

Citizen silence: Missed opportunities in citizen science

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Abstract

Citizen science is personal. Participation is contingent on the citizens' connection to a topic or to interpersonal relationships meaningful to them. But from the peer-reviewed literature, scientists appear to have an acquisitive data-centered relationship with citizens. This has spurred ethical and pragmatic criticisms of extractive relationships with citizen scientists. We suggest five practical steps to shift citizen-science research from extractive to relational, reorienting the research process and providing reciprocal benefits to researchers and citizen scientists. By virtue of their interests and experience within their local environments, citizen scientists have expertise that, if engaged, can improve research methods and product design decisions. To boost the value of scientific outputs to society and participants, citizen-science research teams should rethink how they engage and value volunteers.

Keywords: community science, crowdsourcing, inclusivity, public engagement, societal benefits

Involving the public in research via citizen science, community science, crowdsourcing, and public engagement in science provides data useful to scientists and an experience meaningful to the participants. Throughout this article, the term *citizen* refers to a volunteer community member who provides an observation and does not refer to citizenship status (see Cooper et al. 2021). Citizen scientists' motivations for participation vary, but most report altruism or personal development regarding a topic important to them (Skarlatidou et al. 2019).

In biological projects, community members volunteer their time to observe objects of scientific inquiry (e.g., streams, birds, backyard wildlife, street trees, plants). Access to these data enables research that would otherwise be impossible. The relationship between professional scientist and citizen scientist is largely data centered and acquisitive: "Please give us the data so we can go do science." Citizen scientists supply data but infrequently engage with the outputs of data analysis (Schölvinck et al. 2022). Professional scientists interact with citizen scientists to carefully train them to collect or analyze data but often neglect to include them at the end of the study by sharing how their contributions were used to generate scientific results, models, or decision-making tools (Wehn et al. 2021). Any additional value of working with the public is either omitted or muted by the conventions of scientific products. In many projects, the public is instrumental in the science but is, like a scientific instrument, a silent means to an end.

This one-way relationship is exemplified and affirmed by peer-reviewed publications. Most peer-reviewed articles integrating citizen science data have limited descriptions of citizen scientists' motivations and involvement beyond their role in logging data (e.g., recruitment and training, data validity, reliability). This is particularly true of studies in the Global South, where one review of citizen science projects found no investigations of the partici-

pants' motivations (Walker et al. 2021). This focus on data is reinforced by ardent concerns over data quality. It is true that data drive research, but the value of working with citizen scientists should not be limited to data. There are two problems with this arrangement: one ethical and one pragmatic.

Ethical dilemma of data-centered relationships

In citizen science projects that examine public goods and shared resources—such as water, biodiversity, air quality, open space, or climate—citizen scientists are also stakeholders. Their motivations for participating tend to extend beyond the well-documented pedagogical benefits, such as learning impact, learning outcomes, and improved science literacy, to interest in the data outputs and applications (Skarlatidou et al. 2019). Where citizen scientists have a vested stake in a shared resource, science teams should be obliged to share the outputs of data.

Scholars are increasingly criticizing one-way extractive (Mahajan et al. 2020) relationships between researchers and citizen scientists. Researchers take data but do not always make the effort to close the loop by taking the study results back to their contributors. Scholars question the ethics of this open-loop approach (Rasmussen and Cooper 2019), especially for research involving public funding or shared natural resources where citizen scientists report they participate for altruistic reasons (Church et al. 2019).

Pragmatic dilemma of opportunity costs

Extractive relationships with citizen scientists miss opportunities to learn from communities about how the research is meaningful to them, society, and their local places. Citizen scientists are

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experts of their home locations with valuable and often untapped knowledge about social and ecological systems. Citizen scientists' familiarity with their local environment can yield more accurate data collection (Danielsen et al. 2021). But beyond that, their participation indicates personal reasons worth unveiling that, if known, can better connect the needs of a project (science) with those of the community (society).

