Open Source Mapping in Latin America: Collaborative Approaches in the Classroom and Field

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ABSTRACT

Open source mapping platforms (such as OSM) are innovative tools that can enhance student learning and engagement in Latin American geography courses. Use of these tools can also facilitate new collaborations between students/scholars and communities responding to social and economic challenges in Latin America. In this paper we discuss the use of these tools in three different educational settings. We begin by describing the work of YouthMappers, a new international network of open source mappers that formed in 2015 with chapters in Latin America. YouthMappers can be a resource for geography departments anywhere in the world interested in developing open source mapping skills and projects. We then provide three examples from our own department of how open source mapping is used to build skills, enhance data collection, and foster international collaboration between U.S. and Latin American researchers and students. We conclude by discussing the benefits and challenges of employing these tools in the classroom and the field.

KEYWORDS: *Open Source Mapping, Participatory Mapping, Latin America, Collaborative Learning, Geographic Pedagogy*

RESUMEN

Las plataformas de mapas con código abierto (como OSM) son herramientas innovadoras que pueden mejorar el aprendizaje y la participación de los estudiantes en los cursos de geografía de América Latina. El uso de estas herramientas también puede facilitar nuevas colaboraciones entre estudiantes / académicos y comunidades que responden a los desafíos sociales y económicos en América Latina. Comenzamos describiendo el trabajo de YouthMappers, una nueva red internacional de geógrafos que se formó en 2015 con grupos en América Latina. YouthMappers puede ser un recurso para las facultades de geografía en cualquier parte del mundo interesadas en desarrollar habilidades y proyectos de mapeo de código abierto. Luego compartimos tres ejemplos de nuestra propia facultad sobre cómo se usa el mapeo de cógido abierto para desarrollar habilidades, mejorar la recopilación de datos y fomentar la colaboración internacional entre investigadores y estudiantes de EE. UU. y América Latina. Concluimos discutiendo los beneficios y las dificultades de emplear estas herramientas en el aula y en el terreno.

PALABRAS CLAVE: *Mapeo de Código Abierto, Mapeo Participativo, América Latina, Aprendizaje Colaborativo, Pedagogía Geográfica*

INTRODUCTION

Over the last two decades, the emergence of open mapping platforms that support participatory and/or volunteered geographic information practices have created a revolution in the production of geographic knowledge and the application of new tools to address social and environmental problems (Goodchild, 2007; Elwood, 2008; Buzai & Robinson, 2010; Sinha et al., 2017; Solís, McCusker, Menkiti, Cowan, & Blevins, 2018; Coetzee, Minghini, Solís, Rautenbach, & Green, 2018). One of the major developments in this transformation was the release of OpenStreetMap (OSM) in 2004. OSM is an open source platform where volunteer mappers create a free and open map of the entire world. The data are created by volunteers digitizing aerial imagery and collating public sources of geographic data. It is essentially a Wiki, where anyone is allowed to contribute and review the accuracy of edits.

Rather than being produced by rigidly controlled and top-down processes, as has been the cartographic norm, open platforms invite broad participation in the production of geographic information, and ultimately of knowledge. Yet there are legitimate concerns about open data quality and reliability as well as the potential for "volunteers" to undercut the paid work of experts or to extract information for outsiders without clear benefit for community members (Chambers, 2006; Solís et al., 2018). Philosophically, the community of open source mappers is committed to creating data that are accessible (open) to multiple stakeholders, with the assumption that greater accessibility may go so far as to support an emancipatory agenda that uses "spatial technologies to disrupt socially and technologically-mediated forms of exclusion and disempowerment" (Elwood, 2008, p. 178). Unlike other widely accessible platforms such as Google or Apple maps, the data in OSM are not owned by anyone and can be used for a variety of people for vastly different purposes including research, humanitarian response, or assistance with basic services.

Open source mapping tools have the potential to promote a geographic pedagogy that is collaborative and experiential while also building geographic knowledge that is accessible, dynamic, and even project-driven (Sletto, Muñoz, Strange, Donoso, & Thomen, 2010; Smith et al., 2012; Solís, Huynh, Carpenter, De Newbill, & Ojeda, 2017; Solís et al., 2018; Hite, Solís, Wargo, & Larsen, 2018). Typically, such skills are taught in geographic technique courses, but we feel that integrating these skills into regional and field courses can enhance knowledge creation and subject engagement (Healy & Jenkins, 2000; Coetzee et al., 2018; Hite et al., 2018). As Coetzee et al. (2018) concluded after evaluating project-based open mapping exercises, "students demonstrate learning in areas of technical skill and subject matter knowledge in many geographical domains... Students also learn about places of interest, and people's lives in locations remote from their daily geographies" (p. 41). This article came out of a special session on new pedagogical tools for teaching Latin American geography at the Conference of Latin American Geography (CLAG) meeting in San José, Costa Rica, in 2018. We argue that open source and participatory mapping tools can be integrated into teaching Latin American geography, one of the most popular regional courses taught in the United States. Our experience is that these tools have increased student engagement by addressing current needs and contributing information that others can access and use.

