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Tactical Interventions: Environmental Sensing and Socially-Engaged Arts

Maria Michails

ABSTRACT

Restless with my artistic output of participatory gallery-based installations that engaged audiences about broader issues around energy and resources in crisis, I've recently shifted my practice toward working directly with communities in addressing *their* local environmental problems. Appropriating the popularity of citizen science and do-it-yourself making as tactics for engagement, this new work builds upon an important history of engineered artworks and activist strategies to make environmental sensing devices *with* community participants. *Airtracs* is a two-year community-based project that uses electronic toys as a starting point for dialogue and hands-on learning about the cradle-to-grave life cycle of electronics. The project then progresses to air quality monitoring, augmenting remote control toy trucks (rovers) equipped with cellular networking and inexpensive sensors to push data to a server. The rovers are created by youth participants living in an environmental justice community with a long-time struggle with the City of Albany and the State of New York to reduce the air pollution in their neighbourhood. Building upon a history of similar art and activist initiatives, this paper demonstrates how these community-based projects challenge regulatory standards in air quality assessment, confronting the controversies and critical issues revolving around calibration and data quality of low-cost sensing devices.

KEYWORDS

Air quality monitoring, citizen science, critical making, do-it-yourself, socially-engaged art

Introduction

In recent years, I have become increasingly agitated and restless with making large-scale participatory installations that rely on enormous funding to produce and incur transport costs too high for most galleries to absorb. But that's not the real reason I was agitated. I was beginning to see that direct engagement with communities could potentially make greater impact to the social change I seek. My agitation has become even more urgent, in part due to today's political climate, with the threat of returning to a pre-EPA era of unabated industrial emissions and dumping of toxic waste into our air, soil, and water; an era of little to no regulations to protect ecosystems and public health. My earlier human-powered projects made connections between resources in crisis and energy specific to place. For example, energy and water in the desert (Fig. 1) or energy and topsoil depletion in the Prairies or Midwest (Fig. 2).

Fig. 1 *EMERGY* (2008/10)

Fig. 2 *SOIL* (2014)

Visitors to the gallery became performers, operating the mechanism to generate electricity to power what's going on. These projects allude to the extraction, processing, and combustion of fossil fuels in order to have electricity or food production. *The Petri Series: Benzene* was the first time I connected petrochemicals with environmental and human health. In these works I've engaged with scientific information and taken creative liberty in connecting dots. But as I begin a new body of work within PhD studies, I'm interested in co-producing information with the community I am working with. Air quality and its impact on public-health has been the focus of my research and creation lately.

Urban air pollution has been a persistent environmental problem since the start of the Industrial Revolution. In more recent decades, regulations put into place to limit emissions have reduced particulates in many North American and European countries. But standards are empty hope for those living nearby the emitter unless regulations are enforced. An overwhelming proportion of those affected by industrial pollution in the United States are African-American, Hispanic or other minority and low-income populations who live in neighbourhoods adjacent to industrial plants and waste disposal areas (Corburn; Brown et al.; Pellow). Known as *fence-line* communities, these residents bear the brunt of the nation's pollution problems. Environmental justice groups, artists, and amateur scientists have engaged communities at risk by employing a variety of tactics and strategies to address ambient air pollutants. Although their approaches may vary their objectives respond to

public demands for safer standards and regulatory enforcement by governmental agencies.

In the first half of this essay, I discuss several artist and activist projects that engage the public with air quality monitoring. The increasing availability of low-cost do-it-yourself (DIY) techniques and electronic components provide an opportunity for communities and the public to collect and interpret their own data while also challenging regulatory standards, data sets and procedures set by government and industry experts. In the second half of this paper I discuss my current research and the community-based project that I am co-creating with youth living in a low-income neighborhood in South End Albany, New York as part of my PhD work. Under the auspices of an informal educational experience, I combined DIY making and a citizen science model with the artistic process.

Engaging with environmental issues within a community structure has, of course, presented a new set of parameters that are both exciting and challenging and have required careful consideration when attempting to bridge disciplinary fields outside of a solo studio practice. Shifting my practice from gallery-based participation meant I could not use the gallery as the point of intersection with the public. In addition to ethical concerns, questions about who owns the art afterward have yet to be resolved. Furthermore and, in my opinion, of greater importance, to facilitate my desire for working directly with communities in addressing *their* local environmental problems, I found it not only necessary but useful to turn to methodologies used in the Social Sciences.

Socially engaged art and the ethnographic tension

Although at the early stages of this new socially-engaged work, I am keenly aware that I am blurring the line between art making and what has been alluded to as 'social work' by some critics. This is a very entangled subject that I will only briefly address in order to focus more on the actual project in the space allotted. However, some theoretical points and background context are useful in laying down the grounding of what I hope to accomplish with this new work.

