Pokémon Go, pH, and projectors: Applying transformation design and participatory action research to an environmental justice collaboration in Chelsea, MA

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Laura J. Perovich¹*, Sara Wylie² and Roseann Bongiovanni³

Abstract: Environmental issues such as climate change and toxic contamination have become a lived reality for communities globally, yet as a society we have been slow to address many of these challenges. While designers have begun partnering with interdisciplinary teams to take on large social issues, the process of design, the timescale of academic work, and the pressing needs of communities experiencing the brunt of these issues are frequently ill-aligned. In this paper, we examine a year-long exploratory collaboration between an environmental justice group in Chelsea, MA, a social scientist, and a design/technology scholar to develop approaches for studying water contamination in Chelsea’s industrialized waterway and design interventions that could lead to structural change. We expand on the benefits of a slow and processional approach to co-developing research and design.

ABOUT THE AUTHORS

Laura J. Perovich is a PhD candidate at the MIT Media Lab (Object-Based Media) who uses art and technology to increase engagement and action around environmental issues. Her data physicalization research uses aesthetics to create new perspectives and considers ways that measuring can become a mechanism for intervention.

Sara Wylie is an Assistant Professor of Sociology/Anthropology and Health Sciences at Northeastern University. Wylie co-founded the Environmental Data and Governance Initiative, an organization responding to changes in U.S. federal environmental policy, and Public Lab, a community organization that develops open-source, DIY tools for community-based environmental analysis.

Roseann Bongiovanni is the Executive Director of GreenRoots, a resident-led organization dedicated to environmental justice. Over more than two decades, Roseann has implemented many projects including park developments, air emission reductions, and campaigns to defeat projects that would exacerbate the community’s environmental and public health burdens. She is a lifelong Chelsea resident and former City Councilor.

PUBLIC INTEREST STATEMENT

Nine million people die prematurely per year from pollution worldwide, yet as a society we still struggle to address global environmental issues like climate change and industrial pollution. Some cities carry more of these burdens than others, including Chelsea, Massachusetts where the waterfront is zoned for industrial use and is largely inaccessible to the community. Like most industrial areas, Chelsea is an environmental justice community where its majority non-white, non-English speaking, and low income residents bear the burden of industries that serve the New England community. Pollution from these industries is potentially linked to Chelsea residents’ health issues such as increased asthma rates. This paper presents our community research partnership to use art and science to expand the agency of Chelsea residents to make their environmental justice issues visible and actionable. Our interdisciplinary work provides a concrete example of transformation design and participatory action research.
questions, tie our process to a theoretical framework connecting transformation design and participatory action research and point toward other potentially valuable frameworks such as civic science. We provide practical examples that can serve as guideposts for others starting similar collaborations and discuss systems-based changes that can encourage highly interdisciplinary transformational collaborations.

**Subjects:** Environmental Studies; Environment & Society; Environment & Health; Engineering Education; Technology; Anthropology—Soc Sci; Sociology of Science & Technology; Art & Visual Culture; Design

**Keywords:** transformation design; co-production; participatory action research; community-based participatory research; environmental justice; citizen science; civic science; STS (science technology and society); advocacy; art & technology; art & environment

1. Introduction

This paper describes the first year of a cross-disciplinary environmental justice collaboration that draws from transformation design approaches. Our team has a shared goal of participatory action research that contributes to local advocacy and includes researchers from the Massachusetts Institute of Technology (MIT) Media Lab focused on art, design, and technology, researchers from Northeastern University working in sociology and environmental health, and advocates and students from GreenRoots, a community-based organization in Chelsea, Massachusetts (MA) focused on environmental justice (GreenRoots, 2018). We describe the first year of our collaboration to illustrate the generative power of an open-ended and processional approach founded in transformation design and PAR and provide practical examples of our work that others can use as guideposts in launching their own collaborations.

2. Theoretical framework and collaborative foundation

2.1. Transformation design and participatory design

In 2006, the United Kingdom (UK) design council described transformation design, which prompts designers to turn their skills toward large social challenges such as climate change and human wellness, and declared that it “could be the key to solving many of society’s most complex problems” (Bruns, Cottam, Vanstone, & Winhall, 2006). This new approach is part of a 50-year diversification of design from a hierarchal expert-based approach that solves very specific object-based problems to a field that includes more cooperative collaborative models that take on social challenges through process-based investigations. Transformation design has influences in previous models of design such as strategic design which shifts the focus from finding answers to developing a process that could find the right questions to ask, interrogative design which helps us see the unacceptable parts of the world, and frameworks for less hierarchical design processes, such as co-design and co-creation, which recognize all participants as co-creators of the processes and the outcomes (Sanders & Stappers, 2008; Wodiczko & Deutsche, 2016).

