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Addressing diversity in science communication through citizen social science

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Abstract   This article seeks to address the lack of sociocultural diversity in the field of science communication by broadening conceptions of citizen science to include citizen social science. Developing citizen social science as a concept and set of practices can increase the diversity of publics who engage in science communication endeavors if citizen social science explicitly aims at addressing social justice issues. First, I situate citizen social science within the histories of citizen science and participatory action research to demonstrate how the three approaches are compatible. Next, I outline the tenets of citizen social science as they are informed by citizen science and participatory action research goals. I then use these tenets as criteria to evaluate the extent to which my case study, a community-based research project called *Rustbelt Theater*, counts as a citizen social science project.

Context: what is citizen social science?   This article seeks to address the lack of sociocultural diversity in science communication by exploring what citizen social science (CSS) offers the field. The global COVID-19 pandemic has made the injustices of our social systems painfully clear. The surge in Black Lives Matter protests around the world attests to the inequitable access that Black, Indigenous, People of Color (BIPOC) and other minority groups have to our social institutions. Science is no exception. Minority groups face structural challenges and inequalities when it comes to participating in science, through either informal or formal means [Dawson, 2018; Ottinger, 2010; Ottinger and Cohen, 2012]. The natural (basic and applied) sciences continue to struggle with recruitment and participation of individuals who are not white, heteronormative, able-bodied men. Meanwhile social science fields like sociology and anthropology have been explicitly addressing social justice issues for decades. Science communication needs to catch up [Halpern, 2019; B. Lewenstein, 2019;

Tancoigne, 2019]. Promoting CSS projects can help bring diverse actors into science communication.

Citizen social science is citizen science (CS) that recognizes the investigation of social issues as part of the scientific endeavor. CS, in turn, is a community-based research practice in which scientists collaborate with publics to produce research that advances scientific inquiry and/or addresses a common need [Bonney, Cooper and Ballard, 2016; Buckland-Nicks, Castleden and Conrad, 2016; Haklay, 2013]. In this vein, CSS utilizes a community-based research framework to bring together *social scientists* and publics in order to solve complex social problems [Haklay, 2017; Heiss and Matthes, 2017; Ochu, 2014; Purdam, 2014]. CSS acknowledges that "science" extends beyond the natural sciences. The National Science Foundation recognizes that social sciences like anthropology, sociology, political science, and economics falls under STEM (science, technology, engineering, and mathematics) categories. Science communication literature should reflect all the STEM fields while being open to the more humanistic methods of empirical research found in the social sciences.

CSS embraces the diversity of both scientific disciplines and of human societies. As a BIPOC scholar and activist, I advocate for the further development of CSS practices that draw on traditions from both the natural and social sciences in order to foster democratic scientific pursuits that work towards the well-being of all people, not just those who benefit from the current neoliberal structures of science. Combining CSS with a well-established form of community-based research found in the social sciences called participatory action research (PAR) will help foster the equitable development of CSS. PAR seeks to empower oppressed or subjugated communities by making them equal partners in the production of practical knowledge that communities can utilize for positive social transformation and justice [Reason and Bradbury, 2001].

I begin by situating CSS within the histories of CS and PAR to demonstrate how the three approaches to scientific inquiry are compatible. Next, I outline the tenets of CSS as they are informed by CS and PAR goals. I then use these tenets as criteria to evaluate the extent to which my case study, *Rustbelt Theater*, counts as a CSS project. *Rustbelt Theater* is a PAR environmental justice research project that I co-developed with Save Our Children, an afterschool enrichment program in South Elyria, Ohio, in 2011.[1] I reflect on this case study to highlight the opportunities and challenges of such collaborative social science research, and to demonstrate how PAR projects like *Rustbelt Theater* help us expand our understanding of CS. Including CSS projects such as *Rustbelt Theater* in CS literature will help address the lack of diversity in the field of science communication, both in terms of the kind of science practiced and the groups of people who participate in science communication. I will demonstrate how PAR-inspired CSS projects are taken on by socioeconomically disadvantaged communities seeking justice and positive social transformation.

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[1]I received Institutional Review Board Approval from Oberlin College to conduct this research. IRB approval #S11ESJF-0I.