The article begins with a literature review on the participatory aspects of open source mapping and how it can be an innovative pedagogical tool for Latin American courses. We then discuss YouthMappers, a new international collaboration of open source mappers formed in 2015 that includes university chapters in the U.S. and Latin America, among other regions. YouthMappers is a key player in the promotion of open mapping strategies in universities around the world and is a strategic institution in the diffusion of this technology. To encourage faculty and students to experiment with these tools, we present three examples of open source mapping projects from our own classroom experiences in the United States, Guatemala, and Panama. We conclude with a discussion of the benefits and challenges of working with OSM in the classroom and the field.

PARTICIPATORY AND OPEN SOURCE MAPPING AS A PEDAGOGICAL TOOL

There is extensive literature on participatory, volunteered, and open source mapping in general, and in Latin American in particular (e.g. Herlihy & Knapp, 2003; Offen, 2003; Kingston, 2007; Sletto et al., 2010; Bryan, 2011; Reyes-García et al., 2012; Smith et al., 2012; Vergara-Asenjo, 2015; Herlihy & Tappan, 2019). Participatory Geographic Information Systems (PGIS) and Volunteered Geographic Information (VGI) have great potential as means of engaging students with data creation. Ever since 2010, when the crowdsourced map was initially implemented for a crisis situation after the earthquake in Haiti, numerous OSM contributors provided their support in mapping events in the aftermath of a disaster (Meier, 2012; Eckle & De Albuquerque, 2015; De Albuquerque, Eckle, Herfort, & Zipf, 2016) or supporting sustainable development goals (Solís et al., 2018). Such engagement attracted interest from academic circles as well as humanitarian aid organizations (Crowley & Chan, 2011). Despite the attention, OSM has been used more for praxis by humanitarian disaster response organizations than it has been studied academically, though this is slowly changing (Kingston, 2007; Reyes-García et al., 2012).

Even before open platforms existed, participatory mapping played an important and sometimes contested role in geographic research in Latin America (Herlihy & Knapp, 2003; Offen, 2003; Sletto et al., 2010; Bryan, 2011; Reyes-García et al., 2012; Wainwright 2013). The areas populated by native peoples remain some of the most under-mapped places in the world. Participatory mapping is a "bottom-up approach" that allows people to create maps for their own use, in contrast to the traditional "top-down approach" relying on governments to create maps for specific state purposes. This approach rests on the belief that local populations have the best and most detailed knowledge of their spaces and environments (Herlihy & Knapp, 2003; Herlihy & Tappan, 2019). Local geographical knowledge that participatory mapping activities rely on can be used to complement existing formal data sets, inform planners and policymakers, and empower residents to envision improvements of their spaces (Gaillard & Maceda, 2009). Participatory mapping has been a standard method used by many academics to study how different groups of people experience and defend their communities, especially indigenous peoples (Sletto, 2009; Smith et al., 2012; Vergara-Asenjo, 2015; Herlihy & Tappan, 2019).

In the context of Latin American Geography, the work of Sletto et al. (2010) in mapping the unmapped settlement of Platanitos in Santo Domingo, Dominican Republic, underscores the value of participatory GIS. Working with graduate students from the University of Texas over several trips, the team partnered with community members to create a map of all buildings, community boundaries, historical flooding (based on living memory), streets, alleys, and public spaces (Sletto et al., 2010). They created a unique and valuable GIS data set about and for the community. The difference between this project and working with an open source platform is one of accessibility. Open platforms can be accessed and used by anyone with internet access. Certainly, there may be cases when scholars or communities collect geo-spatial data that they do not want to share in an open access environment. In this article, however, our interest is in the application of open source mapping approaches for geographic education and service, in which the data collected (building types, street names, infrastructure, or services) fill important gaps without revealing private information.

Maps have power and influence over people and places. Not surprisingly, the act of participatory mapping has been problematized as contributing to a neoliberal agenda (Bryan, 2011), potentially disempowering groups (Chambers, 2006; Bryan & Wood, 2015), and perpetuating unequal power relations and access to data (Elwood, 2008), to name a few issues. Crampton (2009) makes the argument that technology itself has shifted our understanding of maps away from final static products towards "maps as practices" to inform how things become. In his view, maps are always participatory, performative, and political (Crampton, 2009, p. 845). In a recent analysis of whether or not participatory mapping increased conflicts in the Bolivian Amazon, the authors concluded that "mapping projects do not bring about conflict per se. Rather, the process and the results of participatory mapping can help in conflict resolution or contribute to conflict generation or exacerbation depending on the political and socio-economic context in which they are conducted" (Reyes-García et al., 2012, p. 657). In other words, maps operate in particular contexts. All maps are created by authors interested in telling particular stories about the world through visualization, with some maps being more deceptive and problematic than others (Monmonier, 2018).