In particular, Sanders & Stappers tie transformation design to participatory design, which began in Europe in the 1970s and sought social change. Papers from the Design Participation conference in 1972 pointed toward “a need for new approaches to design if we are to arrest the escalating problems of the man-made world” and claimed that “citizen participation in decision making could possibly provide a necessary reorientation” and that these new processes ought to include “participation at the moment of idea generation” (Sanders & Stappers, 2008). Our work builds from this radical history and employs many of the design structures based in participatory design suggested by Sanders & Stappers; for example, we conduct design for a purpose instead of
focusing on design of a product, and our design practice is based in acting as facilitators that provide tools for a collective effort.

Because transformation design is meant to create fundamental change—“radical change” even (Sangiorgi, 2011)—it requires an interdisciplinary collaboration that can look outside the normal solution space (Bruns et al., 2006). The participatory design techniques embedded in transformation design emphasize the initial exploratory and ambiguous “fuzzy front-end” work in the collaboration—the “activities that take place in order to inform and inspire the exploration of open-ended questions” and support capacity building throughout the process (Sanders & Stappers, 2008).

2.2. Chelsea, MA as a site for transformation design
Transformation design is necessary in Chelsea, MA in part because the lived conditions of the community are the outcome of a design process that directly precludes the community from influencing many aspects of the environment they inhabit. The Chelsea River waterfront is one of about ten “Designated Port Areas (DPAs) established by the Massachusetts Office of Coastal Zone Management to promote and protect water-dependent industrial uses” (EPA, 2014). This state designation means the city of Chelsea has little to no control over its waterfront—it is in effect rendered into a service region providing vital resources to the city of Boston, the state of Massachusetts, and indeed the entire Northeast, though other communities rarely recognize the valuable services the city provides. It hosts a number of industries including a major road salt storage depot, the New England Produce Center, petroleum tanks that provide 70–80% of the region’s heating fuel and 100% of Logan International Airport’s jet fuel, rental car lots, and freight forwarding companies.

In this context of design exclusion, transformation design can help us explore ways that the Chelsea community can make evident their lived inequity and show how the present use of the waterfront impacts their quality of life and health.

2.3. Participatory action research as a framework for transformation design
Transformation design seeks to take on society-level challenges like those found in Chelsea, but may struggle with historic design structures: it can be difficult for designers with traditional training to recognize that everyone is creative (Sanders & Stappers, 2008), design consultancies must adapt their business models to use these practices (Bruns et al., 2006), and transformation design’s anti-consumerist perspective may struggle to take hold in our capitalist society (Sanders & Stappers, 2008). Because of this, designers may benefit from partnering with social scientists who have extensive experience with participatory action research (PAR) and are trained to take a deep social and historical systems-based perspective (Minkler & Wallerstein, 2011).

PAR is a form of research developed to assist in enacting grassroots change in conditions of structural oppression (Minkler & Wallerstein, 2011). It emphasizes local context, asserts the importance of research done “with” people, not “on” or “for” people, and frames collaborations as learning opportunities for all participants (Chevalier & Buckles, 2013; Hammond, Hicks, Kalman, & Miller, 2005). PAR has been applied to a range of contexts and challenges, from creating photographic documentation processes with diverse women’s groups to understand, reflect on, and engage with policy around women’s health, to developing antidrug campaigns with adolescents in the Southwestern United States, to middle school students in New York City using video and interviews to start discussions on local water quality and community land use (Gosin, Dustman, Drapeau, & Harthun, 2003; Mordock & Krasny, 2001; Wang, 1999). Pedagogy of the Oppressed, Paulo Freire’s foundational text on PAR, posits that a first step to transformational change is changing the questions and expectations oppressed people feel they can express (Freire & Macedo, 2000). What role can transformation design play in creating experiences that alter the frames people commonly think with?
2.4. GreenRoots and environmental justice in Chelsea, MA

PAR is methodologically suited to environmental justice communities such as Chelsea where residents are structurally excluded from the resources in their community and bear an outsized burden of environmental harms. Chelsea is a 1.8 square mile city located across the Mystic River from Boston, MA, as seen in Figure 1. The United States (US) Environmental Protection Agency (EPA) has identified Chelsea as an environmental justice community, as many industries in or nearby the city come with significant environmental and health risks and the population of Chelsea is low income (median household income is 65% of statewide median household income), minority (65% Hispanic, 77% ethnic/racial minority), and English isolated (65% speak a language other than English at home) (EPA, 2014; US Census Bureau, 2017). Unlike affluent areas of neighboring Boston, Chelsea's waterfront has no community boating program, no contiguous public access, and very limited greenspace (e.g. parks, playing fields, or natural landscapes) on the water, and many Chelsea residents have never experienced the waterfront recreationally despite being surrounded by water on three sides.

GreenRoots is a resident-led environmental justice organization that has been working in Chelsea for more than two decades and conducts advocacy on many local quality of life issues such as water access, green infrastructure, and local water quality. Their office is located on Chelsea's waterfront in a building that used to house chemical manufacturing, and acts as an initial community claim to the present and future of the waterfront. Local oil storage facilities are one area of interest for GreenRoots, as there are seven such facilities in or immediately adjacent to Chelsea, the EPA has not conducted an overall assessment of the impact of these facilities on public health and the local environment, and existing environmental permits may not always be promptly reviewed. The map in Figure 2 shows the location of these and other environmentally

Figure 1. Chelsea, Massachusetts (img: Matt Frank).
GreenRoots’ environmental justice efforts are supported by their Environmental Chelsea Organizers (ECO) student group, consisting of six high school students who select their own environmental justice projects and sometimes conduct scientific activities with environmental researchers, such as tree counting or water sampling. Figure 3 shows ECO students working with researchers during a water quality workshop. The group meets roughly 10 h a week during the school year and 20 h a week in the summer and is supported by a GreenRoots staff member.