The development of citizen science in the natural sciences shares striking parallels to the development of participatory action research in the social sciences. Both CS and PAR have diverse histories filled with a plethora of related but subtly different terminologies. CS has been referred to as crowd science, community science, civic science, and participatory science; while PAR's related terms include participatory research, action research, community-based participatory research, and action science.[2] In both the histories of CS and PAR we find this narrative: two main streams with differing goals independently emerge and later converge into the umbrella terms ("citizen science" and "participatory action research") we use today. CS scholars should look beyond such labels to recognize that CS — if expanded to include CSS — is practiced in other fields. In this section I summarize the development of CS and PAR to demonstrate how these parallel histories may share a fruitful future together through CSS.

Development of citizen science

In recent decades, citizen science projects have exploded onto the science communication scene as a radically different approach to how scientists and publics (or non-science experts) interact with one another.[3] CS provides an alternative to the deficit model that drove early scholarly pursuits in science communication and public understanding of science. Under the deficit model, publics lack the scientific knowledge needed to improve their lives and better society; it then becomes the duty of scientists to effectively communicate their science and fill that gap. In the last thirty years, scholars and practitioners have pushed against the deficit model of science communication and public *understanding* of science towards new models of public *engagement* in/of science [Bauer, 2014; Bonney, Ballard et al., 2009; Skarlatidou, Hamilton et al., 2019]. Moreover, CS not only *communicates* science through public engagement, but *does* science [Hoover, 2016]. In CS projects, publics are involved at different points in the scientific process of knowledge production.

From CS's inception in the 1990s, two strands emerged [Eitzel et al., 2017]. One was proposed by Rick Bonney and his colleagues at the Cornell Lab of Ornithology in 1994 [Cooper and Lewenstein, 2016; Krasny and Bonney, 2005]. Historian of science Jeremy Vetter [2016] has traced the centuries-old tradition of scientific fieldwork as conducted by "amateur" or "hobby" naturalists, who contributed to scientific research by collecting specimens and data out in the field. It was not until the professionalization of the scientific disciplines and the institutionalization of scientific methods that "professional" scientists relegated these field practitioners as "amateurs" and "hobbyists" [Cooper and Lewenstein, 2016]. Drawing from ornithology's long tradition of volunteer fieldwork like that described by Vetter, the Cornell Lab initiated several large-scale projects that embraced amateur involvement in science, wherein scientists relied on members of the public to help collect large amounts of data on birds [Krasny and Bonney, 2005]. In its first decade, the Cornell Lab's CS projects had limited public participation. Scientists set and managed the agenda, and recruited publics primarily for data collection, like

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[2]See Hoover [2016] for a case study combining CS and community-based participatory research.
[3]See three special issues on citizen science: B. V. Lewenstein [2016], Skarlatidou, Ponti et al. [2019] and Weitkamp [2016].

crowdsourcing. For some scientists, however, CS was the only feasible way for them to conduct their research [Krasny and Bonney, 2005].

Alan Irwin independently coined the term "citizen science" while teaching at Brunel University in 1995. Yet, stemming from a sustainable development context, his version referred to the democratization of scientific research. In his book *Citizen Science*, Irwin argued that public expertise, generated outside of formal scientific institutions and developed from the experiences of everyday people, was crucial to developing and producing scientific research that addressed important environmental problems. In his vision of CS, members of the public actively work with scientists to answer pressing questions (such as concerning the health of their environments) and obtain results that could be mobilized to create positive change in their communities. By collaborating with publics from the inception of a scientific project to its dissemination, and by giving them a key stake in every step of the processes, scientific research would become democratized.

Cooper and Lewenstein refer to these two camps of CS as contributory or participatory (Cornell Lab) and democratized (Irwin) [Cooper and Lewenstein, 2016]. The divergence of these two forms of CS has resulted in "citizen science" and its related terms meaning different things to different people. As a result, a wide variety of projects have flourished, ranging from scientists crowdsourcing stargazing [Bonney, Phillips et al., 2016] to indigenous communities working with scientists to protect their natural resources from exploitation [Stevens et al., 2014]. Several scholars who follow the development of citizen science recognize that the Cornell Lab's and Irwin's initial ideas about citizen science can be understood along a continuum rather than two different trajectories. Cooper and Lewenstein write:

> "increasingly, practitioners of the 'participatory' citizen science see democratic citizen science as their goal…" [2016].