Ethnography has traditionally been the methodology of social/cultural anthropologists, carried out as observational, descriptive writing about the customs and everyday activities of people, particularly of cultures different from one's own. In the late 1980's a rupture in the profession shifted the way in which ethnographic study was carried out, both in practice and in writing. Dubbed as "the self-reflexive turn" it brought into focus the subjectivity of the researcher. The debate centered around an edited volume by anthropologists James Clifford and George E. Marcus. *Writing Culture* assembled a series of essays by practitioners who advocated for an interdisciplinary ethnography, arguing that the ethnographer's image of culture was very much a product of an ongoing dialogue between researcher and interlocutor, therefore, the voice of the "other" should be heard (Clifford and Marcus). Ethnographic approaches have since seen a broader

appeal in the humanities and social sciences with each discipline re-conceptualizing the method suited to their needs.

The "ethnographic turn" in contemporary art surfaced in the works of practitioners across the creative domains, from theatre to performance and visual arts, as artists sought to work directly with and within the public sphere. Socially-engaged art (SEA), commonly referred to as "community-based art" or "social practice," finds its roots in the social movements of the 1960s (Helguera 2). SEA relies on social interaction between the artist and the interlocutor as its definitive element. Although earlier associations of art practice that encompassed social interaction were understood as "relational aesthetics," "social practice" (the term most commonly used for socially engaged art) avoids a modern or post-modern positioning of the artist as either an "illuminated visionary" or "self-conscious critical being," preferring a more democratized construct of the artist as a professional working within society (Helguera 3). The positioning of the artist – as a figure capable of facilitating a democratized engagement – has elicited criticisms questioning this "democratized" rhetoric (Bishop "Antagonism"; Bishop "The Social Turn") and counter-criticisms defending SEA as a dialogic form of aesthetics (Kester). These arguments remain within the framework of institutionally-benefitting debates that we expect from art historians. A direct analysis of SEA's use of methodologies borrowed from the social sciences, such as anthropology, was addressed by art historian and critic, Hal Foster.

In his essay "The Artist as Ethnographer?" Foster makes his argument based on several assumptions which place the "do-gooder" artist in conflicting positions. For one, the (usually outsider) artist has "institutionally sanctioned authority" to engage the "other" in the "production of (self-) representation" (Kwon 138). In the past, the artist aligned with the oppressed worker in fighting against exploitation from "bourgeois institution[s]" whereas today, it is "the cultural and/or ethnic other in whose name the the artist often struggles" (Foster 302). Secondly, the assumption that "artistic transformation" is also the site of "political transformation" and that this is located in the "field of the other," obscures the fact that many of these projects are initiated (and funded) under the same institutional umbrellas that historically have oppressed the "cultural and/or ethnic other" the artist aims to give voice to. He writes that the "quasi-anthropological artist today may seek to work with sited communities with the best motives of political engagement and institutional transgression, only in part to have this work recoded by its sponsors as social outreach, economic development, public relations … or art" (303). Foster views this predicament as reiterating the position of a benefactor or an "ideological patron" rather than unseating the bourgeois paradigm that would give the interlocutor his/her emancipation.

This uncomfortable and ambiguous positioning is precisely where socially engaged art should reside, argues artist and educator, Pablo Helguera. SEA may align itself with other disciplines, such as ethnography, anthropology and sociology, but it nonetheless can navigate this ambiguous position while fully attached to its subject and to problems that "normally belong to other disciplines" (5). This uncomfortable and ambiguous positioning may afford some liberty but also calls for reflexivity, ethical consideration, and

responsibility (Foster stresses the importance of this as well). Helguera believes this "is exactly the position [SEA] should inhabit" (4). The unpredictability and messiness of community interaction demands upfront disclosure of motives, not just ideas, to confront/address/acknowledge the artist's outsider-ness as well as insider-ness within "institutionally-sanctioned" norms. These relations, which may arise early or later in the project, require a certain skill set that is not generally in an artist's toolbox. That said, SEA's links to and conflicts within art and anthropology "must be overtly declared and the tension addressed, but not resolved" (4).

Perhaps it is for this "messy" reason that artists are attracted to the more traditional modality of anthropology and its ethnographic fieldwork method, as Foster criticizes, because it is a stable practice – despite the flaws of a "naturalistic" documentarian form of production. Nonetheless, it is a space where interesting art can happen (Marcus 86). Fieldwork, in my experience, can be a way to enter a community through a practice of observation, presence, interaction and building of friendship while being conscious of one's outsider-insider position. In the *Airtracs* project, for six months I employed ethnographic methods – listening, taking notes, talking to residents and introducing myself to community leaders. In order to gain *invited* entry, I attended weekly community meetings at Ezra Prentice Homes, the community I wanted to work with, striking up casual conversation about the topic of the meeting. Those meetings were the opportunity for people to get to know me and for me to get to know individual members, without any expectations that I would get to do the project I had in mind. Although I live several miles across and beyond the river, I nonetheless now consider this community my neighbor.