Even with these concerns, PGIS and open mapping have become important tools for researchers and development professionals investigating the challenges faced by marginalized communities in Latin America. Local spatial knowledge is known to be invaluable for mapping practitioners, who often turn to universities and student groups to assist in incorporating this knowledge into open and proprietary GIS platforms. Conversely, incorporating PGIS in experiential learning benefits new forms of learning through socio-spatial analysis among educators, students, and community members (Elwood, 2009; Esnard, Gelobter, & Morales, 2001).

Geographer Gaurav Sinha and colleagues have written at length about the pedagogical benefits of participatory mapping. In particular they underscore five learning objectives in which participatory GIS contributes to better learning outcomes: (1) recognizing and appreciating the uniqueness of places, communities, and local knowledge systems; (2) understanding the relationship of people and landscapes through service learning in communities; (3) gaining practical training in field methods of collecting, managing, processing, and visualizing geographic information using geospatial technologies; (4) gaining experiential and practical introduction to mixed-methods research and hybrid qualitative methodology; and (5) fostering critical reflexivity by explicitly accounting for positionality and identity issues in geographic knowledge production (Sinha et al., 2017, p 166).

With regards to field-based projects as opposed to classroom mapping exercises, Sinha et al. (2017) emphasize that the development objectives must be explicitly conveyed to the communities where one is working, so that mapping is not perceived as a mere training exercise for students. We agree with the conclusions of the aforementioned study, and add that using open source technologies allows for new kinds of international collaboration that can be face to face or virtual. Our reflections on the mapping projects discussed here affirm that these instances of knowledge co-production not only build new skills among students, but also encourage them to engage with communities and collaborate with diverse actors to bring about positive change or solve a particular problem. Experiential learning that integrates community service also propels students to think critically about selecting their methodologies and study sites as well as appreciate the social dimensions of participatory mapping.

YOUTHMAPPERS: AN OPEN SOURCE COLLABORATIVE AND RESOURCE

An innovative and relatively new open mapping collaborative is YouthMappers, an international network of student organizations committed to creating and using open spatial data to address global development challenges in particular localities. As of May 2019, 149 universities in forty-two countries have formed student-led chapters in the network and collectively they have made more than 16 million edits to OSM (www.youthmappers.org). We strongly encourage geography programs interested in open source mapping and its applications to consider sponsoring a YouthMappers chapter. Our department, and this research, benefitted from working with YouthMappers as the George Washington University was a founding member.

The YouthMappers network began in 2015 through a grant from the U.S. Agency for International Development's Geocenter to collaborators from George Washington University, Texas Tech University, and the University of West Virginia. In Latin America and the Caribbean, there are YouthMappers chapters in Panama, Colombia, Belize, Costa Rica, Honduras, Nicaragua, and Jamaica. Any university student organization can apply to form a YouthMappers chapter; there are currently over forty chapters in the U.S. From our experience it is a unique way to grow a community of mappers within and outside of geography programs, and to engage them in applied mapping, service, and research. In their analysis of YouthMappers blog posts, Rebecca Hite and colleagues (Hite et al., 2018) found that students' description of mapping with the organization helped students feel connected to other countries without leaving their own. They also benefit from the diverse social interactions the organization provides.

YouthMappers emphasizes the creation and utilization of open data and open source software for geographic information directly related to development objectives in unmapped or under-mapped places where USAID works to end extreme poverty. Yet YouthMappers chapters can choose the settings and themes they want to map. The collaborative mapping approach also seeks to encourage youth, especially women, to engage in mapping projects. All new data created by YouthMappers is open and accessible to the public, and particularly to local populations planning for the welfare and vitality of their own communities. Capitalizing on web-based open geospatial technologies, YouthMappers' mission is to cultivate a new generation of young mappers and leaders to create resilient communities and to define their world by mapping it. Funds from USAID and other sponsors allow for annual meetings of chapter leaders throughout the world.

The potential for participatory and volunteered geographic information is vividly seen when students in the classroom are engaged in mapping for a particular cause, typically through mapping parties or mapathons (to be discussed in the next section). Our experience affirms that student engagement is elevated through creating group projects that respond to specific humanitarian and development efforts. YouthMappers chapters connect students with an international network that demonstrates the links between knowledge production in an academic setting on the one hand, and development and humanitarian objectives on the other (Solís et al., 2018).

We turn now to three examples of how open source mapping can be used in short-term study abroad, in the classroom, and in graduate student research. In each of these examples, the mapping exercise was driven by real-world problems that came from local stakeholders who needed information. All the projects were collaborative in nature, requiring local partners and working with local community members. In each of these examples, the data produced were available to anyone with internet access through OSM.[1] Some of these projects were technically demanding, others less so.

OPEN SOURCE MAPPING DURING A SHORT-TERM STUDY-ABROAD COURSE

A short-term study-abroad course in Panama in 2012 provided one of the authors with an initial opportunity to use open source mapping in a geography field course that focused on demographic and landscape change in the Casco Viejo, a UNESCO World Heritage site in Panama City. The project included eleven U.S. and sixteen Panamanian geography students who participated in data collection and analysis. The course explicitly relied upon collaboration among student groups and used open source mapping as a means to collect and share data. The project focused on a locally designed problem-oriented research question that built upon existing work done by a Panamanian scholar, who was part of the project. Since many departments offer short-term study-abroad courses, this example shows how open source mapping can be incorporated into a study-abroad experience. For a more detailed discussion of this project and the pedagogical principles underlying it, see Solís, Price, and Adames De Newbill (2015).