Haklay [2013] offers a typography of CS that takes into account the full continuum of citizen science, from contributory/participatory to democratic, and organizes them according to non-hierarchical levels of public participation: crowdsourcing (volunteered computing, or publics as sensors, with little cognitive engagement), distributed intelligence (publics collect data and perform some basic interpretation), participatory science (publics help define the question and engage in data collection, but generally leave analysis of results to scientists), and collaborative science (publics participate in every step of the research process, including analysis, publication, or utilization of results to achieve a certain goal).

The type of citizen social science I propose in this article aligns with Haklay's "collaborative science" and Cooper and Lewenstein's "democratized science," in which scientists and publics become partners in each step of the research process — from question development to the dissemination of findings. Moreover, both descriptions of CS include key aspects of participatory action research, such as scientists collaborating with publics to co-produce research. Combining the tenets of CS with PAR will create not only a participatory and democratized science, but a liberating science.

Development of Participatory Action Research (PAR)

PAR is research with the people, by the people, and for the people. Like CS, its diverse history can be traced back to two different interventions in social science research. The first came from the WWII U.S. context, when social psychologist Kurt Lewin and sociologist William Foote Whyte in the 1930s and 40s studied organizational behavior and how the democratic participation of industrial workers in their organization's decision-making processes improved the organization's effectiveness and group cohesion [Adelman, 1993; Whyte, 1990]. Lewin and Whyte grew to recognize that including the workers they studied in the research process, from the original design to the presentation of results, improved the quality of their studies. Lewin called this way of conducting research action research, and Whyte called it participatory research.

Another branch of PAR developed from the popular education and liberation movements of the 1960s and 70s, springing up in developing countries around the world.[4] A frenzy of activism and research led to the convening of practitioners and activists at the first World Symposium on Action Research and Scientific Analysis in Cartagena, Colombia in 1977, launching an international PAR network that remains highly active today. Community development professor Budd L. Hall attributes the first use of the term "participatory action research" to Colombian sociologist Orlando Fals Borda, who coined it as a way to acknowledge and combine the varying terms used at that time [Hall, 2005]. By the 1990s, both the U.S. and international branches of PAR converged. PAR's tenets have since inspired countless community-based research in fields like development sociology, public health, gender and feminist studies, and environmental studies [Graça, Gonçalves and Martins, 2018; Hoover, 2016; London et al., 2018; Tanabe, Pearce and Krause, 2018].

PAR is action science, or science for the common people [Hall, 2005; Reason and Bradbury, 2001]. PAR describes a process of investigation that seeks to challenge the traditional notions and power relations of researcher-as-expert and participant-as-subject-of-study by emphasizing active participation and collaboration, democratic decision-making, critical analysis of pertinent social issues affecting participant communities, and collective ownership of research projects [Gaventa quoted in Brydon-Miller, 1997; Kemmis and McTaggart, 2000].

PAR practitioners seek to not only foster more equitable collaboration between social scientists and the people they engage with to conduct their research, but also to support social justice. They believe that the harnessing of community knowledge is power. By hailing participants' lived experiences as a kind of expert knowledge of their specific social contexts, and by encouraging participants to create new collective knowledge, PAR strives to empower all those involved in the research process to bring about positive social change from the community-level [Maguire quoted in Brydon-Miller, 1997]. In the words of Reason and Bradbury:

> "[Participatory] action research is not about knowledge for its own sake, but knowing in the pursuit of worthwhile purposes — which we may describe as the flourishing of human persons, communities, and the ecologies of which they are part" [2001].

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[4]For a rich account of these movements and their influence on PAR, see Fals Borda [2001].

Participatory action researchers are invested in dismantling the existing systems of oppression [e.g. prison-, medical-, and food-industrial complexes — see Best et al., 2011]. They work alongside communities to combine science and academia with experiential community knowledge, thus catalyzing collective action.

Converging CS and PAR streams

Both collaborative CS and PAR challenge the top-down approach to (social) scientific research. These paradigms seek to disrupt "normal" science and democratize the knowledge production process so that multiple forms of knowledge and expertise are recognized, including those of underrepresented or vulnerable populations seeking to gain access to the tools they need to dismantle injustice [Fals Borda, 2001].

As demonstrated in Table 1, PAR and collaborative CS are highly compatible:

Table 1. Comparison of tenets of PAR and collaborative citizen science [Kemmis and McTaggart, 2000; Reason and Bradbury, 2001].

Tenets	Participatory Action Research	Collaborative Citizen Science
for, by, with communities (participatory and collaborative)	✔	✔
uses multiple knowledge systems	✔	✔
produces living knowledge	✔	✔
reflexive towards theory and practice	✔	✔
action-oriented to produce practical outcomes for communities	✔	✔
democratic	✔	✔
liberating	✔	?

