class to the Mayor of Nashville explaining the problems the students identified, but exams began, and the letter will be held to be sent out at the beginning of the next school year.

Student Survey

Upon conclusion of the project, a student survey was conducted. From the survey question "After today's mapping event, how much did you learn about Zika Virus?", 84.0 percent of students who participated in the event answered "Learned a lot", 14.0 percent answered "Learned a little", 2.0 percent answered, "Didn't learn anything". From the survey question "After today's mapping event, how much did you learn about mosquito breeding sites?", 76.0 percent of students who participated in the event answered "Learned a lot", 24.0 percent answered "Learned a little", 0.0 percent answered, "Didn't learn anything".

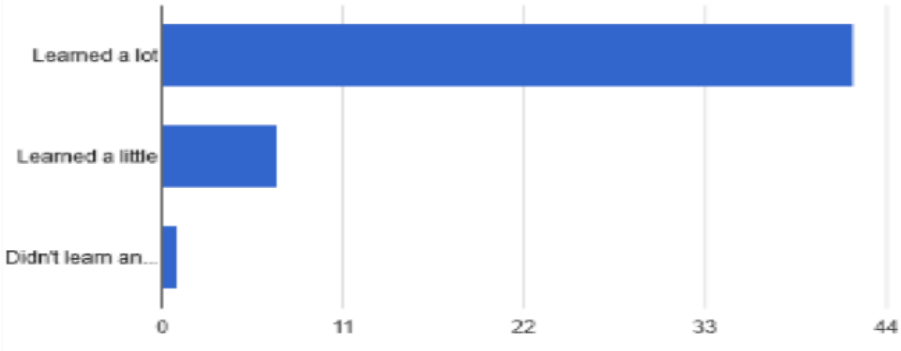


Figure 1: Survey Question: After today's mapping event, how much did you learn about the Zika virus?

The initial results are impressive. Several of the 240 students have decided to concentrate on the STEAM curriculum (Art was added to the STEM curriculum), in their journey through the educational system. The Metro Nashville Public School System (MNPS) has decided to increase its emphasis on the STEAM curriculum, which up to now was principally in MNPS high schools. Beginning in the 2017-2018 school year the STEAM curriculum will be strengthened in the middle school curriculum. Following the Community Mapping Project:

- There are between 12 and 20 6th grade students interested in science and health/medical careers.
- More than half of the students (28) in the 7th and 8th grades are interested in science and in careers in health, medicine, and dental services.
- The most significant achievement is that 90% of the students in these three grade levels at both schools have developed a new interest in science and found that this new process of learning about science, in a hands-on way, is exciting and fun.
- Also exciting, and the second benefit that we have been able to achieve at both schools is that they will be starting an afterschool program, under the auspices of the Health Occupation Student Association (HOSA), that will work with the science teachers in the schools to develop an advanced interest in science, science projects, and science learning.

Conclusion

The students were excited about the active learning segment using their mobile telephones to gather data and then seeing that data displayed on a map, where it was much easier to analyze visually. We learned that residents, who live in communities challenged by health care and financial resources are extremely concerned about their environment, this was evident in the advocacy displayed by the students, for their communities. The students involved in this project decided to write a letter to the Mayor of Nashville asking her to become more proactive in addressing the need for education regarding personal and community management and control of mosquito breeding. The students agree it needs to be important to everyone all the time because of the health risks and the impact on the environment and on communities.

Overall, the students were excited by what they learned and what they needed to do to protect their families and their community. We have had a number of the students indicate they will focus on medical and health careers as they move through their formal education. Six students in the Middle School for the Performing Arts have committed to turning their spotlights on STEAM courses, emphasizing the Sciences. Our collaborative efforts with the teachers, school librarians, administrators, and parents have helped us to identify bright, interested students, who were not sure that science could provide a career that would be stimulating and satisfying to them. These students have now made an initial commitment within themselves that science is of growing interest to them and might unfold into a wonderful, fulfilling career for them.

As a result of the National Library of Medicine Grant "Mosquito Breeding and Zika Virus Mapping," we have gained close ties to the Science Teachers and the STEM curriculum at both Creswell and Haynes Middle Schools.

Community Mapping for K-12 Students Measuring Fine Dust with Community Participatory Mapping

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Background

The Community Mapping Center in Seoul, South Korea is a non-profit organization that promotes civic engagement and empowerment using location-based technology. The Center was founded in 2013 by Dr. Wansoo Im who is currently an Associate Professor at the Division of Public Health Practice and Director of the National Community Mapping Institute at Meharry Medical College in Nashville, Tennessee. The Center has used community participatory mapping, also known as "Community Mapping" to educate, engage, and empower underprivileged community members.