The research sought to understand the changes occurring in the Casco Viejo after it was declared a World Heritage site in 1997. As is often the case, a World Heritage designation led to increased investment (both foreign and domestic), renovation of historic buildings, new residents, new jobs, and a growth in tourism. But the once densely settled area with many poor residents also experienced a major demographic turnover. An area with 10,000 residents in 1990 had less than 3,000 residents in 2010 (Solís, Price, & Adames De Newbill, 2015, p. 54). Many of the older residents who were renters or squatters were steadily pushed out; they were replaced by elites living in restored homes and tourists staying in boutique hotels. Panamanian law professor Ileana Porras has critiqued the pace of change in Panama City, with its forest of high rises and pockets of historic preservation, as "binge development" that is "blissfully unconcerned with future repercussions" (Porras, 2008, p. 394).

From the inception of this project, course leaders wanted U.S. and Panamanian students to work together on a project that would be meaningful to both groups. Students were first introduced digitally via Skype before meeting in person in Panama. Then the students worked together conducting surveys and entering the survey results into a digital survey manager (in this case Survey Monkey). Ten survey teams of two to three people included a mix of local and U.S. students. This fostered collaboration and trust, and having ten teams allowed for efficient data collection and entry. The teams

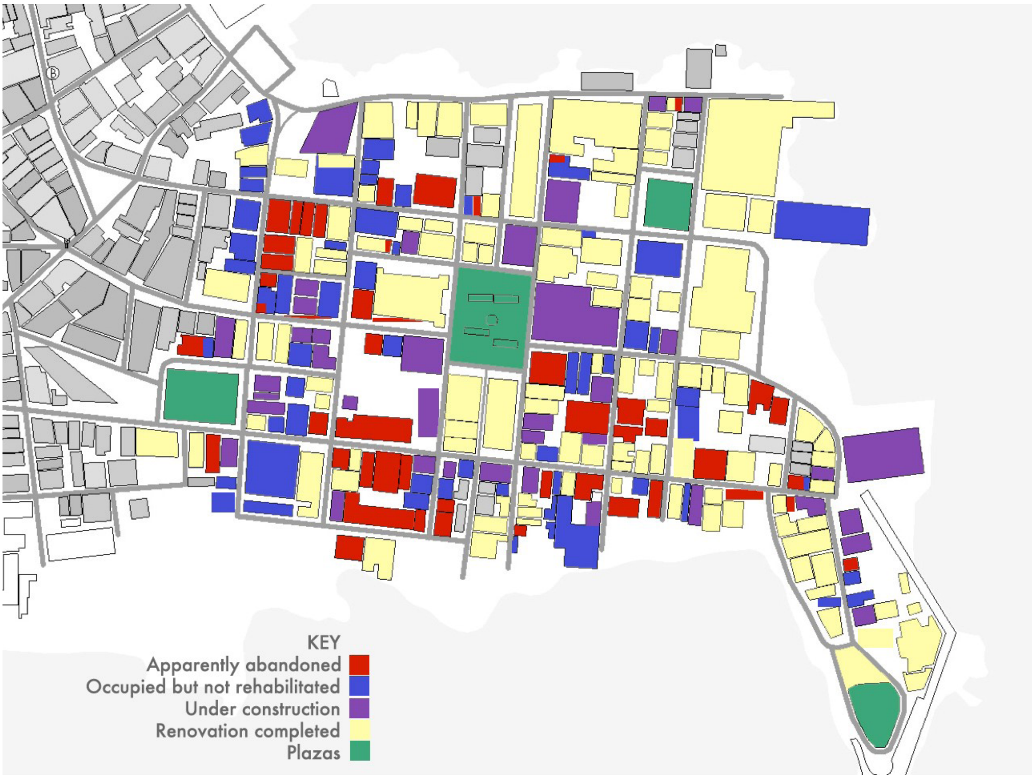

Figure 1. Mapping the Status of Buildings in the Casco Viejo, Panama City, May 2012. This UNESCO World Heritage Site experienced a dramatic transformation, with older residents being displaced as historic buildings were renovated for tourism and international investors/residents.

administered paper surveys among area residents, businesses, and visitors. In the space of one week, 160 surveys were conducted and the entire study area was mapped. Collectively, the students entered the data from the paper survey into Survey Monkey, which automatically tabulated the results, thus allowing the teams to discuss and interpret them.

Since the project area was relatively small (roughly forty city blocks), students did a building-by-building survey, noting the status of the structures in 2012. This status was included in the OSM attribute data, which allowed the team to produce Figure 1. As the figure suggests, this is a dynamic urban landscape with half of the buildings either abandoned, being rehabilitated, or occupied but not rehabilitated. Figure 1 was of particular interest to area stakeholders as it gave a timely snapshot of the pace of change in the urban landscape. At the end of our two-week research period, student groups presented their preliminary findings to diverse stakeholders in a public lecture at the main office for the Casco Viejo redevelopment (*Oficina de Casco Antiguo*). This, too, was an important component of the collaboration as it allowed us to share findings, demonstrate the use of OSM and make data accessible, and engage in a dialogue about the nature of change in this historic neighborhood.