PAR and CS share the same principles except for being "liberating." Due to its roots in Third World liberation movements, the literature on PAR is explicit about its emancipatory goals. By contrast, collaborative CS literature seems to merely imply that liberation from oppressive social systems will follow the democratization of science. Next, I elaborate on the tenets of both PAR and collaborative CS to create a set of criteria for CSS research that more strongly supports liberation.

Citizen social science: integrating citizen science and participatory action research

Several science communication authors have pointed to the compatibility of PAR's tenets and collaborative citizen science aims [Eitzel et al., 2017; Irwin, 1995; Krasny and Bonney, 2005]. For example, Cooper and Lewenstein write, "a larger reason for refining citizen science methods is to increase capacity for research agendas to align with public interests" [2016]. Yet science communication scholars have not yet made explicit connections between PAR, CS, and CSS. Despite the ease in which PAR and CSS fit into the collaborative CS framework, CSS remains a largely untapped avenue for exploration [Schäfer and Kieslinger, 2016]. For instance, of

the 1,144 citizen science projects logged on scistarter.com, the premier spot for CS practitioners to post about their work, only 51 projects are listed under the "social science" category. Kullenberg and Kasperowski [2016] note that in their quantitative analysis of nearly 2,000 publications on CS (or related terms like "crowdsourcing" and "civic science") from 1982–2015, they could not detect "citizen social science". Given the lack of diversity in the field, science communication scholars and practitioners should embrace PAR-inspired CSS efforts, since the projects often involve underserved communities that are tackling complex social problems in their quest for justice and liberation.

CSS practitioners should aim for all seven of the tenets in Table 1 and emulate PAR by explicitly committing to social justice. CSS projects should involve all members of society, not just the underserved, to address social challenges. Yet all members can still support social justice through CSS. By committing to social justice, CSS can better support the needs of underrepresented, underserved, and underprivileged communities by hailing them as research partners, privileging their lived experiences as an important form of expertise necessary for tackling complex social issues like poverty, pollution, discrimination, and wellbeing disparities. Take the case of the Yolngu Indigenous community in Australia [Kemmis, McTaggart and Nixon, 2014]. By engaging in PAR, they were able to transform their local school from one that perpetuated colonialist education models to one that inculcated Yolngu students with Indigenous language, knowledge, and culture. When community partners become CSS research partners, their voices provide new, diverse perspectives. In sum, situating CSS within the PAR framework can help bring more diverse publics into the science communication conversation.

Several researchers have drawn on community-based methodologies from the social sciences to produce projects that I consider CSS projects.[5] While these researchers use different terms other than CSS to describe their work, it is important to recognize that, to borrow from Shakespeare, "a rose by any other name would smell as sweet." Projects can, and should, be understood by different names and labels as they travel between different disciplines so that a wide range of scholars, practitioners, and publics can work in an interdisciplinary fashion. Complex social problems require expertise from all these sectors.

Methods and results: *Rustbelt Theater* case study

In this section I reflect on my collaboration with Save Our Children, which culminated in the PAR project entitled *Rustbelt Theater*: *Children's Environmental Justice Narratives from South Elyria, Ohio*. I demonstrate how looking at *Rustbelt Theater* through a CSS lens helps to broaden conceptions of CS and diversify the science communication field.

Project description

Save Our Children is an afterschool enrichment center for elementary and middle schoolers in South Elyria, Ohio. I first volunteered there as an elementary school-level theater teacher for the 2010 summer program. Then for the 2011

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[5]See Sannazzaro's [2014] work on citizen cartography; Sagarra et al.'s [2016] integration of citizen science in computational social science; and Sullivan and Lloyd's [2006] community-based environmental science.

summer program, the students, staff, and I together embarked on a PAR project that explored the children's understanding of environmental justice issues in Elyria. Environmental justice means the equitable distribution of environmental benefits and risks among communities [Schlosberg, 2009]. I utilize the "ecosocial" understanding of the environment, which includes the social, built, and biophysical/ecological surroundings of South Elyria residents [Bronfenbenner, 1979; Peeters, 2012]. While U.S. environmental justice literature has traditionally focused on the inequitable distribution of polluting facilities and toxins, *Rustbelt Theater* develops the literature by placing emphasis on structural barriers to eco-social benefits [Lester, Allen and Hill, 2000].