2.5. Citizen science and a new collaboration
As a precursor to our team's work, Perovich and Wylie began collaborating in the summer of 2015 to explore the potential of citizen science tools for social change, focusing on further developing tools to help communities understand and document water quality issues (Wylie, 2014a, 2014b).

Citizen science engages the public in collecting scientific data, asking research questions, and finding patterns (Bonney et al., 2009). It has been used to detect disease rates in birds, to search
for new stars and galaxies, and to monitor air quality (Bonney et al., 2009; Dutta et al., 2009; Raddick et al., 2013), and some communities have successfully used these tools to support advocacy efforts or policy change. For example, community driven “bucket monitoring” of air quality in a neighborhood near Shell Chemical sites in Louisiana contributed to advocacy efforts that eventually led to regulatory enforcement action against the company (Ottinger, 2010). In that spirit, our collaboration has a particular focus on “civic science” forms of citizen science that remind us that citizen science technologies are not an end in themselves or inherently liberatory but rather should be used as tools for “questioning the state of things” and building a collective, mutually respectful space (Fortun & Fortun, 2005; Wylie, Jalbert, Dosemagen, & Ratto, 2014).

Wylie’s and Perovich’s initial collaboration centered on further development of one particular citizen science tool, the Thermal Fishing Bob, which detects and displays potential “hot spots” of pollution in water bodies and began at Public Lab (a community organization Wylie co-founded). The device includes a light-emitting diode (LED) that changes its color based on the temperature of the water, since large deviations in water body temperature can indicate sources of pollution; for example, combined sewage overflows are polluting and create an area of higher temperature water. Long exposure photography can capture the temperature fluctuations and create an aesthetic location-based rendering of the information, as shown in the concept image in Figure 4 taken on the Charles River. Figure 5 shows three prototype form factors for the tool, including bobs that can be dragged through the water in pool floats and smaller wax sphere bobs that can be released into the water en masse, and demonstrates the varying color of the bobs as they are exposed to different temperatures. Communities can use this tool to illustrate how industries occupy space beyond their defined private boundaries, and to increase their ability to witness and understand industrial pollution in situ and in real time.

In 2017, Wylie and Perovich approached Bongiovanni about the possibility of testing Thermal Fishing Bob prototypes near the oil storage facilities in Chelsea, and expanding the work into a general collaboration that would be useful to GreenRoots and the local community. GreenRoots was interested in citizen science tools that could help them explore their longstanding concern...
over the cumulative environmental impact of the seven oil storage facilities that line the Chelsea waterway. Our overlapping interests led to an initial workshop with ECO which surfaced a wide range of follow-up research activities described below and led us to continue this work on roughly...

Figure 4. Aesthetically focused demonstration of Thermal Fishing Bobs near the Kendall Cogeneration Station (img: Jorge Valdez).

Figure 5. Three different Thermal Fishing Bob prototypes (img: Laura Perovich).
a weekly basis from May 2017 to October 2017, with occasional meetings later in the year when the cold weather limited outdoor activities. Regular meetings are scheduled to resume in the summer of 2018. Perovich and Wylie conducted all workshops with ECO, with additional support from a Northeastern summer student and GreenRoots staff, and discussed ongoing work with Bongiovanni on roughly a monthly basis.

2.6. Synthesized theoretical framework

The first year of our collaboration is founded in a PAR and transformation design framework suggested by Sangiori, with further influence from environmental justice and citizen science (Sangiorgi, 2011):

1. **Active citizens**

   Participation creates change. “The central condition for transformative practices is the understanding of citizens as ‘agents’ and their active role in the creation of wellbeing” (Sangiorgi, 2011).

   **Project application:** How can the process of design and research create participation and increase community presence on the waterfront in Chelsea? (3.1)

2. **Intervention at community scale**

   Community-level intervention brings more stakeholders to the table and shifts the focus on change from the “user” to the “community.

   **Project application:** How can the process of design and research help create community events and spaces that reach beyond the researchers and GreenRoots to the broader community? (3.5)

3. **Building capacities & research partnerships**

   Entering a participatory design and research partnership requires a shift in organizational structures and mentalities which gives more people a voice and can be transformative in itself.

   **Project application:** How can GreenRoots lead the development of both the research and the design process? How do we create settings that bring ECO’s ideas to the foreground and lead to community driven decision-making processes? (3.2)

4. **Re-distributing power**

   All people are “co-learners” and have ownership of the process, products, and knowledge.