As a predominately African-American low-income community, the Ezra Prentice Homes neighbourhood is situated at the Port of Albany, New York, and impacted by multiple fossil fuel combustion sources. Although it was the sharp increase in media attention to the crude oil trains that initially attracted me to this community (and to PhD studies), it quickly became clear that the community's long-standing grievance was with poor air quality in this corridor and what they felt was the cause of many of the illnesses residents are afflicted with. Until recently, their complaints to officials to do something about it have "fallen on deaf ears." In the summer of 2015, armed with the preliminary results of a recent health study (initiated by AVillage...Inc., the grass-roots non-profit that I ultimately partnered with) that showed a high proportion of the residents suffer from one form of respiratory ailment or another, they called on the city, the State of New York, and the media in order to be heard. [1]

[1] See study at AVillage...Inc., http://www.avillageworks.org/home.html.

In the Spring of 2016, I built an air quality monitoring rover (Fig. 3) in the hopes of attracting Ezra kids to engage with it. When the New York State Department of Environmental Conservation (the DEC is the state agency in charge of approving permits for fossil fuel transport projects and the focus of the community's hostility) announced they were going to invest in a comprehensive air quality study in the neighborhood, I decided it was a timely moment to approach the AVillage...Inc. with my rover. I proposed an after school program for youth to make a series of rovers and wearables that

would monitor air quality in their neighborhood. The program culminated with an Earth Week event that included an exhibition, kids activities, and a citizen science air quality monitoring rover walk and data mapping activity alongside one of the scientists from the DEC Division of Air Resources who brought along their expensive instrument affixed to a specially designed backpack (Fig. 4). In addition to the Tinker Space after-school program with the Ezra kids, I worked with computer science students from another local institution to develop a web platform that would network with the *Rover Fleet,* uploading our data and location-tracking the rovers while they "roam" in the neighborhood collecting temperature, humidity and particulate data. Still in progress, the website will serve as an information center as well as a repository of audio recorded personal narratives about what it is like to live at Ezra Prentice Homes.

The two-year project has a multifaceted goal: pedagogically, it is a learning opportunity for participants and myself in new technologies and strategic deployment; it is an opportunity to build community in becoming more active in addressing the health hazards associated with carbon emissions in their neighborhood; and, it aims to ensure that the New York State DEC not only keeps its promise to conduct continual air monitoring but engages in open dialogue with the community about the standards and methods they are using to interpret the data. In my conversations with the scientists, they expressed their intent to include local knowledge but it is not clear how this will manifest and in what capacity local knowledge will be integrated, and whether or not local *knowledge-making* will be sought.

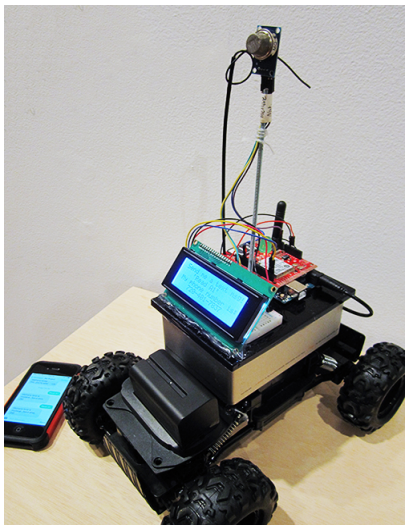

Fig. 3 Maria Michails, *AQM Rover (prototype)* (2016)

Fig. 4 *Citizen Science Air Monitoring Rover Walk,* Earth Week Event at Ezra Prentice, Saturday April 29th, 2017

Citizen science and DIY making as knowledge production

Citizen science refers to the participation of non-scientists in genuine scientific research. These activities range from data collection and/or interpreting results, environmental monitoring, even shaping research questions, such as in a community-based project. Often, research projects are done in collaboration with professionals leading the research project. Projects therefore vary in scope, duration, spatial parameters, and objectives. Prior to

the formalization of the scientific profession in the late 19th century, much scientific observation of the natural world was conducted by non-experts with a deep interest in the natural world. Many – such as John Muir, John Burroughs, and Henry David Thoreau – were naturalists, hobbyists, amateur astronomers, or had an interest in weather patterns and bird identification. These "self-directed" pioneering scientists published some of the earliest information about ecology and natural history in North America (Bonney and Dickinson 4). The importance of such activities were, and continue to be, the production and publication of scientific knowledge. But citizen science need not necessarily be used for this purpose alone.