In summer 2011 we worked through an eight-week Theater of the Oppressed workshop series that culminated in an original play starring the children. Theater of the Oppressed is a set of community-based theater techniques inspired by the popular education movement in Brazil, and one of the movements that inspired PAR. The goal of Theater of the Oppressed is for participants to dramatically analyze real-life oppressions/obstacles/challenges they face and act out potential solutions to overcome them. Through the Theater of the Oppressed workshops, the children produced and performed an unscripted original play for Save Our Children's 2011 summer showcase.

I collaborated with around 15 third and fourth grade children ages 8–10, mostly African American, Latinx, or mixed race, along with about 5 Save Our Children teachers and staff. After that summer, I combined my field notes, interviews, and audiovisual materials of the workshops, rehearsals, and final performance to transcribe the children's play into a script. The script is embedded in a multi-vocal, multi-perspective ethnography of our two summers of collaboration. The ethnography maintains the performative nature of the research process while drawing out themes related to children's local knowledge and environmental justice. Working from an ecosocial perspective of the environment, environmental justice issues are linked to ecological degradation, community well-being, and social justice [Case, 2017]. These themes, presented in the final play, are the results of this case study: Save Our Children student, teachers, and staff described environmental justice issues in South Elyria as structural barriers that limit access to adequate employment, education, housing, transportation, nutrition, recreation, and health care.

The final play

The final play (that both children and adults, in our frenzy to rehearse, somehow forgot to title) is about three families, each from the past, present, and future of Elyria. Each family has economic troubles. In preparation for the play, the children explained their characters' backstories to me. One student who I call Kenneth explained, "I'm a rich man [from the future]. And there are next-door neighbors who sometimes don't have enough stuff. Sometimes they don't have a car and they come to get stuff and ask for money, and I bought them a car so we can still be friends".[6] Naomi told me her character is a single mother living with six children in the present (2011 at the time); though due to a deficit of class actors, she ended up having only two children in the final version of the play. Gerald's character is from

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[6] All names have been changed.

the past, an escaped slave whose mother died, and who runs away with what is left of his family to start a new life in Elyria. Yet they continue to struggle because the abandoned house they found in the forest is falling apart.

The play opens in present-day Elyria, 2011, when Mother is fired from her job due to poor attendance. Her employers do not know that Mother cannot find regular childcare for her children Ariel and Alexa, which is why she sometimes had to miss work. Single and now jobless, Mother does not know how she will provide for her two daughters. In the next scene, DrakeV6 and his son, Roco, are a wealthy Elyrian family from the future. When Roco refuses to accept his responsibilities as a young adult, his father uses a time machine to travel with him to the past to teach Roco a lesson. Now in the past, they meet the two escaped slave brothers, Harpo and Jeremiah, who have become lumberjacks to save up enough money to move out of their dilapidated home. Harpo does not want to be in this dangerous line of work, and wishes he had some other way to support himself and Jeremiah. After the families introduce themselves, Jeremiah fiddles with the time machine, accidentally sending them all to Mother's house in 2011, present-day Elyria. The three families meet and decide to pool together their resources to solve each other's problems. Harpo babysits for Mother until she finds a new job. He saves enough money babysitting to buy him and his brother a new house. Meanwhile, Roco, who also babysits for Mother, learns to be responsible by caring for Ariel and Alexa. Having solved their problems, the families return to their respective time periods and live happily ever after.

The play's resulting themes of job insecurity, poverty, and oppression may have been fictitiously portrayed, but they speak to the realities of South Elyria. Children can read and interpret their environment, and it is reflected in the stories they tell. During interviews, their teachers and guardians — grown-ups who have lived in the same town for about as long as the children have been alive — corroborated the children's lived and imagined experiences. Both children and adults possess local knowledge about the physical, social, and economic aspects of South Elyria's environment. Such knowledge is crucial to environmental justice research, since the environment serves not just as an indicator but also a cause of inequality. People influence their environment as the environment influences them; the environment affects all aspects of people's lives. Thus, examining an array of community issues from an environmental justice lens can help connect seemingly disparate issues while building social capital, coalitions, and solidarity. Eradicating the structural inequalities found in one's environment — that permeate through all aspects of one's life — requires a collaborative effort, just like the effort the three Elyrian families made in the play's finale.