   **Project application:** How can we learn from each other and share knowledge across disciplines in a way that minimizes pre-structured expectations about expertise based on age differences, education, and experiential differences? How can we all be both teachers and learners? (3.2)

5. **Building infrastructures & enabling platforms**

   Instead of specific outcomes, the process creates “platforms made up of tools, roles, and rules [that] delineate the weak conditions for certain practices and behaviors to emerge” (Sangiorgi, 2011).
Project application: How can we use existing citizen science tools and develop new community-specific civic science tools to further the aims of our research collaboration? (3.3)

(6) Enhancing imagination & hope

“Part of the process of change is the capacity to imagine a possible and better future” (Sangiorgi, 2011). This imagining relies on (4) redistributing power and (5) building infrastructure & enabling platforms to be effective.

Project application: How can we design ways for GreenRoots to project their ideas and presence onto Chelsea’s industrial waterway? (3.4)

(6) Evaluating success & impact

“Design literature is generally characterized by a highly positive rhetoric on the role and impact of design in society, while a more critical approach is becoming increasingly necessary” (Sangiorgi, 2011). Project evaluation is critical in transformation design, as the potential to do harm or good is often much higher than in traditional design practices.

Project application: How can we iteratively and collectively evaluate our work to understand both its direct material impacts as well as changes in social attitudes and processes? (3.5)

3. Summer workshops 2017

These seven principles of transformation design and PAR suggested by Sangiori inform our slow, iterative, and open-ended design process. In our first year, we explored different ways to investigate the physical, social, and research space, from developing citizen science tools to designing interventions that reframe environmental justice issues. This paper brings together the theoretical considerations and practical context of our collaboration through describing a few of our workshop sessions. We hope it will serve as a practical on-the-ground perspective on how highly interdisciplinary work influenced by PAR might create outcomes and processes even more transformative than originally imagined by transformation design.

3.1. Principle (1) active citizens: Pokémon Go

Active citizenship is a foundational piece of transformation design theory. It focuses on people’s ability to create value, not just consume it, and provides a foundation for the collaboration.

In practice, we found that brainstorming sessions could be a useful mechanism for thinking broadly about how to pursue our shared aims and unearthing projects that center on ECO’s interests and ability to enact change in the community. Some of these projects were particularly outside our knowledge and comfort zone which made it natural for ECO to take the lead in developing and implementing them. One idea from our brainstorming is discussed below; other resulting projects that we are implementing on a longer scale are included as future work in Section 4.2.

3.1.1. Activity

Our brainstorming process was based on the team idea mapping method which focuses on inclusion of all ideas and increased collaboration and participation (Joseph & Arockiamary, 2014). It included an open-ended prompt, individual brainstorming using post-it notes, group sharing and sorting of ideas, and documentation of additional ideas that emerged in the process. We often followed up with small group iteration on a few ideas.

One brainstorming session explored hands-on, aesthetic, or real-world-based ways to engage people with information about the oil storage facilities violating their water pollution permits (US EPA, 2015). Though this data is available online, it is difficult to find and interpret. We wanted to
develop real-world manifestations of this information that could reach people on a visceral level in spaces they already engaged with. We explored a few examples of data performances and data physicalizations (Evans, 2016; Hunt, 2017) and then moved into brainstorming.

3.1.2. Response

One idea that ECO developed in this session was to use the creatures in Pokémon Go to communicate information about local water quality. Frequent Pokémon Go players, two ECO members proposed asking Niantic to create a pollution-themed Pokémon Go Gym near local oil storage facilities featuring raid battles with new customized toxic monsters, or even with existing monsters that reflect the environmental damage done to the area, like Weezing and Muk. Others speculated that making a PokéStop by a facility would bring community members unfamiliar with the area’s environmental justice issues to the waterfront and could increase use of a short poorly maintained public foot path along the waterfront. Perovich, Wylie, and ECO were excited by the idea but saw no immediate clear way it might be achieved. This conversation led to a number of follow-up sessions that explored racial and economic bias in Pokémon Go (Colley et al., 2017; Juhász & Hochmair, 2017) and ways of using the game to increase awareness of local waterfront access points. After learning about the Emerson Engagement Lab’s Participatory Pokémon Go project (Emmerson Engagement Lab, 2017) from Wylie and Perovich’s participation in Boston’s Civic Media Consortium, we collectively decided to make a video that pitched adding a PokéStop to nearby Port Park. Built on the site of a former oil storage facility, Port Park represents a significant environmental justice victory for the neighborhood. It is the first real greenspace on the river, won as part of a settlement following advocacy efforts of GreenRoots and others to control dust blowing from the uncovered road salt piles into the community (Daniel, 2012). We collectively generated ideas for the video’s footage, composition, and narrative, split into two groups to write the video text and gather the footage, and came back together to edit the video for the contest, which can be viewed in Figure 6 or at https://vimeo.com/230798537.

