

EDITORIAL CONTENT

The Theory and Practice of Citizen Science: Launching a New Journal

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The field of citizen science is growing with breathtaking speed. Thousands of citizen science projects are now under way around the world, engaging millions of individuals in the process of scientific discovery. In the US, citizen science has been featured at the White House and the federal government has launched a website to showcase federally funded citizen science projects (citizenscience.gov). The largest research and innovation funding program in the European Union, Horizon 2020, is investing heavily in citizen science to tackle societal problems. The Australian government has published a vision for citizen science throughout the country (Pecl et al. 2015). Three professional associations supporting citizen science recently have been launched: The Citizen Science Association (CSA; citizenscience.org), the European Citizen Science Association (ECSA; ecsa.citizen-science.net), and the Australian Citizen Science Association (ACSA; citizenscience.org.au/). Some researchers consider citizen science to have emerged as a distinct field of inquiry (e.g., Jordan et al. 2015). Dozens of articles focused on citizen science are appearing every month, some in prestigious journals such as *Science*, *Nature*, and *Bioscience*, and a number of journals across a huge range of disciplines recently have or soon will publish special issues on citizen science, including *Ecology and Society*, *Journal of Science Communication*, *Journal of Microbiology and Biology Education*, *Conservation Biology*, and *Biological Conservation*.

In this exploding citizen science landscape, what is the role of *Citizen Science: Theory and Practice* (CSTP)?

CSTP is an online, open access, interdisciplinary and international journal sponsored by the CSA in cooperation with ECSA and ACSA. As a global venue for scholarly exchange about citizen science, the journal's focus is to explore and better understand citizen science in all its facets – for example, lessons from successes and failures in the development and implementation of citizen science tools and projects; techniques for the communication and visualization of project results and measurement of outcomes; and critical examination of the many ways

that citizen science can yield a range of scientific, educational, and social outcomes.

CSTP takes a broad, inclusive, and evolving view of citizen science. The field celebrated a milestone when “citizen science” appeared in the Oxford English Dictionary in 2014 with the following definition: “The collection and analysis of data relating to the natural world by members of the general public, typically as part of a collaborative project with professional scientists.” However, while this definition is a good starting point, it fails to convey the richness, scope, and value of this expanding field. For example, it leaves out the fact that citizen science embraces projects in which volunteers participate in roles *beyond* data collection and analysis; projects in which individuals work not only in teams but also by themselves, with or without the collaboration of scientists; projects that are human-focused rather than ecologically focused; projects that emphasize issues raised not by scientists but by communities; and certainly more types of participatory science that are yet to be imagined.

The OED definition does describe one important type of citizen science, which allows scientists from a huge variety of disciplines to ask and answer questions they couldn't address in any other way. This includes an uncountable number of projects in which people make and share observations, often across large geographic areas and over long spans of time (Miller-Rushing et al. 2012). It also allows millions of people working online to help process otherwise unmanageable amounts of data in projects that involve activities such as classifying images, transcribing texts, or tagging pictures (Sauermaun and Franzoni 2015).

But citizen science also allows non-professional scientists to ask and answer important scientific questions. Often such questions focus on local or regional issues of environmental justice, public health, or natural resource management, and addressing these issues may include partnerships between community-based organizations and professional scientists who lend technical support (Haklay 2013). Further, some community science efforts that traditionally have been isolated to small-scale tracking of local issues are now becoming networked to tackle widespread issues of social and environmental justice as well as questions about effective conservation practices.

Citizen science also can embrace makers and hackers who are opening new frontiers by designing open hardware and software, sometimes to help communities with

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Members of the Cascades Butterfly citizen science team on Sauk Mountain. Photo by Karlie Roland, NPS, via North Cascades National Park on Flickr (CC BY 2.0).

environmental monitoring, sometimes to assist researchers with exploration (Wylie et al. 2014).

Online, citizen science participation can go beyond data processing, for example, by producing the world's most powerful computing systems via distributed computing networks or by tapping the imagination and creativity of people via citizen science games and puzzles which, for example, help scientists study diseases (Curtis 2015). Online crowdsourcing also includes novel advances in machine-and-human learning to increase the speed of discovery (Kamar et al. 2012).

In sum, through its many configurations of science-society partnerships, citizen science holds the potential for developing new ways to collectively solve big problems and to fundamentally change the relationship between science and society.

Citizen Science: Theory and Practice provides the space to enhance the quality and impact of citizen science efforts by deeply exploring the citizen science concept in all its forms and across disciplines. By examining, critiquing, and sharing findings across a variety of citizen science endeavors, we can dig into the underpinnings and assumptions of citizen science and critically analyze its practice and outcomes. Such explorations can examine methods, approaches, benefits, costs, impacts, and challenges of citizen science and will help us better understand the role that citizen science can play in environmental science, public health, physics, biochemistry, community development, social justice, democracy, and beyond.

The first issue of CSTP provides a glimpse at the range of inquiry that is supporting and advancing the citizen science field. For example, with the rising popularity of citizen science, informing scientists and policy makers of the rigor and quality of citizen science data and the scientific significance of project outcomes has become urgent. Several recent syntheses document the impacts that citizen science has on our understanding of biodiversity (Theobald et al. 2015) and on policy and natural resource management in the U.S. (McKinley et al. 2015). However, the subtleties of the methods and conditions under which projects can ensure quality control and quality assurance while effectively engaging public participants in research remains a key challenge in the field. Three research papers in the first volume of CSTP tackle this issue head on: **Strategies Employed by Citizen Science Programs to Increase the Credibility of Their Data** by Amy Freitag, Ryan Meyer, and Liz Whiteman; **Mapping Life: Quality Assessment of Novice vs. Expert Georeferencers** by Elizabeth R. Ellwood, Henry L. Bart, Jr., Michael H. Doosey, Dean K. Jue, Justin G. Mann, Gil Nelson, Nelson Rios, and Austin R. Mast; and **The Wabash Sampling Blitz: A Study of the Effectiveness of Citizen Science** by Rebecca Logsdon Muenich, Sara Peel, Laura C. Bowling, Megan Heller Haas, Ronald F. Turco, Jane R. Frankenberger, and Indrajeet Chaubey.