Discussion: evaluation of *Rustbelt Theater* as a citizen social science project

Here I evaluate *Rustbelt Theater* as a CSS project, using the 7 tenets of CSS as criteria points.

Table 2 shows the evaluation results. Rustbelt Theater met 4 out of 7 CSS criteria:

Table 2. Evaluation results of *Rustbelt Theater* project based on CSS criteria.

Citizen Social Science Criteria	Rustbelt Theater
1. for, by, with communities (participatory and collaborative)	✔
2. uses multiple knowledge systems	✔
3. produces living knowledge	✔
4. reflexive towards theory and practice	✔
5. action-oriented to produce practical outcomes for communities	?
6. democratic	?
7. liberating	?

I combined qualitative content analysis of the ethnography with my own anecdotal evidence to determine if the project met the criteria, detailed below:

1. CSS for, by, with communities (participatory and collaborative)

The idea for our research came from a mix of Save Our Children organizational need, student desires, and a shared interest addressing community issues. I began working with Save Our Children after I learned that the organization was looking for volunteers to teach art classes and that the students were interested in theater. Having been involved in theater productions for over 10 years, I volunteered to teach. On my first day volunteering, Save Our Children's program director — I call her Ms. Vincent — a South Elyria resident herself, briefed me on the predominantly African American, working-class community I would be partnering with. She spoke of the decline in economic prosperity as more jobs and families migrated away from the area, the increase in street violence and crime, issues with food security, and the concentration of heavy industry that has waxed and waned in the region. Coming from an environmental studies background, the obstacles facing South Elyria struck me as issues of environmental justice. I kept this thought in the back of my mind as I spent the summer of 2010 teaching theater at Save Our Children once a week to a mixed class of third and fourth graders. Environmental justice was not a theme that summer; I placed emphasis on getting to know my students while showing them an array of theater techniques to see which they enjoyed most. The students were particularly fond of Theater of the Oppressed exercises. During this time, I built rapport with the two homeroom teachers for the class, Ms. Monica and Ms. Candace, and with other Save Our Children teachers and staff. I learned more about the daily workings of Save Our Children and the challenges facing the neighborhood. Together we spent the summer building the foundation for our research partnership.

Before the start of *Rustbelt Theater*, I was a Mellon Mays Undergraduate Research Fellow at Oberlin College. Mellon supports minority students who seek careers in academia by training them to conduct research early in their professional development. For my Mellon research, I thought about Ms. Vincent's description of South Elyria's needs and Save Our Children's efforts to meet them through educational enrichment; about the children, teachers, and staff at Save Our Children who I had grown close to, and wanted to continue working with; and about my own position as a scholar of color who believed in PAR principles and

wanted to produce meaningful work that was for, by, and with communities. I saw my theater classes as an opportunity to collaborate with residents of South Elyria in a theatrical exploration of community issues. I ran my idea by Ms. Vincent to collaborate on a study of the ways that theater could serve as a tool for exploring community issues. She greenlit the project. I also shared my idea with Ms. Monica and Ms. Candace, whose class I would teach theater to next summer 2011. They informed me that they were planning a summer curriculum called "The Great Outdoors" that centered on outdoor/environmental education and thought that my concern about environmental justice in Elyria dovetailed nicely with their teaching plans.

While I developed the overarching research question for *Rustbelt Theater* — how can the Save Our Children community utilize theater as a tool for exploring issues they encounter in their daily lives — it was greatly informed by my relationship with Save Our Children. I chose theater and performance ethnography as the research method because of the organization's need for arts teachers and the children's desire to learn theater. I made the research question flexible enough so that the theater participant-researchers could identify and work through community issues. While I designed the structure of the 8-week theater workshops, each class component was driven by the students' preferences and conceptual themes; they helped decide what games to play and what topics to explore. The children created the play's characters and plot with minimal guidance from me. (I took notes of character names and relationships, reminded the students of their previous plotline decisions, and encouraged them to develop a rich story filled with details.) I chose to apply an environmental justice analysis to the children's final play because of my own training in environmental studies, and because the concept is broad enough to cover the range of issues that the Save Our Children community identified and explored throughout the workshop series. Part of the research outcome, the student-created-and-performed final play, stands testament to the power that the children wielded through creative license in the research process. Though I wrote up the findings as an ethnography called *Rustbelt Theater*, it represents the voices of the children, teachers, and staff, not just my own. I tried as much as possible to tell the collective story about the Save Our Children community. Finally, for research products, each student, teacher, and staff that participated in the play received a recording of the final performance. I also gave copies of the ethnography and my lesson plans to Ms. Vincent to keep for Save Our Children's institutional records, for future use for classes, or for grant-writing materials. From *Rustbelt Theater's* inception to conclusion, the project was participatory and collaborative.