In recent years, South Koreans have struggled with severe air pollution at record highs that are extremely detrimental to their health. There is no clear understanding of what sources exactly contribute to the high levels of PM2.5, which are dangerous atmospheric particulate matters, in South Korea. Despite government initiatives to mitigate the impact of PM2.5 no significant reduction in PM levels has been recorded.

The Community Mapping Center is working to develop the Particulate Matter Citizen Information Network (PMCIN) to educate the public and better understand what determines the levels of fine dust in the air. PMCIN is an open data platform that connects community collected air pollution data with existing air pollution monitoring data, leveraging existing work and systems. The portal is accessible to the public and the interactive map has relevant GIS layers such as wind, air pressure, and traffic and industry point data. The Community Mapping Center has engaged the public from the outset, involving them in the collection and use of PM data to encourage grassroots public health campaigns for air pollution mitigation in South Korea.

Description of Project

The Center worked with a volunteer organization in South Korea to develop personalized PM monitors (DIY kits) and educate and organize K-12 students on collecting air pollution data. The purpose of these efforts was to help students:

- Learn the scientific method and the process of informed active civic engagement; learn the causes of fine dust and its impact; and increase students' environmental sensitivity.

Dr. Im's most recent community project took place in April 2019 with students from multiple grade levels. Third-grade students assembled dust sensor monitoring kits and learned how to measure the levels of fine dust at their school campus. High school students measured PM levels, temperature, and humidity in the Hongdae area and paired this data with land and building usage in the area. They also measured fine dust levels inside each station in the Seoul Metropolitan Subway Station Line 2.

Photo: Students assembling a fine dust monitor at DukGye Elementary School in YangJoo City.

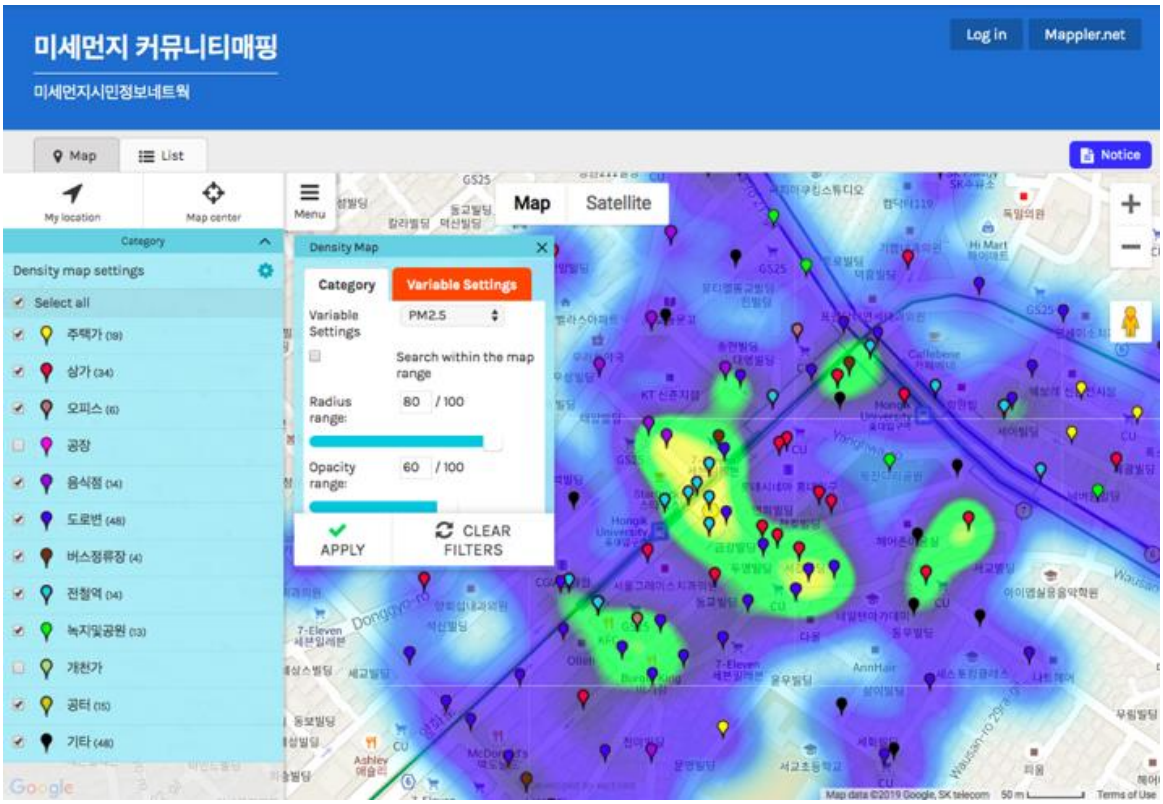

Photo: PM sensor data collected by high school students with land/building usage.