This video draws out ECO’s role as active citizens in our collaboration and GreenRoots’ agency in the community; it is driven by student ideas and interests and tells the story of GreenRoots’ success in creating community access to the waterfront. The video itself was publicly shared online, providing a space in which ECO is narrating and inscribing their success into the public sphere. This is particularly notable since Chelsea, an environmental justice community, was not available as a location in the contest’s submission dropdown menu even though this competition

Figure 6. Participatory Pokémon Go video (video: ECO, Perovich, Wylie).

See: https://vimeo.com/230798537.
was about addressing inequalities in the distribution of PokéStops. Thanks again to the personal-
academic networks animating our research we were able to contact the organizers who allowed
the submission from Chelsea. The video highlights the presence and power of ECO, of GreenRoots,
and of Chelsea in physical space, digital space, and Boston's Civic Media network.

We were very excited to learn that ECO’s submission was successful and a PokéStop will be
established at Port Park. This success will expand in minor but still significant ways the population
of Chelsea citizens who visit the park, thereby increasing its importance in the community’s civic
life and further building Chelsea residents’ claim on the waterfront as an important healthful
resource, not only an industrial burden.

3.2. Principles (3) building capacities & research partnerships and (4) re-distributing power:
Thermal Fishing Bob
Hands-on projects can be a productive way to build partnerships with new collaborators. Well-
designed multi-faceted projects can immediately draw out the expertise of everyone at the table
which helps to build capacity and begins the re-distribution of power among the team, principles
(3) and (4) of Sangiori’s framework.

On the practical side, we found it useful to choose a project that works for a variety of learning
styles and skill-bases (e.g. artistic, environmental, technical). It is also important that this activity is
seen primarily as a tool for raising questions and building a collaborative team, not as a final
product.

3.2.1. Activity
Our summer workshops began with three sessions on our original Thermal Fishing Bob prototype.
The first workshop focused on the hands-on building and electronics, the second focused on light
painting as expressive photography, and the third was a walking trip to try the Thermal Fishing
Bobs in the local river. These workshops were based on previous workshops with Northeastern
students (Wylie, 2014b, 2014a). We discussed all aspects (technical, artistic, local) at each of the
workshops in order to give a full picture of the project.

3.2.2. Response
The students all successfully built Thermal Fishing Bobs. They had a variety of comfort with and
enthusiasm for electronics, but were able to work with each other to make it an enjoyable activity.
The students created the Thermal Fishing Bobs with greater ease and speed at later workshops,
demonstrating an increased community capacity that Sangiori cites as a central principle of
transformation design.

The students were very engaged in testing long exposure photography apps on their phones and
using different combinations of Arduinos and LEDs to create their own images. Many students
used the dark bathroom to create images and encountered interesting light artifacts from the
bathroom mirror, as seen in Figure 7. They were intrigued by the possibilities for dance-related
light painting and light “graffiti” in public spaces and these ideas expanded our understanding of
their visions for the public spaces in Chelsea.

In order to try the prototype bobs in the water, we needed to know how and where we could
access the river. As increased water access is one of GreenRoots’ goals, it is perhaps not surprising
that this proved challenging. Fortunately, following Sangiori’s PAR-based model where all partici-
pants are teachers and power is distributed, ECO members were able to find access points
including the “lightly” maintained harbor walk next to GreenRoots’ office. Figure 8 shows our
team working at our prototype testing location and demonstrates the centrality of the oil facilities
on the waterfront and the challenges faced by community members trying to access the river. Our
team made an initial claim to the space by conducting environmental science there and our trip
also allowed us to witness the informal ways that Chelsea community members already inhabit

Perovich et al., Cogent Arts & Humanities (2018), 5: 1483874
https://doi.org/10.1080/23311983.2018.1483874
this industrial space, for instance through fishing on the waterfront. This drew out a number of civic questions that could contribute to our collaboration: Are people eating fish caught in the river? How does the industrial infrastructure impact the fish and the anglers’ health? Engaging in the Thermal Fishing Bob investigation underlined the importance of these new environmental health questions and also positioned GreenRoots to begin their own research to answer such questions.

ECO students wrote brief reflections on their experience with the Thermal Fishing Bob and identified areas for design improvement that show their increased capacity and ownership of the tools:
My Thermal Fishing Bob was originally red and pretty soon after it came in contact with the water it turned greenish blue. Next time I would like to try it off the bridge just so the bob would be more in the middle of the water and not next to the shore because usually the water is a lot colder the deeper you are.

There was also a lot of wind so every time I put in the bob, it would always go back to the shore. Another problem was that there were a lot of rocks by the shore and in the water so the wire would get caught on the rocks.

Students observed the visual “data” from the Thermal Fishing Bobs and showed agency by providing ideas for new experiments based on their prior knowledge and their local understanding. They identified design weaknesses in the Thermal Fishing Bobs particular to their local experience of them (wind, rocks) which suggests increased ownership of the tools and points toward new design questions for the team. Our follow-up discussions investigated the local relevance of temperature as a pollution marker and contributed to our decision to begin developing a citizen science tool with a broader water quality sensor platform (e.g. pH, conductivity, turbidity) that might be more relevant to the industrial waterfront in Chelsea.