2–3. CSS uses multiple knowledge systems and produces living knowledge

Rustbelt Theater incorporated the knowledge systems of children and adults; students and teachers; non-profit workers and academics; and locals and visitors to explore Save Our Children and South Elyria community issues. All the project participant-researchers, including me, came into the project with different perspectives, worldviews, and expertise about our lived experiences. Given the diversity of experience, knowledge, and expertise, I paid special attention to power relations so that no one knowledge system dominated. This is important because the project involved both children and adults of socioeconomic minority groups as research partners. Paying attention to power relations does not mean striving for

equal power relationships between children and adults, but it does mean that the adult researchers like me ensured that the children had opportunities to lead when it was appropriate for their developmental level. For example, I structured the 90-minute class session, tracked the time between activities, led the activity prompts, and made sure that the children followed classroom rules while being respectful of each other. The children, in turn, chose their favorite games to play during workshops; had full control of characters and storylines; and when two students wanted to film the activities, I gave them my camera. Through dramatic dialogue, the children interpreted, analyzed, and created new knowledge about their experiences. They then shared it with an audience of their teachers, guardians, and friends. In the *Rustbelt Theater* ethnography, the children's voices brought to bear crucial knowledge about an underserved community.

What kind of critical research did the children produce through theater? Children are not usually considered capable of conducting research, developing critical consciousness, or actively contributing to social science beyond the scope of being research subjects. This skepticism about children's ability as researchers likely stems from the Western dominant ideological claim that empirical, quantitative, and positivist forms of knowledge are the most valid. This claim subjugates other forms of knowledge — such as the experiential, local, emotional, interpretive, hermeneutic, and critical — as well as the knowledge holders. *Rustbelt Theater* gave children the opportunity to collaborate with adults and present, analyze, and produce knowledge about the conditions of South Elyria. This is a valid form of knowledge. Both children and adults possess local knowledge about the physical, social, and economic aspects of South Elyria's environment. *Rustbelt Theater* acknowledges the validity of South Elyrian children's and adults' subjugated knowledge and hopes to serve as an empowering form of social research.

The Save Our Children community's identification of the broad issues effecting South Elyria (including access to affordable housing, childcare services, green spaces, and healthcare) provides the crucial first step to dismantling environmental injustice. By including children's voices in environmental justice discourse, gains can be made towards distributional and procedural justice [McComas, Besley and Black, 2010]. Children are observing, honest, and creative, and their interpretation and presentation of local knowledge as it relates to their environments constitute an underrepresented perspective in environmental justice and science communication literature that deserves acknowledgment.

4. CSS is reflexive towards theory and practice

Throughout the research process, I was acutely aware of the struggles I faced while attempting to uphold all of PAR's principles as the 2011 summer workshops progressed. Working through this struggle was a reflexive process that ultimately reoriented the project towards those PAR principles. Time again I expressed doubt in my field notes about the appropriateness of the research question and research group. After the first day of the project, I wrote, *"I like that the class can be so positive and that they can have so much fun, but I am worried about how deep we can really get [into environmental justice issues] with this age group."* After the second workshop, I wrote, *"While I am having a great time with the kids, I am fairly certain that they are not quite the right age group to be discussing environmental justice problems with."* Was I

forcing the matter upon them? Or perhaps my explanation of environmental justice did not align with their developmental stage. As the summer continued, I realized that I had been unrealistically expecting the students to conform to my worldview, and to be able to identify and articulate their experiences as environmental injustice on a level on par with academic environmental literature. Such articulation would have required that the children not only adopt my perspective, but also develop higher-level cognitive skills not expected in children of that age. It would have required an understanding of the interactions among complex social structures that shape people's lives, of the social inequalities inherent in those structures, and how inequality results in substandard environments for minorities. I had not yet given the children space to express themselves on their own terms.