Photos: Senior Students from SongNae High School measuring PM levels in the subway stations in Seoul, S. Korea

Reflections

Below are reflections from two students who participated in the event.

JoonYoung Lee, a 3rd-grade student at DukGye Elementary School in YangJoo City, South Korea

I was not interested in fine dust but the topic became very interesting when I made a fine dust monitor and measured the level of fine dust. I learned that fine dust is very harmful to my body and learned the difference between fine dust and ultra-fine dust. I hope our air becomes cleaner soon. The fine dust should disappear. I would like to breathe clean air without fine dust as soon as possible. Now I am thinking of my future career because of this project. I want to make a robot that predicts the level of fine dust when I go to a college and let them know there is a robot like that.

SiJoon Kim, a senior at SongNae High School at Bucheon City, South Korea.

I learned the characteristics of the areas that showed a high number of PM2.5 when I did community mapping for measuring fine dust. The PM2.5 levels were much higher in smoking areas, BBQ restaurants, and parking lots than in other areas. I was able to see what activities produced fine dust. I felt that we have to do our best to reduce fine dust after I realized how bad the air quality is in our surrounding area. I am interested in our environment, and I would like to share what I learned with the people that I know so they can value the importance of environmental protection.

We measured the level of fine dust in Seoul Metropolitan subway line 2 (inside of the subway, and in the subway station). I usually go to school by train, and I often wondered about the fine dust inside the closed space. For me, it was very interesting to measure the concentration of fine dust inside the train. From the process, I was able to learn three things.

The first finding was the relationship between humidity and fine dust. I do not know if this is obvious, but I noticed that the higher the humidity the lower the concentration of fine dust. I was wondering "if the fine dust adheres to the moisture in the air?"

The second finding is that when more people were inside the subway train, the higher the concentration of fine dust. I thought about this, but I had never checked it myself. By directly measuring the concentration of fine dust inside the subway we found that the more people there are, the higher the concentration of fine dust.

Third, there is a clear difference in the fine dust levels of different subway platforms (open platform on the ground vs. underground). The open platform showed a higher level of fine dust than the underground ones. The ambient level of PM2.5 was very high on that day and I didn't see any air filtering in the open platform. I wonder what the measurements will be when the ambient level of PM2.5 is low.

I want to know where many of these fine dust particles are being generated. I want to make a hypothesis and then start a project to determine the cause of the fine dust by measuring the fine dust to test the hypothesis. For example, the hypothesis that a coal-based power plant is a major cause of generating fine dust and that the concentration of fine dust around the thermal power plant will be high, and that the cause of fine dust is to be found by measuring the fine dust around the thermal power plant directly.

In urban areas such as the Hongdae area (one of the busiest areas in Seoul), I could examine bus stops with a lot of moving cars, a factory, a charcoal grill house, and so on. It is possible to find the cause of fine dust and it is an important step to removing the cause. I think it is more necessary to remove the cause of fine dust and develop techniques to replace them instead of finding ways to deal with the problems caused by fine dust.

After measuring fine dust as part of community mapping twice, I changed my behavior. Before even though the concentration of fine dust was very high I never wore an air filtering mask but now, I wear an air filtering fine dust mask every time the fine dust concentration is high. It is because I learned how fine dust can affect our body from this process. I hope more students will become aware of how serious a problem fine dust is in our society.

Conclusion

The community mapping events in South Korea have shown that participatory mapping can be a good way to get the community engaged. Some students even showed interest in continuing to acquire more knowledge about PM in order to become advocates for change. The students enjoyed the experience and acquired more knowledge about the places they frequent,

like the subway station. They collected information on PM1.0, PM2.5, PM10, temperature, humidity, and pictures of the location where the reading was taken. Although the community mapping was a small-scale event, GIS and the information gathered can be used on a larger scale to help find ways to minimize PM in the air, and therefore help the Seoul community live in a healthier environment.

Chapter Conclusion

- Community Mapping is very valuable tool for community health
- ICT Technology enables GIS to become more powerable, accessible, and affordable at the community level
- Community members can view various different data, and collect their own data for their own community needs
- Even though technology and data area available, community members are most important in community health.
- Community mapping can educate, engage, empower community members so they can understand what is happening to their community, and how to change it.

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