Citizen Science: The American Experience

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Introduction
The Federal Crowdsourcing and Citizen Science Community of Practice\(^1\) defines citizen science as “the contributions of the public to the advancement of scientific and engineering research and monitoring in ways that may include: identifying research questions, designing and conducting investigations, collecting and analyzing data, developing data applications, developing technologies for science, and solving complex problems”.

Similarly, the European Environment Agency\(^2\) defines citizen science as “public involvement in projects or ongoing programmes of scientific work by which individual volunteers or networks of volunteers, many of whom may have no specific scientific training, perform or manage research-related tasks, such as observation, measurement or computation”.

In both communities, it is understood that citizen science describes public engagement in science discourse, science execution, and policymaking. But why should trained scientists care about this field?

In an age where trust in science, and scientists, is fading, citizen science offers a unique opportunity to increase public awareness of scientific developments and methods. It offers a pathway to provide hands-on Science, Technology, Engineering, and Medicine (STEM) training; outside of the classroom. It offers the opportunity for increased science literacy. It offers a mechanism for creating the next generation of scientists and ensuring that the talent pipeline is healthy. It holds the potential to advance and accelerate scientific discovery, at enhanced spatial and temporal granularity, using a model of co-creation. It offers the promise of increased science diplomacy and advocacy.

The Promise
Though the term “citizen science” was first mentioned in October 1979\(^3\), the first successful engagements surfaced in the 1990s\(^4\),\(^5\),\(^6\). Human curiosity, passion, and a desire to learn and contribute are the main drivers of this field from the perspective of the public\(^5\).

From the perspective of the scientific community, the promise of citizen science lies in the answer to the question “If you had 100,000 people to help you solve the hardest problem in your field, how would you include them?”

Think of the progress that could be made in solving very difficult, very important, multi-disciplinary problems, such as those highlighted in the UN
Imagine the possibilities.

A young scientist could devise and scale experiments that were once thought of as impractical. Scientists could transform observers and enthusiasts in the general public to active study participants and collaborators. The scientific process could be more inclusive and responsive to feedback from the consumers of scientific knowledge.

The first step in this journey is to articulate how to responsibly and ethically include people with no formal knowledge of the scientific method into the ecosystem of science.

The process of conducting a scientific experiment has several well-defined stages (Figure 2). There are many ways to involve the public in scientific research and monitoring. Helping with data collection and facilitating data processing are the two most obvious, popular, and easy to implement methods currently being used. Though, careful thought has to be put into the validation of data (and results) and the appropriate (fair and ethical) compensation and attribution models.

In the United States, three decades of citizen science experiments may provide some insight for others venturing into the space.

Citizen Science Stories

From discovering a new form of Northern Lights to monitoring bushfires, the range and impact of citizen science projects is diverse and varied. In the United States, there are several projects that demonstrate this value.

Crowd Hydrology

Running since 2011, The Crowd Hydrology...
A project (http://www.crowdhydrology.com) acquires measurements of water levels in streams and lakes from all over the United States. These measurements are collected from citizen scientists who are asked “What’s the water height?” and then told to text their observations to the project’s phone number.

This project has grown from covering 8 states in 2015 to 19 states in 2020. This expansion is due to the involvement of citizen science groups.

**The Clean Air Coalition of upstate New York**

In upstate New York, citizen scientists that were monitoring air quality found high levels of benzene - a known carcinogen - in their environment. The residents then reached out to the New York state Department of environmental Conservation (DeC) for help. After an investigation by the DeC that lasted a year, it was confirmed that the benzene levels exceeded the DeC’s health-based annual guidelines. This information spurred enforcement actions by the DeC and the Environmental Protection Agency (EPA).

Tonawanda Coke - a coke manufacturing company - was identified as the bad actor and found guilty in March 2013 of breaking 14 Federal laws under the Clean Air Act and the Resource Conservation and Recovery Act. Since the EPA’s enforcement action, there has been a reported 86% reduction in benzene from the continuous air monitor at Grand Island Boulevard and a 68% reduction at the air monitor on Brookside Terrace. Citizen scientists made all of this possible.