These workshops built the capacity of researchers Perovich and Wylie through the information exchange and learning central to PAR. We initially approached this project as an opportunity for further development and deployment of the Thermal Fishing Bob, but these early workshops made evident the larger structural problems of the oil storage facilities and the many missing pieces of simple information crucial to using these citizen science tools, including the exact discharge locations for the seven facilities. We realized that citizen science tools such as the Thermal Fishing Bob could be a useful piece of our collaborative process, but in order for them to be effective they needed to be embedded in a systematic critique of the regulatory and social environment that produces and sustains Chelsea’s waterfront as an industrial ecology in which the residents most impacted by its harms are excluded from shaping its future.

3.3. Principle (5) building infrastructure and enabling platforms: pH bob

An ultimate aim of our collaboration is to create sustainable platforms or processes that are maintained by the community and serve as long-term resources for a variety of challenges (Sangiori principle 5). This is closely tied to issues of ownership, agency, and power re-distribution.

On the practical side, new collaborations may benefit from connecting communities to existing platforms where they can become active agents and creative actors. This can help indicate what types of platforms may be useful to the community and what additional spaces should be developed to facilitate long-term community benefit.

3.3.1. Activity

One workshop explored the technical side of a potential hydrogen (pH) probe from the maker community that we could use to test the water quality in the Chelsea River. pH was of particular interest to us as a tool for long-term community monitoring of industry, since our investigation of what the oil storage facilities emitted found that these facilities were violating EPA pH restrictions. We were also interested in increasing ECO’s engagement with the maker community which provides a number of accessible online platforms and kits for basic electronics development and citizen science. This hands-on activity went through the electrical wiring and programming of the pH probe and tested it against standards, so we could later use it to create a pH equivalent of the Thermal Fishing Bob (e.g. mapping pH to LED color for river-based light painting).

3.3.2. Response

Students successfully used online resources to wire and program the probe. They calibrated and tested it using standards (solutions of known pH) and then tried it with three solutions where we
had expected outcomes—vinegar (acid), baking soda water (base), and tap water (roughly neutral).

While most of the outcomes returned as expected, we were surprised to see a pH of over 8.5 from the tap water at GreenRoots. Figure 9 shows a labeled plot created by ECO of the pH readings of various local water samples, including the drinking water, relative to our calibration standards. After re-calibrating the probe, verifying the wiring, and looking for debugging help in the online community, we tested the tap water again with the same result on two separate probes, much to our surprise. This led us into an impromptu research session—is this reading correct? If so, why is the pH of Chelsea tap water so basic?

Our investigation of these questions built fluency with many online platforms, including the City of Chelsea, academic searching, and the Massachusetts Water Resources Authority (MWRA) website. We eventually found that the water treatment plant that serves Chelsea adds sodium carbonate and carbon dioxide to increase the pH and buffering capacity of the water in order to reduce the leaching of lead from old pipes into the water supply (MWRA, 2018). We further discovered from conversations with the EPA that one reason they don’t act on pH violations by the oil storage facilities is because the pH of the incoming water is so high. Our findings led ECO to develop many new questions: Is raising the pH of drinking water to avoid lead contamination a good strategy for protecting public health? Are there any personal, community, or environmental impacts of serving a city with basic water? Our citizen science workshop raised important civic science issues and provided an unexpected opportunity to develop methods for investigating local infrastructure. It also suggested that our team could create future platforms that would allow new research questions and practices to emerge from the specific social and physical community environment.

3.4. Principle (6) enhancing imagination & hope: large-scale projection
Our collaboration is not seeking to do “damaged-based” research that calls attention to the suffering of structurally marginalized communities (Tuck, 2009) but rather research that is future oriented and imagines, projects, and enacts more just environmental relationships (Dillon et al., 2017). Our team often discussed the importance of both reflecting current realities in Chelsea using civic science tools and also creating moments for collectively imagining a new future. This is Sangiori’s sixth principle of transformation design and reflects our view of environmental justice as both a critical and productive process that helps participants become agents in their environment instead of passive victims of inequity by formulating their own research questions, expressing their presence in a place, and claiming the future.

In practice, enhancing imagination and hope may benefit from an artistically inspired approach. In the case of place-based collaborations, the city itself may be considered a “canvas” for
imagination through media such as street art, large-scale projection, and participatory installations. Gathering-in, re-imagining, and re-making a public space, even temporarily, can provide people with an emotionally resonant vision for the future and animate progress on platform building and re-distribution of power (principles 4 and 5).

3.4.1. Activity
One of our brainstorming activities surfaced the idea of using large-scale projection to engage the community with environmental justice and pollution issues in public spaces. This concept responds to the local landscape that contains many large white surfaces from the oil storage facilities and salt piles.

Though we had no prior experience with large-scale projection, we became interested in the potential of this media for artistic, emotional, and imaginative engagement. This session began with an exploration of artistic, political, and commercial large-scale projections and continued into a design prototyping session to develop ideas for what and where we could project imagery in Chelsea to prompt imagination of new futures.