The aim of this example is to suggest that even short-term study-abroad courses can be reoriented to enhance student research experiences, apply new research tools to address real-world problems, and foster meaningful collaboration among university students in a host country with students from a U.S. university. Such collaborations must be intentional from the beginning and build upon existing relationships, typically among university professors or staff in local institutions or NGOs. Use of open source tools, however, means that the data created are accessible to the local community afterwards.

USING MAPATHONS TO ENGAGE STUDENTS IN DATA CREATION

Mapathons, or mapping parties, are a form of engaged data creation in the classroom where students add map details such as buildings, roads, basic infrastructure, and services in under-mapped areas. The majority of mapathons are hosted in response to a disaster (Quill, 2018); however, mapathons can serve as a way to create a base layer of information for a variety of projects and needs. Mapathons tend to draw a diverse population, including international students and community members from an affected area, because they are informal and social in nature, they are also fun.

Teaching geography specifically through mapathons achieves many goals, such as improving spatial literacy skills, providing students with a sense of place and location, engaging students in learning through community service projects, and connecting to places around the world with humanitarian and development needs (Hite et al., 2018; Coetzee et al., 2018). In addition, learning key concepts of digital mapping and open source GIS technology broadens future career options for students. These events provide an opportunity for intercultural conversation and can give local populations a chance to share their stories, and to educate others on the challenges faced by their communities (Sinha et al., 2017). The authors' department hosts a half-dozen mapathons a year, but in this article we discuss mapathons linked to a specific project in Guatemala.

Two of the authors working on a capstone project for the Pan American Development Foundation (PADF) organized two mapathons to create base data for a project in the municipality of Mixco, Guatemala. The mapathons included a YouthMappers chapter, staff from PADF, undergraduate students in a Latin American Geography course, and students in Guatemala. The municipality of Mixco, part of metropolitan Guatemala City, is a setting where informal housing makes the population particularly vulnerable to natural disasters. For this reason, two communities within Mixco were the site of a year-long PADF program called "Yo Me Preparo," or "I'm getting prepared." This program sought to help local residents prepare for natural disasters in several ways, one of which was creating a detailed map of the community.

The first mapathon of Mixco was hosted at our university library with PADF employees, professors, and students. Pizza and snacks were provided and in just a few hours, baseline data with over 1,300 building footprints were created by tracing rooftops from satel-

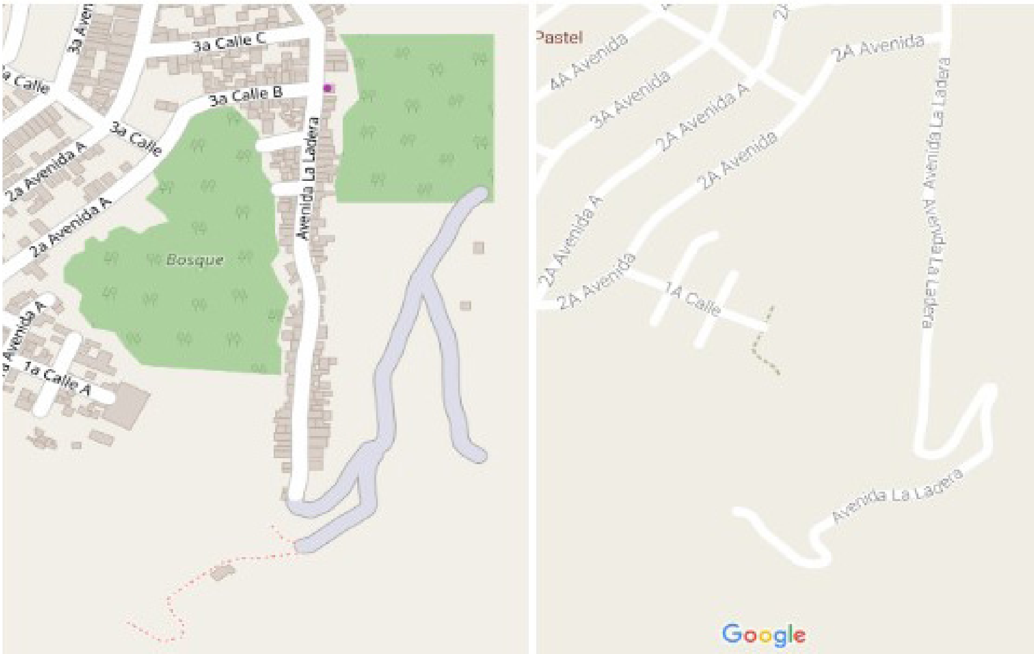

Figure 2. Screenshots of Mixco on OpenStreetMap (left) and Google Maps (right) show greater detail on the OSM map generated through mapathons.

lite imagery. The second Mixco mapathon included a remote training session via video call with students at Rafael Landivar University in Guatemala City. PADF staff members in Guatemala City were trained remotely prior to the second mapathon to provide on-site assistance to the participants. It was the first attempt known to us to conduct online remote training on the OSM platform with a school in a different country. By the end of the second mapathon, the study area had been mapped. Figure 2 shows significantly more detail on the OSM map than the Google map of the same area.