There are varying theories emerging from the social sciences on what might be better approaches to fostering environmental care. Studies show that knowledge and information are not enough to change attitudes and behavior, and fiscal incentives (through mandated policies) may work to change our behavior but not necessarily our attitudes, therefore, the behavior does not stick if policy becomes lax (Dobson and Bell). This is especially true with industrial polluters. If there's a lack of enforcement of regulations today, what will it be like tomorrow if regulations are removed altogether, as the current US administration has promised?

In light of this new prospect, the third goal of my project – to push up against standards and regulatory enforcement – could very well be rendered moot. Regardless of this looming threat, I have chosen to use models of citizen science coupled with DIY making – popular forms of contemporary engagement in the sciences and the craft movement – as methods for tactical interventions. Precisely because of the mainstream popularity of these approaches, recruiting participants has been an easier task. Framed as art, the monitoring devices have the potential to transcend certain barriers and open channels of communication, particularly between expert agents and community members, as was the experience with our rovers. Could it have a persuasive effect on local policy-makers? (Both the Mayor of Albany and the City Councilwoman of the district showed up to our event, with the Councilwoman going on the 1.4 km walk with us). If regulatory bodies are dismantled, would not it be even more relevant to have the public take over monitoring?

The desire to collect data for environmental justice purposes, often a result of years of being ignored by regulators, has seen new models of citizen science being developed. Projects widely referred to as community-based participatory research (CBPR) involve monitoring the environment of a local community to assess air, water, noise or light pollution, for example. Research may be initiated by an NGO at the request of a community organization representing a group of residents with a particular grievance. This may also include a partnering institution such as a university or research center. Jason Corburn, in his popular book *Street Science*, refers to CBPR as a co-created or "co-production" model. In this type of citizen science, participants (usually residents living in the community) are more deeply involved in the creation of the study, project protocols or data analysis (Dickinson and Bonney 5; Corburn 40-41). The co-production model assumes that "scientific knowledge and social order evolve jointly. [That]

political decision making does not take 'scientific knowledge' as a given, but seeks to reveal how science is conducted, communicated, and used. [It] problematizes ... notions of expertise, challenging hard distinctions between expert and lay ways of knowing" (Corburn 40-41). In other words, Corburn's premise is that community knowledge and knowledge-making provides vital insight and should be taken into consideration along with expert findings in the decision-making processes that will effect the community. This type of citizen science model can provide fertile ground for environmental arts practitioners wanting greater involvement with community in their praxis.

Paralleling early non-expert citizen science observation, the DIY movement has been associated with consumer culture since the early 1900s. [2] The ideals of open culture are at the center of the DIY movement, inspiring a return to making, modifying, or repairing without the aid of an expert and, in turn, sharing this knowledge. Citizen science and DIY making can sometimes overlap, with projects being intrinsically collaborative in nature and often innovative. The combined approaches can create a platform for critical engagement with the politics behind scientific information and technological access. When these methods are used toward public engagement for environmental monitoring, protection and awareness, information can have a potentially powerful effect, mobilizing communities to take action, standing up to corporate manipulation, and swaying policy decision-making in their best interest.

[2] See: http://en.wikipedia.org/wiki/Do_it_yourself.

With community-based projects there is often a lot of talk about empowerment. The degree of authentic empowerment and the results it could have – for procedural justice for example – for a marginalized, fence-line community, places greater emphasis on the politics of data and how that data is interpreted. According to science and technology scholar Gwen Ottinger, community empowerment through environmental surveillance is constructed *not* through "copious data collection" but through "the power to define the issues, the power to enforce laws, and the power to choose" their environmental circumstances, countering any carte blanche assumptions that doing citizen science, in this case environmental monitoring and data collection, will empower those who engage the science (Ottinger, "Constructing" 221).

It is important to point out that to be empowered does not necessarily mean to be able to change one's political, economic or environmental state, although there is potential for such. The ability to shape narratives that are reflective of the community's experiences are crucial to providing context and meaning to data when having to make correlative assumptions about environmental pollution and public-health, for example. Nonetheless, communities and the public at large, have mobilized to create their own devices for monitoring, collecting and interpreting data. My current project builds upon a history of environmental monitoring by activists and artists (such as Natalie Jeremijenko, Beatriz da Costa, and the Louisiana Bucket Brigade) who have reached out to communities and/or partnered with grassroots organizations to put low-cost devices into the hands of the people.

Fig. 5 Louisiana Bucket Brigade, *Bucket Monitors* (c.1996)

Fig. 6 EPA-approved *Bucket Monitor* (c.2002)

In the late 1990s residents of Norco, Louisiana waged a heated campaign against the petrochemical company Shell Chemical in their neighborhood, claiming that the company's emissions of toxic air pollutants were making them sick. In nearby Diamond, residents demanded that Shell bear the costs of buying their homes so that they may relocate to a safer place. Ottinger recounts that "the resident activists in Diamond tried to demonstrate that the air that they were breathing was hazardous to their health" by collecting air samples (that were then sent to a professional lab for analysis) using simple DIY devices known as "buckets" (Figs. 5 & 6). Ottinger claims that the Diamond residents did more than "'prove' (or attempt to prove) ... that the local air quality was poor, [they] fundamentally challenged the standard practices used by regulators [governmental and industry experts] for assessing air quality" (Ottinger, "Buckets" 245).