3.4.2. Response
ECO students put together a sketchbook of roughly 10 prototype images, as well as a number of questions to inform iteration and development of prototypes. Many of the images presented literal and hopeful environmental messages, such as trees with new leaves, while a few explored the possibility of a more abstract approach focused on self-reflection, such as modified Rorschach tests. The sketchbook included a range of visual techniques, including pictures and written text, color and black and white images, and detailed and minimalist designs, so we could explore what types of images were best suited to the technical specifications of the projector as well as the social context of the projection. ECO was particularly interested in presenting alternative visions for the environment, such as building a skate park on the waterfront, which was an important reminder not to focus on damage-centered research but rather to think about the importance of projecting alternative possibilities into the present as a radical claim on the future. We also discussed possible interactive projections, for instance could the grim statistics on pollution from these facilities give way to community visions of the future of these sites as participants kicked balls at the projection or moved in a specific way.

After the workshop, we were able to use our academic and arts networks to find a projector, learn about projection mapping and interaction approaches, get legal advice on large-scale projection in public spaces, and connect with artists with experience in political public projections. We plan to continue this project by testing and developing our prototype projections, creating a deployment scheme for the projector, and hosting an event in Chelsea that includes large-scale projection for collectively re-imagining the future.

3.5. Principles (2) intervention at a community scale and (7) evaluating success & impact:
GreenRoots community canoeing & kayaking event
In order to create an impactful community-level intervention, it is important to share the process and products of the team’s day-to-day work with the broader community. This brings a larger portion of the community to the table and connects the team to bigger community initiatives and concerns that can suggest future directions of work. It is also an opportunity to witness early successes and impacts of the project.

On the practical side, community advocates often host or attend a number of community events. Participating in these events can be an accessible way to connect to the larger community, especially early in the collaboration.
3.5.1. Activity

GreenRoots organized and hosted an end of summer canoeing and kayaking event to get the community at-large onto the Chelsea River. Industrial spaces are designed to be inhospitable and accessing them can be experienced as transgressive or legally challenging—for instance GreenRoots notified the Coast Guard about the event and they were present throughout it. This “uneasy” access to the waterfront underscores the double bind our research investigates and shows how humans can be excluded from the waterfront “for their own safety” though pollution from the facilities is actively discharged into the waterway and air and seeps into the neighborhood. Our team had a table at this event inviting people to talk with us and to try some of the tools we worked on over the summer.

3.5.2. Response

During this event, we were able to interact with residents of Chelsea and share some of our team’s work on water quality sensing tools to see what ideas resonated with the broader community. We spoke to city officials and local business owners to learn more about their wishes for the area and opportunities to engage with city programs and reflected on the initial outcomes of our project based on the material and growth frameworks described by Sangiori. ECO put together most of the instructions and electronics for our table, showing their increased capacity and fluency with these tools. ECO also tested a remote controlled boat during the event to assess its suitability as a form factor for our new water quality sensors in the next generation of the Thermal Fishing Bob, as seen in Figure 10. Many Chelsea residents had their first opportunity to use the river for recreation when they went out on the water in kayaks which was a key moment of personal growth.

This event also allowed us to gather local knowledge that we identified a need for in our first workshop (3.2) but had struggled to acquire for months: Where exactly are the outflow pipes that transfer water used by the oil storage facilities into the river? We had not been able to find this information online or by asking EPA officials, but we used the kayaks at the event to visually locate the outflows and document them as shown in Figure 11.

4. Conclusion

In this paper, we describe the first year of our highly interdisciplinary collaboration through the lens of transformation design and PAR, with influences from environmental justice and civic science.
4.1. Successes and challenges

We share our process and preliminary outcomes to mark the collective small successes that are vital to building trust, momentum, and purpose in community centered research collaborations. Our work illustrates how transformative collaborative research can enable new research tools, methods, and theories to emerge—most of these outcomes were not premeditated and would never have crossed our minds as “aims” at the project’s outset. In our first year, our team expanded our ability to question inequitable environmental relationships by:

1. increasing digital and physical access to Chelsea’s waterfront with our successful bid to add a PokéStop on the Chelsea River (3.1)
2. learning from each other to build citizen science tools and to test them by appropriating the waterway as a location for citizen science (3.2)
3. collectively discovering the elevated pH of Chelsea drinking water (3.3)
4. increasing the community’s claim on the present and future of the space through developing large-scale projections for local industrial sites (3.4)
5. taking to this industrial waterway in kayaks to discover a facility’s outflow pipe that we could not find online (3.5)
6. developing a shared research framework based on increasing the community’s physical and imaginative rights to this waterfront

Based on this year of work investigating the oil storage facilities, we successfully applied for a $15,000 grant from the Center for Research on Environmental and Social Stressors in Housing Across the Life Course (CRESSH) to develop a set of data performances about the aggregate permit violations by the oil storage facilities. This includes $7,000 for GreenRoots to help continue to fund the ECO youth program.