**Community Collaborative Rain, Hail, and Snow Network**

Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS) engages more than 35,000 volunteer observers, in the United States, Canada, Puerto Rico and the U.S. Virgin Islands, to measure precipitation using standardized rain gauges. Each time a rain, hail or snow storm occurs in the area that a volunteer lives in, the volunteers take measurements of precipitation from as many locations as possible. These precipitation reports are then recorded on their Web site at www.cocorahs.org. The data are then displayed and organized for their end users to analyze and apply to daily situations ranging from water resource analysis and severe storm warnings to neighbors comparing how much rain fell in their backyards. Each year, this data is used to produce a Drought Impact report.

**Lessons Learned**

When it comes to collaborating with the public to get useful and usable data collection, Nolan Doesken, from the CoCoRaHs project said it best. You need instrumentation that is accurate and easy to use (low cost helps too). You have to define understandable protocols and relevant use cases. You must have effective training for your citizen scientists. You have to create a system that enables easy and satisfying data entry. You have to ensure that data is quickly accessible to be viewed or shared.

When it comes to the core principles that a scientist has to consider when crafting a citizen science project it boils down to figuring out the framework...
and particulars around data quality (and fitness for use), openness (attribution, compensation, etc.), and meaningful public participation. Ensuring that the public sees the greater good (or meaning) in participating in your project is critical.

In terms of existing barriers to citizen science projects getting off the ground and being broadly successful in the scientific community, the two primary factors are the scientific community itself and the discoverability of projects. Firstly, the scientific community is engaged in a discussion around the pedigree, training and acceptability of non-scientists into the world of science, which is counter-productive, may be a significant deterrent to the public volunteering, and may hinder its own long-term progress. Secondly, if citizens can’t find projects that are of interest and that they are passionate about, then the value and impact of citizen science projects decreases significantly. Websites like SciStarter.com and citizenscience.gov are helping in this regard. However, more needs to be done.

Conclusion
Citizen science is moving from an interesting thought experiment into a legitimate vehicle to move the needle on scientific discovery. In places likes the United States that have several decades worth of work in this space, we can see the potential benefits of this new approach to doing science. As scientists, this paradigm has the potential to open unexpected doors to new insight and discovery; if we are wise enough to get out of our own way.

1 Federal Crowdsourcing and Citizen Science Community of Practice, https://www.citizenscience.gov
2 European Environment Agency Annual Report 2013. ISSN 1561-2120. https://www.eea.europa.eu/publications/eea-annual-report-2013/download
3 James Oberg (11 October 1979). “The Failure of the ‘Science’ of Ufology”. New Scientist. Vol. 84 no. 1176. pp. 102-105.
4 Irwin, Alan (1995). Citizen Science: A Study of People, Expertise and Sustainable Development. Routledge. ISBN 9780415130103.
5 Bonney, Rick; Ballard, Heidi; Jordan, Rebecca; McCallie, Ellen; Phillips, Tina; Shirk, Jennifer; Wilderman, Candie C. (July 2009). Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education (Report). Center for Advancement of Informal Science Education.
6 Cavalier, Darlene; Kennedy, Eric (2016). The Rightful Place of Science: Citizen Science. Tempe, AZ: Consortium for Science, Policy & Outcomes. p. 54. ISBN 9780692694831.
7 University of Helsinki. “Citizen science discovers a new form of the northern lights.” ScienceDaily. ScienceDaily, 29 January 2020. http://www.sciencedaily.com/releases/2020/01200129094120.htm
8 Caroline Tang. “Citizen scientists get snappy to monitor bushfire-ravaged environment”. January 30, 2020. https://phys.org/news/2020-01-citizen-scientists-snappy-bushfire-ravaged-environment.html