The accessibility of new technology makes it possible to augment, for example, an iPhone with an app that tracks everything from endangered species to radiation and air-quality. Low-cost DIY devices can measure atmospheric conditions, chemicals in water and soil, and a plethora of air quality sensors are available to test for particulates and gases. Environmental activists and NGOs are employing open-sourced technology and knowledge

and deploying these devices to groups who act as environmental watchdogs while collecting data. The ability to mobilize large numbers of people in political action, as we have seen in the last several years, can now have almost instantaneous change to current situations. This swift mobilization occurred during disaster and recovery efforts to safeguard public health in Japan during the Fukushima Daiichi nuclear meltdown. A radiation monitor called *Safecast* (Fig. 7) was deployed along with a web platform for storing and sharing data when citizens did not trust what the government was telling them.

Similar to the goals of the 90s Bucket Brigade, *Safecast* challenged the protocols, methods and exclusive, often expensive, technologies that were being used by the institutional and industry experts. Acting quickly to develop their technologies, the groups open-sourced their code and design plans and through a crowdsourced approach were able to utilise free global expertise to prototype and build their devices that were then deployed and re-deployed to achieve greater accuracy with each iteration. The overlap of Citizen Science and the DIY maker movement creates an opportunity for artists, designers, engineers and scientists to work together toward common goals; that of engaging diverse participants to become active agents of change for their neighborhoods or community.

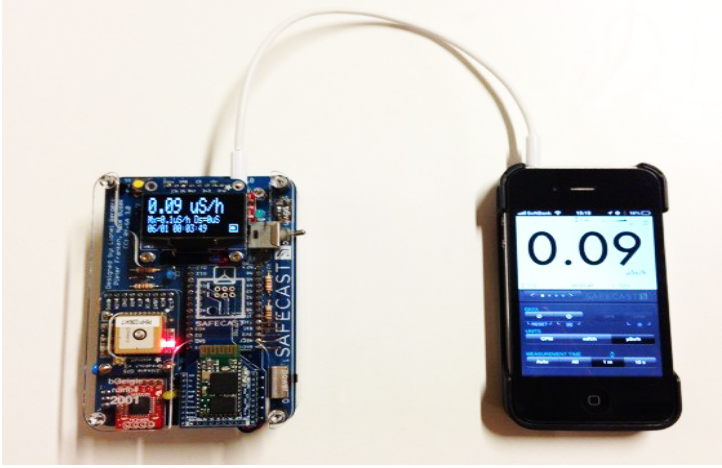

Fig 7. Safecast, *bGeigie Nano* (radiation monitoring device) (2011-present)

Environmental sensing and the arts

Where or how should arts-based disciplines situate themselves when working with environmental sensing? After spending time with the New York State DEC scientists and two Department of Health scientists, I learned that air chemistry is complex and that monitoring to determine precisely what is in the air and how it affects our health requires many layers of expertise, study, and interpretation before conclusive correlation to public health can be made, something these scientists are reticent about making. To start with, it became very clear to me that without highly sensitive and complex instrumentation this work would be nearly impossible. The scientists that I spoke to were not outright dismissive of low-cost sensors. On the contrary, they realize the sensors are proliferating the consumer market and that they need to participate in shaping the narrative of these devices. They too

recognize this as an opportunity to engage and educate the public about air quality. This openness was not what I expected.

The proposition to work in parallel with these scientists has been enticing to me (I am now quite embedded with the air quality division, having organized a public outreach event during Earth Week to collect data using our rovers alongside their expensive handheld instruments). But something seemed amiss with this working mode. I have come to realize that by being a bridge between the public and the scientists the political edge that I have sought – in other words maintaining a critical stance – has had to be tempered. That does not mean that I refrain from asking difficult questions. On the contrary, I have found that by forming a relationship with the scientists based on mutual respect for each others' working methods, I can ask challenging questions and broach criticality through inquiry rather than outright criticism.

Media art historian Edward Shanken claimed that "investigatory research has played a central role in socially-engaged art since the late-1960s, particularly with respect to institutional critique and other forms of systemic analysis. Such work tends to shift emphasis away from objects *per se* and to make visible the invisible mechanisms of institutions" (Shanken 1). Similar to investigative journalism, artworks that interrogate, intervene or investigate systems of environmental pollution – or polluters such as in the above situations – do not necessarily have legal authority but can act as agents of change by "creating public awareness that instigates action. Moreover, certain strategic uses of digital 'real-time systems' as artistic media, provide modes of relating to and interacting with information that make it concrete in ways that are particular to network cultures." In other words, not just advances in accessible hardware, such as small inexpensive microcomputers (eg. Arduino), but the ever-expanding online networks, have enabled artists and users "to access and manipulate previously inaccessible data" and their platforms (Shanken 1).