Our collaboration also reiterates a number of common systems-based challenges in transformation design. First, few funding sources are available to support a year of ambiguous foundational work—the “fuzzy front end”—which was crucial to our open-ended exploration of the space, partnership building, and knowledge exchange. More funding agencies should add low-level one-year funding for exploratory interdisciplinary work that encourages the evolution of outcomes and metrics throughout the process. Second, collaborators on these projects must be comfortable moving between fields in response to the needs and interests of the community. More academic programs could train students for this type of highly interdisciplinary work that builds bridges from design to other fields.
4.2. Future directions

Based on our early successes and learning opportunities, we are working on a number of related projects in the second year of our collaboration, including:

(1) developing waterfront community performances of historical data on environmental permit violations by local oil storage facilities, based on ideas developed in our team’s brainstorming (3.1)

(2) continued development of water quality sensors to create citizen science tools for in situ water quality visualization suited for industrial waterways like the Chelsea River and planning for a community event around these tools, based on reflections from the Thermal Fishing Bob activity (3.2)

(3) designing workshops with community members, advocates, and environmental officials to understand the potential uses of open environmental data in communities and to develop platforms that increase the legibility, transparency, and usability of these open data systems, based on the need for infrastructure and enabling platforms identified in the pH Bob activity (3.3)

(4) further prototyping of potential large-scale projections, exploration of suitable local sites for projection, and strengthening of partnerships with local artists and legal experts to build toward an event for community re-imagination of the waterfront, based on our team’s projection brainstorming activities (3.4)

(5) participating in community events and industry meetings, and seeking input from local and national agencies to better understand systems that connect the community and local opportunities for change, based on conversations at GreenRoots’ kayaking event and ongoing discussion within the team (3.5)

Illustrating the learning cycle characteristic of PAR research, our project evolved from a narrow focus on using the Thermal Fishing Bob tool to understand the cumulative impact of oil storage facilities in Chelsea, to broader questions about the structures that sustain these inequitable systems. Our collaboration became a learning opportunity for all participants (Hammond et al., 2005): ECO students increased their familiarity with coding, electronics and citizen science, Wylie and Perovich increased their understanding of Chelsea’s role bearing burdens for the broader community of Boston, and GreenRoots gained a richer understanding of local water pollution and regulatory systems. Our growth as a collaborative team was evident in our success in rapidly creating a video for an unexpected opportunity to seek the PokéStop on the waterfront that ECO had proposed earlier in the summer. Despite a tight deadline, we were able to create a video that everyone contributed to and was proud of, demonstrating increased mutual trust and understanding across the team.

While it seems a small step, this video achieved all of the aims we learned to articulate through the process of our summer’s work and provided a foundation for our continued investigation: (1) ECO wrote and told their own narrative to an online audience otherwise unfamiliar with their experiences, (2) it was a narrative about their victory pushing for more greenspace rather than their “victimhood,” (3) it further contributed to building public access to the Chelsea River, and (4) it expanded the bounds of Emerson’s Participatory Pokémon Go challenge itself as Chelsea residents were not formally invited to participate in the project which despite aiming to target overlooked communities had been limited to Boston proper. All those things would have been true whether or not the pitch was successful, that it was successful demonstrated that ideas imagined and proposed by ECO to improve their environment could be realized, which is the best learning and early project outcome we could all hope for.

Over the past few decades, design has started to take on large social justice issues like industrial pollution and climate change. We hope our reflections on our first year of collaboration will provide
both a theoretical and on-the-ground transformation design framework based in PAR that helps others join us in slowly addressing these complex problems that impact us all.

**Abbreviations**

| Abbreviation | Description |
|--------------|-------------|
| CRESSH       | Center for Research on Environmental and Social Stressors in Housing Across the Life Course |
| DPA          | Designated Port Area |
| ECO          | Environmental Chelsea Organizers |
| EPA          | Environmental Protection Agency |
| LED          | Light-emitting diode |
| MA           | Massachusetts |
| MIT          | Massachusetts Institute of Technology |
| MWRA         | Massachusetts Water Resources Authority |
| PAR          | Participatory action research |
| pH           | Potential hydrogen |
| UK           | United Kingdom |
| US           | United States |

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**Author details**

Laura J. Perovich
E-mail: perovich@media.mit.edu
Sara Wylie
E-mail: s.wylie@neu.edu
Roseann Bongiovanni
E-mail: roseannb@greenrootschelsea.org

1 Media Arts and Sciences, MIT Media Lab, Massachusetts Institute of Technology, 75 Amherst Street, Cambridge, MA 02142, USA.
2 Social Science Environmental Health Research Institute, Northeastern University, 360 Huntington Avenue, 335INV, Boston, MA 02115, USA.
3 GreenRoots, Inc., 227 Marginal Street, Suite 1, Chelsea, MA 02150, USA.

**Ethics approval**

Study protocols were approved by MIT (protocol #1703887541; Bove) and Northeastern University (protocol #17-07-04; Wylie) Institutional Review Boards. Images related to events at or around GreenRoots are included as part of GreenRoot’s employee agreements and event guidelines. All images are used with permission from the photographer or through open source licenses.

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**Cover Image**

Source: Tracie Van Auken.

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