Mapathons can be used as part of a course assignment or an extra-curricular activity. In our experience, student engagement is heightened when they are mapping an area or theme that they already studied in class, such as informal housing in a Latin American city, mining communities in the Amazon, or the U.S.-Mexican border. Moreover, mapping activities tied to a particular development, humanitarian, or research project makes the work more meaningful and immediate. This is why partnering with a NGO or participating in a YouthMappers-directed project can lead to an enhanced learning experience, with students knowing that their efforts will be put to immediate use.

FROM MAPATHON TO PARTICIPATORY FIELD VALIDATION IN GUATEMALA

One of the challenges with mapping areas remotely, as happens in most mapathons, is validation of the data. The final example is based on the work of the authors, who travelled to Guatemala in 2017 to work with

Figure 3. Volunteers in Mixco line up their Field Papers in order to identify which buildings are assigned to them to field verify and assess.

PADF staff to validate the data in the field. This was part of a graduate student capstone project in which field validation and collaboration with local community members were emphasized. Field validation is a concern when imagery has clouds or when similar building materials and the density of structures make it difficult to differentiate individual homes, as was the case in Mixco. In addition to checking the accuracy of the map for the community, the project also sought to conduct a vulnerability survey and engage community members in mapping techniques.

Mixco is a municipality located just northwest of Guatemala City. It was a poorly mapped community situated along a major fault line and within an area that is at high risk of volcanic activity. Mixco is predominantly covered by steep hillsides, which makes the population vulnerable to landslides, erosion, and floods. Additional risk factors include high population density in unsafe locations, low levels of investment in urban planning, insufficient evacuation routes and signage, and limited resources for disaster preparedness training, equipment, and coordination among emergency response mechanisms.

Open source tools for field validation consisted of Field Papers and OpenDataKit (ODK). These tools were used concurrently to ensure that volunteers could collect vulnerability survey data while in the field (Figure 3). Field Papers is a tool that allows mappers to print maps that draw data from traces in OSM; a barcode on each map links a particular area on paper to its proper coordinates. When edited Field Papers are uploaded, they are overlaid with OSM traces in the background so that additional corrections of existing data can be made online and attributes such as points of interest and business names can be added. In preparation for the fieldwork, the authors and PADF held an all-day training workshop in Guatemala City on how to validate OSM data with Field Papers and how to navigate the mobile survey. The training was designed for an audience with little or no knowledge of open source mapping technology. Community volunteers, PADF employees and students who attended the workshop also participated in editing the survey questions. This improved the quality of the survey and ensured that it was sensitive to the socio-economic characteristics of the Mixco community. Field Papers were also used to mark the location of street infrastructure, such as telephone poles, storm drains, and manhole covers.

The vulnerability survey was developed in collaboration between PADF and the authors. It consisted of a building survey and a household survey. The variables collected in the building section of the survey were partially based on a pen and paper survey developed for domestic vulnerability assessments by CONRED, the national disaster response organization in Guatemala. This part of the survey captured data on the type of building materials used, exterior condition, and the type of slope a house was built on. The variables collected in the household section captured socio-economic data from the inhabitants of each building surveyed, such as employment type, income, health issues, accessibility, and so on. It also included questions about emergency plan awareness and previously experienced hazards.

The survey was carried out by seven teams of three to four people, each consisting of representatives from PADF, the authors' university, local residents, and volunteers. The teams were able to survey 105 buildings located along Avenida de Ladera in Ciudad Satélite where houses often display signs of structural damage and/or are located dangerously close to the cliffs. Volunteers walked around with mobile phones and took geolocated photos of each house and other features. These photos were then uploaded and used to identify attributes of each building.

Attribute data from Field Papers was added to OSM, which made it available to all users. To demonstrate the utility of adding qualitative data to OSM, a map of the study area was created and shared with local stakeholders. As seen in Figure 4, field validation activity provided valuable data that can be visualized for various purposes (this is just one example of a series of maps shared with the community); in this case, building material was used to create a thematic map. The open source tools used in the field allowed the team to validate OSM tracing of the community done in the mapathons as well as collect additional attribute data about the community to help better understand its vulnerabilities.

These last two examples show how an in-class exercise (a mapathon) can be linked to a graduate student capstone project tied to the needs of a local community (Mixco) and the work of a development organization (PADF). This level of coordination for different educational outcomes takes planning, but it is an excellent way to reinforce skills and to demonstrate applications.