In 2006, the collective Preemptive Media – a group of interdisciplinary artists made up of Beatriz da Costa, Brooke Singer and Jamie Schulte – built one of the earliest small-form digital air quality monitoring devices. *Area's Immediate Reading* or *AIR* (Fig. 8 & 9) was an experimental project that put a portable device developed by the group into the hands of the public to monitor pollution levels in their local urban surroundings. The project was initially carried out in New York City and later deployed in Riverside and San Francisco, California and Belo Horizonte, Brazil (Dieter 1). The device enables participants to self-identify the quality of the air whereever they may find themselves, tracing levels of nitrogen oxide, carbon monoxide and ground level ozone, chemical compounds associated with by-products of carbon combustion – or smog. The difference between a personal device monitoring air quality versus that of the EPA's large-scale Air Quality Index monitors, for example, is that the EPA monitors produce data from a wide geographic distance and the readings are averaged, whereas the personal device monitors the exposure in the user's immediate surroundings and with as much frequency as the user intends (Michails 38).

Figs. 8 & 9 Preemptive Media, *AIR* (2006-2010)

How might low-cost pollution sensing devices be understood as new forms of participatory engagement with regulatory processes? Michael Dieter writes: "As a techno-social experiment, the AIR project … function[ed] as a subsidiary to government-based information-gathering through the ethos of open-source technology, peer production and activist-based politics" (Dieter 2). The project not only investigated urban pollutants, it was a catalyst in challenging regulatory standards, much like its decade old predecessor, the "bucket." Furthermore, by experimenting with already developed technology, and taking a DIY approach by modifying it, the artists democratized the technology and the information, placing both into the hands of the general public.

In 2005, as an MFA graduate student at Arizona State University, I had the opportunity to work on an iteration of Natalie Jeremijenko's *Feral Robotic Dogs* (2003), collaborating with two cohorts and a group of high school youth in a predominately hispanic neighborhood in downtown Phoenix, Arizona. *Feral Robotic Dogs* (Figs. 10 & 11) were a pack of toy dogs deployed in urban areas for the purpose of "sniffing" environmental toxins in soil that get released as vapor into the air. Jeremijenko, who "mobilize[d] issues of environmental justice and social activism via so-called 'new' media art," worked with students to "hack" into existing toys, converting them into interactive artworks that engaged community participants to draw attention to local environmental hazards left behind from past industrial activities (Philip 70).

Fig. 10 Natalie Jeremijenko *Feral Robot Dogs* (2003-current)

Fig. 11 Natalie Jeremijenko *Feral Robot Dogs* (2003-current)

Jeremijenko at the time had referred to the dogs as being "mediagenic," which was more important than attending to accurate scientific readings of volatile organic compounds. [3] From a theoretical standpoint, *Feral Robotic Dogs* could be considered an example of what Bruno Latour calls "*Dingpolitik*, a densely materialist approach … drawing together legitimate actants around an issue (politics), and presenting a matter of concern, a *topos*, to those assembled (science)" (Dieter 1). The dogs themselves did not collect data but responded to levels of contaminants sensed in the soil or air by exhibiting behaviors (barking sounds) inherent in the toy robot which then alerted those present to the area of the VOC's. The "pack" behavior occurred simply because all the toys had embedded VOC sensors. At the time, low-cost sensors were not as readily available nor were there online forums sharing open-source code. Our cohort used the newly released Wiring board (Arduino's predecessor) and experimented widely, guessing as to what the code would yield. With the release of plug and play components such as Arduino, and today's integrated inexpensive circuits, shields and code-sharing, so much more can be accomplished, and teaching youth (Jeremijenko is working with 5th graders currently) makes it much more accessible. Where *AIR* might be construed as having responded to the "perceived crisis of contemporary forms of governance" (Dieter 1), *Feral Robotic Dogs* engaged participants with hands-on making and a critical engagement with the material's significance and its position within the supply chain that is part of the problem.

[3] In conversation with Jeremijenko during the making of the Phoenix dogs, she conveyed to me how important it was that the media be aware of the robot dogs because of where they are situated. In other words, she pointed out, that industrial plants and compounds are almost always situated in immigrant, low-income, and African-American communities.

The criticality of making in socially-engaged environmental art

The overlapping of DIY making and citizen science finds a natural home under the umbrella term of Critical Making. As an emerging practice, scholar Matt Ratto describes critical making as:

> a research program that explores the range of practices and perspectives connecting conceptual critique and material practices. The impetus for this endeavor comes from the idea that technoscience, when brought to bear on social and ethical dilemmas, requires the development of new

> relationships between traditional forms of critique and critiques embedded in material interventions. (Ratto et al 86)

Other scholars have also proposed this overlap of making and critical thinking known as material thinking (Carter) or maktivism (Mann).

