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Viewpoint

Is Citizen Science Dead?

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Our world is polarized by social, economic, political, and environmental events. It is impossible to discuss scientific discoveries or recommendations without stirring negative reactions and opposing views—whether during informal interactions at the grocery store or during the review process of high impact journals. As professional scientists, we often experience this in the form of distrust from the public. This is partially due to our failure to communicate our work effectively. It is also because we are driven to nurture this industry of scientific investigation, which requires us to maintain control over research directions and authority. As a result, we commonly push scientific discoveries outward toward the public without engaging them in the generation of new knowledge. This brings into question how citizen science fits into the scientific continuum. At its roots, citizen science allows professional scientists to integrate and engage with nonprofessionals to produce scientific results. It is a grand opportunity to bridge the divide, to foster greater collaboration and build trust between the two—and in science more broadly. To accomplish this, we must evaluate issues of inclusion, bias, exploitation, and practicability that exacerbate inequities and limit implementation of, and participation in, citizen science. Without such action, this motivates the question "Is citizen science dead?"

Lack of inclusivity within citizen science is manifest through nomenclature, recruitment strategies, the mechanisms by which the science is conducted, and even the scientific questions being addressed. The term "citizen science" can be a driver of polarization,[1] separating those who feel included from those who feel excluded. Those who participate in citizen science are often highly educated and affluent and lack representation of the whole population,[2] despite the field being described as "public participation in scientific research"[3] and by other less-divisive terms.[1] Using any term to describe scientific efforts or outcomes that separates professional scientists from nonprofessionals creates an instant chasm between the two, bringing into question the authority of the amateurs. Inclusivity of citizen science is also influenced by project-specific requirements including equipment, access, timing, ability, and participant classification. The scientific questions being addressed can also exclude certain populations from benefit, such as those disproportionately influenced by pollution.[4] Nonetheless, collaborative and cocreated citizen science models, in which scientific professionals and nonprofessionals work together to develop and implement research, serve as examples of successful inclusive approaches.[3] Take the case of thousands of University Extension offices across the United States that exist to extend University knowledge and resources to communities. Extension professionals routinely engage in participatory research and engagement with the general population. Relationships are formed with the community, and those lead to development of pressing research questions, implementation of research, and ultimately solutions to local challenges.

Professionalization of science can lead to bias toward citizen science. For instance, scientists may distrust amateur data collectors, despite often relying heavily upon students with limited training to collect "valid" data for their own research. The issue of quality control in data collection and analysis by citizen scientists[5] and ethical issues, such as the amount of effort a scientist can request of a volunteer,[6] are two of the most-common arguments professional scientists make against using these data to support their research. Data quality concerns expand exponentially for large-scale projects where inconsistent data collection in space and time, variability in training, and personal bias can all influence results; though, this may also be true for professional science that uses data sets from diffuse sources. In reality, professional scientists are experts in quantifying uncertainty. Building on this expertise, we must develop standards for citizen science error analysis and help implement plans that identify possible source of errors. Existing models similar to the EPA's Handbook for Quality Assurance and Documentation[7] may serve as guidance.

Lack of feedback from professionals, and failure to recognize members of the public as valid scientific contributors during decision making[8] and peer review[9] can lead to feelings of exploitation. Further, members of the public may be considered only as tools to achieving data, not as research collaborators. This diminishes the value of their contributions to the knowledge generated. This exploitative nature may lead to high turnover of volunteers and to projects with short half-lives. Although we know closing the citizen-to-professional-science loop can only happen when information is passed bidirectionally, it can be difficult to think beyond citizens as instruments, and it takes a significant time investment to accomplish. A solution is to bring citizen scientists to the table

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at the onset of research and to incorporate their participation throughout the scientific process. Active partnerships are not only a way to close the loop but also to build relationships that can ultimately give citizen scientists equal footing to develop and disseminate information that addresses local needs.

Finally, citizen science is not a one-size-fits-all model and has some practical limitations that differ from traditional scientific research, which requires different knowledge, skills, and actions by professional scientists. Some research questions require costly and/or specialized equipment, which limits participation. Collaborating effectively with community members also requires time. Professional scientists must initially build awareness of opportunities to integrate community engagement into research. Later, time is required to recruit, train, support, and provide feedback to participants. Maybe most importantly, time is required to build relationships to facilitate trust, which can be the tallest barrier to entry for professional scientists.[10] Research trajectories can also diverge, with professional scientists focused on developing peer-reviewed publications over an extended time (though with a longer shelf life), whereas citizen scientists value short-term feedback through presentations or Web sites. This divergence can be attributed to a focus on process not products, which is even problematic within professional science. Acknowledgment that citizen science is imperfect is not a complete solution; we must magnify the opportunities for scientific discovery already evident in the peer-reviewed literature. Research through Zooniverse EyeWire, eBird, the Large Hadron Collider, and CoCoRaHS demonstrate the impact and scalability of these programs.

Without addressing the issues of inclusion, bias, exploitation, and practicability, citizen science may, in fact, die, losing its place in the scientific continuum. Professional scientists can change this course. We must remain cognizant of our mission to improve the human condition while creating an environment of inclusion. We are conditioned to weigh the balance of transformative research and the broader impacts of research, and citizen science is no exception. The value of engaging the public in science not only creates greater trust in science, it provides important observations, analysis, and perspective.[11] Acknowledging the barriers to entry related to inclusion, bias, exploitation, and practicability represents a first step to addressing them. Targeted recruitment can increase diversity of participation.[12] Intentional project design and development of quality assurance plans can reduce bias[13] and address issues of practicability.[11] Programs have overcome the barrier of exploitation by developing strong communities of practice through training, data visualization, and regular communications. At the highest standards, citizen science projects define intended goals, data uses, and data quality objectives. Citizen science is only dead if we as professional scientists let barriers of entry of inclusion, bias, exploitation, and practicability get in our way.

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