LESSONS LEARNED: CHALLENGES AND BENEFITS OF OPEN SOURCE MAPPING AS A PEDAGOGICAL TOOL

Our three examples support the claims in the literature that incorporating open source

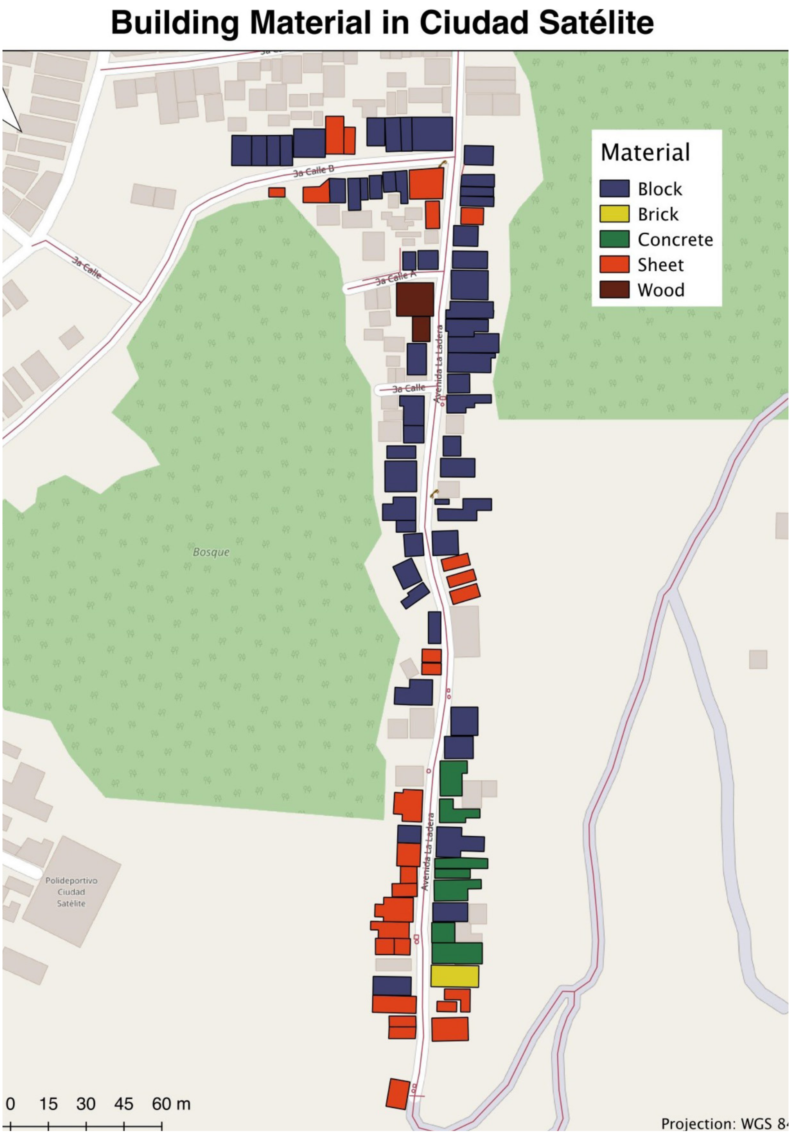

Figure 4. Building Material in Ciudad Satélite. Created from the community mapping project in Mixco, this map details the housing materials for one street in the community. This attribute data is available in OSM.

mapping into the curriculum promotes an effective geographic pedagogy that is collaborative and experiential. Three important lessons learned for those wishing to replicate similar projects concern local needs, local engagement, and scale.

First, having a tangible and specific local need or problem to solve is critical for the success of an open source mapping project. Examples include planning for disaster management, responding to a recent natural disaster, or addressing a specific development issue. The more real-world and immediate the problem, the greater the student or community engagement in the process. It was particularly moving to see the enthusiasm of community members, many with only a high school education, learning how to edit maps on OSM and collect survey data.

Second, the support from local scholars, community leaders, and NGO staff with knowledge and familiarity of the communities in Panama and Guatemala was instrumental in carrying out the mapping activities. Such provisions ensured that the team members were not at risk of experiencing distrust from the local population, and they also increased the willingness of locals to participate and answer sensitive questions about housing tenure, income, and access to resources. Community members who knew the area, the residents, and the dialect allowed for a level of trust that would not have been achievable had only U.S. students conducted the survey.

Third, keeping the scale of projects small led to a successful completion of goals. Scaling down made the project more relatable for participants and made it easier to demonstrate mapping techniques, encourage data creation, and break down the overall project into digestible units for the participants. Fieldwork exercises in Panama and Guatemala reinforced local engagement by allowing people to see their own communities on the OSM map. For the mapathon participants in the U.S., mapping a community in detail as part of a larger development project gave them a sense of global engagement.

One goal for the project's team was to share the experiences from fieldwork with educators and government stakeholders in Latin America, but this was not always easily done. Interactions at universities and government agencies were intended to spark a discussion about the value of engaging students in the creation of open data. These discussions proved the most effective with faculty who decided to incorporate the methodology of collecting data using open source technology in their fieldwork, which was precisely the outcome the authors were hoping for. In the Panama case, students shared their findings with local activists and the agency in charge of redeveloping the study area. Yet, sharing this data did not alter the pace of change in the Casco Viejo.