There are practical reasons scientists should value this expertise by studying citizen scientists' connections to and desires for the research outputs and then, where appropriate, incorporating that feedback. First, this input contributes to the salience of the science with communities. Scientific products incorporating citizen scientist input can better match the needs of more diverse audiences, such as community groups, natural resource managers, regional decision-makers, civic managers, local nonprofit organizations, and others. In Tanzania, the Philippines, and Greenland, citizen scientists conducting local environmental monitoring proposed management interventions on the basis of their familiarity with the local environment and the behaviors of their community (Danielsen et al. 2021). Second, the act of having conversations that gather input can improve relationships between citizen scientists and professional scientists; this can increase participation rates (Storey et al. 2016). Third, scientists can learn from amateurs' experience of and passion for conducting observations and can learn how to improve their own observational skills (e.g., naturalist field identification). Marine ornithologists in Australia sharpened their field identification skills by listening to their project's citizen scientists (Viola et al. 2022). Finally, regardless of the immediate benefit of engaging citizen scientists as more than data-collection instruments, honoring citizen scientists' desires and knowledge effectuates science's new contract with society—toward science that is meaningful to society. This shift in relationship can improve public trust in science, which is essential for a well-functioning democracy and good governance.

We join calls for demonstrations of ways science teams have improved relationships between those collecting the data and those using it (Turrini et al. 2018). How can engaging citizen scientists' voices improve the process and outputs of science beyond just providing data? Even for projects that classify as *contributory*, where citizen scientists contribute data (see Shirk et al. 2012) and where collaboration and cocreation are not possible or desirable, what can be learned by pursuing opportunities to listen to the citizen scientists' voiced ideas and feedback?

Toward salient citizen science

We propose that citizen science projects can become more meaningful and useful to both professional scientists and citizen scientists by developing research that is important to citizen scientists, by identifying citizen scientists' motivations for participating, by identifying citizen scientists' priorities for the research outputs, by engaging and respecting citizen scientists' expertise and local knowledge, and by iteratively incorporating citizen scientists' insights into the project. Integrating these steps requires teams to develop plans to talk with and listen to citizen scientist participants at specified points throughout the project. These interactions build connections and bring insight. Just as researchers may not intuit the range of uses their outputs may have, their assumptions about participation processes that should be easy or messaging that should be clear may also be off. Getting that input from citizen scientists early on and integrating it into the project can make the process of participation easy and fun, rather than feeling like work.

The aim is mutual aid. Knowledge can become salient when knowledge producers recognize the needs users say are most important and then adjust their research agendas to supply knowledge that provides the identified needs—even if this does not involve cutting-edge work publishable in the most scholarly journals (Matson et al. 2016: 112). People will participate in science projects they find meaningful to them and not overly burdensome to engage in on a continuing basis. In this sense, participation rates then indicate aspects of good design, social salience, and relationship building.

Citizen science projects are relational. The quality of the data improves with reciprocity—when the community gets something meaningful from participating. Citizen scientists choose to volunteer their time because a project is meaningful to them in some way. This is especially so for shared public goods in biological and environmental citizen science projects (Danielsen et al. 2021). Science teams should want to learn what is meaningful to their projects' participants as a matter of common interest, interpersonal connection, and mutual aid. Limited communication between program leaders and citizen scientists reduces opportunities for relationship building and trust development (Shirk et al. 2012). Ongoing communication to share the program's goals, outcomes, and status promotes long-term participation and sustains citizen scientists' commitment over time (Rotman et al. 2014). Seeing their input and suggestions integrated into the participation materials and process, the model inputs, and the outputs increases trust (Tengö et al. 2021). These experiences lay the groundwork for future researchers, as well as building trust in the scientific profession as a whole.

We agree with those heralding citizen science as on the front-line for addressing inequalities provided projects are designed to meet participants' needs and community aspirations while respecting local knowledge (Bonney 2021). Making science more responsive to the interests of society creates a more socially robust and meaningful science, worthy of participation, public funding, and continued public support.

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