At the heart of these praxes are critical reflection through the act of making. They propose placing greater importance on process and dialogue than the end product and are less concerned with the sexiness of the newest 3-D printer than they are about "an activity that provides both the possibility to intervene substantively in systems of authority and power and that offers an important site for reflecting on how such power is constituted by infrastructures, institutions, communities, and practices" (Ratto and Boler 1). These material interventions are the glue for the socially-engaged environmental art practices that concern my current research. As a methodology, critical making provides me with a structured approach, but not so structured as to insist on an end product. On the contrary, such open-endedness allows for the participants to shape not only the process but determine the outcome as well. The process of making engages critical analysis, reflective evaluation of success and failure or shifts in perspective about the materials being used, in this case electronics.

As an environmental artist I continually ask: how can my relationship with materials shape my art-making practices? How are the materials I use made and where do they come from? This investigation leads directly to issues of labor, resource extraction, modes of production and waste – important considerations in sustainability discourses. Furthermore, given that the "materials" I am especially referring to – electronics components, digital media and "cloud" technologies – have a tendency to be perceived as ubiquitous, passive, and de-materialized, how then can the act of "making" be a precursor to knowledge production for the sake of environmental justice and ecological sustainability?

While putting together the electronic configuration of the prototype of the *AQM Rover*, I used low cost sensors ordered from China, an Arduino, and a GSM shield that sends text messages of the methane data to your cell phone. I was perplexed by the fact that these sensors, already mounted on their own circuit board, cost a mere $3-$6 each, including shipping. I wondered, what were the real costs? The cost of extraction of finite metals and the toxic waste stream their processing would produce. Whose health would be at risk from this waste stream? Whose labor was exploited? [4] What systems does this uphold or deconstruct? What other alternatives are there that could be explored?

[4] Recent news reports claim that labor costs in China are rising and many factories are automating. But, the average electronics factory worker in China earns $27.50 per day (compared with $8.60 in Indonesia and $6.70 in Vietnam). See: http://www.economist.com/news/briefing/21646180-rising-chinese-wages-will-only-strengthen-asias-hold-manufacturing-tightening-grip.

Material connections and pedagogical overlapping

Under the auspices of an informal after-school program, I worked with 8-15 year old residents of the Ezra Prentice Homes neighborhood, an environmental justice community situated at the Port of Albany, NY. According to the United States Environmental Protection Agency's (EPA),

environmental justice is the "fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies." [5] The foray into addressing air pollution in this neighborhood began with the *AQM Rover,* a modified remote control truck with inexpensive components and sensors. But we wanted to look a little more closely, though, to how electronic toys are made, where they go when we become (quickly) bored of them, what are the environmental impacts, and who comes into contact with them? Electronic waste is a well-documented problem but what does that have to do with the air quality at the Port of Albany and this neighborhood? During our weekly meet-ups, we began by carefully taking apart the used toys to see what they were made of and learn about their (globalized) cradle-to-grave life cycle. We were interested in uncovering the layers of "media archeology" embedded in the electronic toys and electronics in general. In fact, in trying to interest my participants in this portion of the project I asked them to imagine themselves as an archeologist 100 years from now. What conclusions would they arrive at if they were to unearth, say, an iPhone, or a toy animal or its parts?

[5] See the EPA website: https://www.epa.gov/environmentaljustice.

Using photography to document the process of dissecting the toys and laying out their electronic and plastic parts, we then researched each component – its material resources, extraction, process, transport, labor and generated waste. We then re-constructed a new sculpture/toy by using the parts along with recyclables from everyday household detritus (the two works, the prints and the object, will be exhibited in a professional context). This initial engagement was a way to prepare participants in the making of the air-quality monitoring devices, with the critical knowledge they have attained during the toy project about the environmental impacts of electronic components.

Fig. 12 Used electronic toy bought at the Goodwill.

Fig. 13 Deconstructed parts of the same toy.

This learning process of deconstructing and re-assembling was then applied to making – or rather augmenting – a popular electronic toy truck with a much more useful function – sensing air pollution, temperature and humidity. Throughout the process, I showed videos and slides and we had brief discussions about the meaning of process. Ultimately, the conversation led to oil: its embeddedness in every fabric of our culture and materialist existence. The *Rover Fleet* roam the streets, telling us a little more about our

local environment while reminding us of the dilemma we face in reconciling extractive and manufacturing processes that begin with oil and metals and end up as toxic emissions affecting environmental and human health – both near and far.