Given this realization, I gave up on explicitly trying to draw out environmental justice narratives through the Theater of the Oppressed exercises. Instead I broadened the subject matter to family life in Elyria, a topic for which the children had much to share. When it was time for the class to brainstorm ideas for the final play, I asked them to consider family life in Elyria in addition to what they had been learning about their city through the Great Outdoors curriculum led by Ms. Candace and Ms. Monica. The result was a play about three families from three different times in Elyria's history. The children adeptly created family backgrounds and problems. I was impressed by their idea to have a time machine that connects the three families together so that they could help each other with their problems. Their ability to weave together such a rich plot made me realize that even though they still have almost a decade of cognitive development ahead of them, they are keenly aware of their surroundings and have a strong ability to incorporate their observations and experiences into imaginary contexts. And to my surprise, several problems the children generated were indeed tied to environmental justice issues. By letting students act out experiences about family life, which they understood well, instead of notions of the environment that they were less familiar with, the environments that surrounded and influenced their imagined family interactions came out organically.

The third and fourth graders at Save Our Children taught me that children make great researchers if given the chance. I cannot expect children to conduct research in the same way a social scientist does. Collaborating with child researchers requires doing research in a way that is experiential, relatable, imaginative, and fun. The process should allow children to be analysts through play. While this research method may be uncommon, it produces valuable results.

5. CSS is action-oriented to produce practical outcomes for communities

One practical outcome was the play itself. For the students at Save Our Children, implementing an action plan meant sharing their perspectives — through the play — with the adults in their community. This transmission of knowledge from child to adult through storytelling is an ethical appeal for care and community action; it is up to the adults to follow through. I did not, however, follow up with any of the adult residents of South Elyria to see if they took actions to address the issues the children presented in their play once the proverbial curtain fell; I wrote up *Rustbelt Theater* as my honors project in environmental studies, graduated from Oberlin College, and left Ohio. My lack of follow-up after the project's conclusion is a major limitation to my evaluation of the practical outcome of *Rustbelt Theater*.

These are the hardest CSS tenets to evaluate. Because I did not conduct post-project interviews with the participant-researchers, I cannot speak for them. Therefore, I do not know the extent to which the research process felt democratic or liberating to them. What I can say is that I did my best to treat the students, teachers, and staff at Save Our Children as research partners instead of research subjects. I collaborated with them on many aspects of the research design and execution, and used their feedback and suggestions to shape the progression of the workshops. The children took the creative lead. Future CSS research should have evaluation structures in place before, during, and after a project, so that all participant-researchers can reflect on and reorient their efforts towards democratizing the research process. Even harder than evaluating if a project was conducted democratically is determining if it was liberating. Liberation from injustice and oppression cannot occur after one project alone. History shows that it is a long, difficult, and ongoing struggle. Perhaps this last tenet of CSS cannot be measured on a project-level scale; it is nevertheless a crucial tenet to strive for, as it provides hope and inspiration to keep fighting for justice, one project at a time.

Conclusion: challenges and opportunities of citizen social science research

A challenge researchers and practitioners face in community-based research is evaluating the extent to which projects have met the CSS science tenets I have outlined in this article. I have attempted to evaluate *Rustbelt Theater* by translating those tenets into criteria and using content analysis and my own researcher reflections, concluding that *Rustbelt Theater* met 4 of the 7 criteria. Yet a more robust system of evaluation is needed. Some unresolved questions include: How can tenets be best translated into a concrete list of evaluation criteria? What indicators correspond to each criterion? How will those indicators be measured? Equally important concerns relate to who gets to develop the evaluation methods, what types of evaluation methods are considered rigorous enough, and for whom. CSS must strike a balance between being scientifically rigorous while tailored to, and useful for, the community research partners who co-design the project. It is a matter of integrating different knowledge systems — one academic, on the part of the social scientist; and one living, grounded, practical, and liberating, on the part of justice-seeking communities. Every community-based project must perform this balancing act.

Despite the evaluation challenges I faced, this initial evaluation of the PAR case study, *Rustbelt Theater*, as an example of CSS is valuable. Scholars and practitioners interested in CS would benefit from recognizing that CS is practiced in other disciplines under different names, like PAR. Including community-based research conducted in the social sciences will help address the lack of diversity in science communication. CSS projects like *Rustbelt Theater* privilege the voices of children and families that have been deprived of their rights to healthy and safe living environments. The voices of working-class communities of color like South Elyria's are seldom heard in science communication discourse, to the detriment of communities in need of undone science as well as to the scholarly field. Science communication scholars should invest more effort into expanding CSS literature while practitioners should commit to partnering with these kinds of communities to collectively work for equity, justice, and liberation.

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