Science learning, community empowerment, and adoption of conservation behaviors by participants are frequently cited goals for many citizen science projects.

However, guidelines for effective methods of project design to achieve such outcomes are still being tested, and methods of researching and evaluating the outcomes of citizen science for its participants are still in their infancy. Research in these areas has dramatically increased in recent years, but evidence of impacts on, and effective processes for, authentic engagement with citizen science participants remains sparse (Bonney et al. 2015). Four articles in this volume address these issues. First, a research paper by Eva Lewandowski and Karen S. Oberhauser, **Butterfly Citizen Science Projects Support Conservation Activities Among Their Volunteers**, offers suggestions that project designers can follow to help influence conservation behaviors among project participants. Second, a case study by Candie C. Wilderman and Jinnieth Monismith, **Monitoring Marcellus: A Case Study of a Collaborative Volunteer Monitoring Project to Document the Impact of Unconventional Shale Gas Extraction on Small Streams**, describes the methodology of a project that successfully gathers baseline data to study the impacts of horizontal drilling and hydraulic fracturing for natural gas. Third, a research paper by Miranda Straub, **Giving Citizen Scientists a Chance: A Study of Volunteer-led Scientific Discovery** examines the extent to which participants in one project, Galaxy Zoo, take the step from classifying data to engaging in authentic science inquiry. Fourth, an essay by Rachel Becker-Klein, Karen Peterman, and Cathlyn Stylinksi, **Embedded Assessment as an Essential Method for Understanding Public Engagement in Citizen Science**, examines a potentially powerful method of assessment that can help both in project design and in understanding how project volunteers are influenced by their participation.

Broadening audiences so that the practice of citizen science can engage all members of society will require drawing on diverse knowledges, experiences, perspectives, and problem-solving skills. Issues of equity and power abound in participatory science, ranging from a lack of ethnic, cultural, and linguistic diversity to questions of what constitutes participation, collaboration, or partnerships between scientists and the public. An essay in this issue by Daniela Soleri, Jonathan W. Long, Mónica Ramirez-Andreotta, Rose Eitemiller, and Rajul Pandya takes a deep dive into these concerns. **Finding Pathways to More Equitable and Meaningful Public-Scientist Partnerships** presents a series of recommendations that emerged from a session held at the Citizen Science Association meeting in San Jose, CA, in February, 2015.

Citizen science functions in a variety of disciplines, each of which has its own culture, norms, and expectations related not only to research but also to peer-reviewed publishing. That said, a central tenet of citizen science is opening access to the scientific enterprise, and we hope that CSTP can embody that ideal. Open Science practices are transforming academic publishing in ways that provide access and transparency throughout the scientific workflow. With our publisher, Ubiquity Press, CSTP will explore ways to test, adopt, and provide options for a variety of Open Science practices. CSTP already has adopted open access policies that involve charging fees

to authors rather than readers. CSTP provides authors with the option of double-blind peer review. Currently the journal accepts four types of articles (research articles, review and synthesis articles, case studies, and essays) but will be fluid to include more categories of articles and supplemental materials in response to the needs of the citizen science community of practice. Further, in addition to traditional submissions of completed articles, CSTP will explore new means of sharing knowledge and peer review, including publication using the Registered Reports format, in which authors submit proposed studies before data collection, and pre-publication peer review, in which papers are published and then receive published peer reviews, creating a fully transparent process. We are excited to explore changes in academic publishing and the diversity of norms in the varied disciplines involved in citizen science inquiry. While CSTP has launched with eight papers published as a bundle, in the future papers will be published as soon as they are ready (accepted, typeset, proofed) and later archived into separate volumes with multiple issues.

Looking forward we anticipate articles that help us achieve a better understanding of effective project design and the many different ways in which people and researchers benefit from participating in citizen science. We hope to receive articles on techniques for addressing data quality; technologies to aid citizen science; ethics and legal issues—for example, around ownership of data; community collaborations; and an array of topics for which scholarly approaches will help advance citizen science theory and practice. To address all these topics and more, we look forward to submissions from the wide range of citizen science practitioners, including local citizens and community members; educators and evaluators; professional researchers in the natural, physical, medical, and social sciences; computer and information scientists; science, technology, and society scholars; amateur naturalists; activists; ethicists, and beyond. This inaugural issue marks the beginning of a global conversation that we are honored to help facilitate.

Acknowledgments

The authors thank Jennifer Shirk and Abe Miller-Rushing for numerous discussions and comments that improved the focus and content of this article.

Competing Interests

The authors declare that they have no competing interests.

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How to cite this article: Bonney, R, Cooper, C and Ballard, H 2016 The Theory and Practice of Citizen Science: Launching a New Journal. *Citizen Science: Theory and Practice*, 1(1): 1, pp.1–4, DOI: <http://dx.doi.org/10.5334/cstp.65>

Submitted: 12 May 2016 **Accepted:** 12 May 2016 **Published:** 20 May 2016

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