Why is this important? To begin with, my intention with this project is to make ecological and industrial processes visible through making – or in our case de-construction and the re-making process. Jussi Parikka, in discussing the materiality of media, refers to the "connections [between] media technologies, their materiality, hardware, and energy, with the geophysical nature" and how much nature "bears the weight of media culture, from metals and minerals to its waste load" (Parikka viii). Whereas my past human-powered works made these processes visible through interaction with objects I produced for a gallery installation, in this approach learning and articulating about these systems is done by each participant. Through direct engagement with such concepts over a durational period the participants begin to connect the dots between their local environmental problems that affect their community's health and the broader systemic forces exerted upon global communities. Furthermore, where my past works evoked an embodied awareness of a generalized concepts of energy and resources in crisis, this new co-creative approach opens up a greater analysis of these systems.

Conclusion

The accessibility of low cost electronic devices and sensors, too irresistible to bypass, has enabled artists and the tech savvy concerned citizen to explore ways of making their own environmental sensing monitors, be it for air, water, soil and/or weather sensing. For many, this is a fun and challenging pursuit and a way to connect with a community of like-minded interested people. A key tension has revealed itself in recent literature, addressing the fact that "the DIY ethos has been absorbed by corporate culture [and therefore] re-inscribing neoliberal capitalist" intentions that subdue the DIY activist spirit necessary to challenge that very authority (Luther 211). In a similar critique, science and technology scholar Rebecca Lave argues that the use of volunteers as unpaid labor for scientific research plays out a predominately neoliberal agenda while also reinforcing institutional boundaries between expert and amateur knowledge production (Lave). Artists working with communities are not exempt from these types of criticisms. Art can transcend these impediments and make strides toward social change through a true co-creation approach where the participant has agency in deciding, from the inception and once a problem has been identified, what the questions might be or what tactics could be used. Using the artists' knowledge with materials and methods, critically-driven decisions about the making of environmental sensing rovers, for example, could have an empowering effect on a young person's thinking, skill enhancement, and creative problem-solving.

While building and testing the rover, I realised I was confronted with some of the same issues regarding standards, despite using a very different device than the "bucket" monitor. The bucket is a one-time air sample grab whereas

my sensor pings data as often as I decide to set the delay in the code. I see this as an improvement to the frequency problem but both devices need to be properly calibrated and this is where the trouble begins. Where is the baseline data by which calibration is set? Even if there were a baseline, unless it was established using the same device it is difficult to be certain you have an accurate calibration. To address these challenges and attempt to affirm that these sensors have their merits would require reframing their social function or partner with an air quality chemist who may also be an engineer to address the complexities of calibration. [6] There is no question that these sensors are limited in scope – they are just not capable of measuring particulates and gasses at a high resolution. But, should arts-based practices working with environmental sensing worry about "accurate data" collection or concern itself more with tactics and strategies focused on pedagogical or aesthetic goals?

[6] One scientist that I spoke with working in the toxics division of the New York State Department of Health is building in-house systems that are generally lower cost to study air chemistry and toxicity. His research assists the Air Division team at the DEC. He shared with me that in his spare time he is developing small hand-held low-cost sensing monitors for particulates using commercially available PM 2.5 and dust sensors, similar to what I'm currently using. Gasses are difficult to measure at low resolution, therefore I've abandoned the initial methane sensor that I prototyped with.

Artists engaging with air quality sensing technologies would be well served to be aware of the complexities of air quality chemistry. I think, that socially engaged environmental art practices – because of their naturally inclined interdisciplinarity – can and should push against regulatory standards that do not reflect the needs and conditions of those living on the "front-lines" of environmental hazards. They have the potential to build upon the "hard won battles" by The Bucket Brigades around the world, many of whom were able to either intervene with the permitting process of new plants by appealing to their local officials, demanding state regulators provide more frequent and better testing of their own monitoring stations. I would welcome the opportunity to work closely with a scientist or engineer to improve the *AQM Rover* in such a way as to potentially be of service to environmental justice groups and possibly enhance their procedural justice goals. I have decided, for the moment, to focus the initial engagement on pedagogy and awareness rather than data accuracy. As Kavita Philips states, art that "engages with contemporary technologies and communities, via its form, content, and processual deployment, is particularly well-placed to stage interventions and conversations about our place within ongoing transnational ecological processes" (Philip 70).

The co-production of knowledge between expert and amateur has been a primary goal of the citizen science model and the sharing of knowledge is intrinsic of the DIY movement. Ecologically engaged artistic research that draws upon these approaches, I believe, can help foster a culture of environmental citizenship and can contribute toward a cultural heritage rooted in ecological thinking and living. Furthermore, when artists or artist groups engage in DIY making coupled with scientific pursuits, they too are empowered, as agents of change, creatively inventing and deploying tools that can in turn empower the public to bring about political action by the information they make attainable (Michails 37).

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