A rather different reaction was received from government stakeholders when the methodology developed by PADF and the authors was presented to CONRED (Guatemala's natural disaster agency). This interaction was intended to inspire new perspectives on how to incorporate open data collection for disaster prone areas. While CONRED staff appeared interested, the leadership showed surprisingly little interest in our approach. The main concerns presented to the team members were the lack of funding needed to acquire data gathering technology and the lack of incentive to modify long-standing and well-established policies and procedures.

Other limitations to the fieldwork in Guatemala included insufficient time to train volunteers, the condensed format of the fieldwork exercise, the quality of images of the study area, and the precision of the survey coordinates. Even though each team of surveyors had a member with previous experience of using the technology, some participants were less comfortable using it and assumed observer roles. Increasing the number of days dedicated to training and briefings would greatly improve the level of technological knowledge among the volunteers. Also, it was challenging for certain participants to navigate data validation and collecting survey data at the same time.

A few months after the Guatemala project ended, a group of students and a faculty member ventured to other neighborhoods in Mixco to replicate the study discussed in this essay. We regard it as a positive indicator that educators are interested in introducing experiential and applied learning activities. As stated by Healey and Jenkins (2000), a predominant learning style for geographers is interacting directly with the environment, particularly in fieldwork. Although we do not call for complete rethinking of learning inventories and for pushing students out of computer labs and into field collection exercises, it is important that students learn how data are created and understand the impact of data on communities. Such an approach moves geographic skills out of the classroom and into the world of practice and service that can be impactful. It is encouraging that this methodology can be used for small-scale data collection initiatives in many countries of Latin America, but there are challenges in scaling up this methodology that relies on volunteers.

Since these projects, articles have appeared on the significant strides made by YouthMappers and their contributions towards various global campaigns (Solís et al., 2018, p. 145). Building on this new body of research that provides easily measurable results, a more persuasive case can be made to local and national officials about the positive potential impact of engaging student networks (such as YouthMappers) in data creation through open geospatial technologies. Moreover, from our experience, participants also value being part of knowledge production efforts that allow for collected information to be readily shared and available.

In addition to being cost-effective, relatively user-friendly, and easy to reproduce, open mapping initiatives have the potential to mobilize a wide range of stakeholders to engage in community-inclusive mapping projects. Drawing from this observation, we believe that similar methodologies can be replicated in other locations and eventually scaled up to cover vast areas that are in need of publicly available data. In particular, we foresee similar projects in countries that emphasize "*capacitación*" (capacity building) among local populations to equip residents with the knowledge, behaviors, and skills they require to respond to and mitigate local challenges effectively. That said, creating more detailed maps does not automatically translate into solving community problems.

CONCLUSION

In this paper we discuss new pedagogies for enhancing student learning and engagement in Latin American Geography by using experiences from a short-term study-abroad course in Panama, in-situ and remote mapathons, and field validation of OSM data in Guatemala. Drawing from the examples and observations in the field, we contend that open source mapping tools can enhance classroom engagement and international collaboration as well as make meaningful contributions to learning experience in the classroom and the field. Furthermore, the opportunity to conduct international fieldwork allows students to have cross-cultural exchanges that complement classroom learning.

Our experiences using open source mapping and other digital tools across the Americas have enabled new levels of collaboration with students and stakeholders. Creating open source maps, like the generation of any type of new data, is not inherently good or bad. It is simply a new way of gathering information and making it accessible. Yet, we have also seen that by incorporating these practices into our courses, positive student engagement and enhanced learning are fostered. It must be stated that this work benefits from our association with a geography department that integrates these tools into many aspects of its teaching and research. And, international collaboration with local scholars and development organizations have been fundamental to the success of these efforts. We hope this article encourages new forms of experimentation with these tools in the classroom and the field. Building a community of mappers who support educational institutions and partnerships with governmental and non-governmental organizations can offer experiential learning through service-oriented projects that not only produce data but build capacity to address many local challenges.

KEY WEBSITES FOR OPEN SOURCE TOOLS

1. **OpenStreetMap** (https://www.openstreetmap.org): Editable and open map of the world.
2. **YouthMapper**s (https://www.youthmappers.org/): The YouthMappers website provides information on starting a YouthMappers chapter and contributing to projects.
3. **Field Papers** (http://fieldpapers.org/): One can print out Field Papers of anywhere in the world from this website. Each field paper has a QR code, so after the user has marked it up with changes in the field, they can scan and upload their field papers to make changes in OSM.
4. **LearnOSM** (https://learnosm.org/en/coordination/mapathon/): An on-line resource to learn how to edit OSM.
5. **TeachOSM** (http://teachosm.org/en/workflow/): An on-line resource that supports the use of OSM in the classroom.
6. **Open Data Kit** (https://opendatakit.org/): Download and learn how to use OpenDataKit for many types of data collection projects.

NOTES

1 Some of the survey data collected included confidential information and was not publicly shared.

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