2
Ten principles of citizen science

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Highlights

- The Ten Principles of Citizen Science were developed by an international community of citizen science practitioners and researchers to set out their shared view of the characteristics that underpin high-quality citizen science. They are currently available in 26 languages.
- The Ten Principles provide a framework against which to assess new and existing citizen science initiatives with the aim of fostering excellence in all aspects of citizen science.
- At a time when citizen science is rapidly expanding but not yet mainstreamed within traditional research or policy processes, the Ten Principles provide governments, decision-makers, researchers and project leaders with a common set of core principles to consider when funding, developing or assessing citizen science projects.

Introduction

Citizen science is a flexible concept that has been adapted and applied within diverse situations and disciplines. The rapid expansion of citizen science programmes globally presents researchers and citizen science practitioners with incredible opportunities as well as a challenge: creating

cohesion and identifying a common purpose globally, whilst also supporting and enhancing the further expansion, independence, creativity and bottom-up nature of citizen science. Networks such as the global Citizen Science Association (CSA), the European Citizen Science Association (ECSA) and the Australian Citizen Science Association (ACSA) provide forums for the exchange of knowledge and ideas, identification of shared goals, networking and developing best practice. In 2015, the ECSA working group on 'Sharing best practice and building capacity for citizen science' developed a document outlining Ten Principles of Citizen Science. Drawing from the collective experiences of many ECSA members, this series of statements set out the key principles which ECSA believes underlies good practice in citizen science, regardless of the academic discipline or cultural context in which it is applied. Used internationally and currently available in 26 languages, the Ten Principles of Citizen Science provide an important starting point for discussion and debate. This chapter introduces the Ten Principles and their development. It gives examples of good practice and explores how the Principles may challenge current working practices to drive excellence in citizen science, maximising the benefits for science, citizen scientists and wider society. Finally, the chapter considers the policy and innovation potential of the Ten Principles in a rapidly expanding and diversifying field.

Developing the Ten Principles of Citizen Science

The ECSA working group on 'Sharing best practice and building capacity for citizen science' is chaired by the Natural History Museum London and its members come from universities, natural history museums and not-for-profit organisations, representing researchers, citizen science practitioners and networking or co-ordination bodies (see also Sforzi et al. in this volume about the role of museums in citizen science). The working group aims to facilitate the exchange of knowledge, experience, innovation and lessons learned in the field of citizen science, both within and beyond the ECSA membership. The group's first task was to develop a series of principles or characteristics that underpin responsible and impactful citizen science projects, with the aims of supporting those new to citizen science to deliver high-quality projects and providing a benchmark against which to examine existing citizen science programmes. These became the Ten Principles of Citizen Science and were designed to be applicable across a broad spectrum of citizen science activities.

Box 2.1. The Ten Principles of Citizen Science

(for other languages see https://ecsa.citizen-science.net/engage-us/10-principles-citizen-science)

1. Citizen science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding.

   Citizens may act as contributors, collaborators or as project leaders and have a meaningful role in the project.
2. Citizen science projects have a genuine science outcome.

   For example, answering a research question or informing conservation action, management decisions or environmental policy.
3. Both the professional scientists and the citizen scientists benefit from taking part.

   Benefits may include the publication of research outputs, learning opportunities, personal enjoyment, social benefits, satisfaction through contributing to scientific evidence, for example, to address local, national and international issues, and through that, the potential to influence policy.
4. Citizen scientists may, if they wish, participate in multiple stages of the scientific process.

   This may include developing the research question, designing the method, gathering and analysing data, and communicating the results.
5. Citizen scientists receive feedback from the project.

   For example, how their data are being used and what the research, policy or societal outcomes are.
6. Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled for.

   However unlike traditional research approaches, citizen science provides opportunity for greater public engagement and democratisation of science.
7. Citizen science project data and metadata are made publicly available and where possible, results are published in an open-access format.

   Data sharing may occur during or after the project, unless there are security or privacy concerns that prevent this.

(continued)

8. Citizen scientists are acknowledged in project results and publications.
9. Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.
10. The leaders of citizen science projects take into consideration legal and ethical issues surrounding copyright, intellectual property, data-sharing agreements, confidentiality, attribution and the environmental impact of any activities.

Developed between 2013 and 2015, the scope and structure of the Ten Principles were initially informed by reference to existing sets of principles from related disciplines (European Commission 2008; Wing 2014). A longlist of potential principles was generated by working group members before being rationalised and distilled to the 10 most universally applicable. These were presented for consultation with ECSA members and the wider citizen science community multiple times over two years at ECSA General Assemblies, via the ECSA website, e-newsletter and a popular blog written by an ECSA Steering Committee member, with iterative feedback and edits throughout this time. This extensive feedback process led to the Principles becoming more universal (relevant to a diversity of disciplines, projects and audiences), actionable (rather than theoretical), inclusive of individual, societal and policy outcomes, and targeted towards citizen science practitioners (rather than citizen scientists or policymakers). The length of each core Principle was shortened but clarification statements were added to each.

The Ten Principles of Citizen Science were published on the ECSA website in September 2015 (see box 2.1). At the time of writing, the Ten Principles of Citizen Science have been translated by ECSA members into 26 languages to make them accessible to non-English speakers, and this continues to expand.

Global impact of the Ten Principles of Citizen Science

No systematic review has yet been conducted to measure the extent of use and impact of the Principles, but ECSA headquarters and the working group are recording known uses to create a bank of case studies. To date,

Fig. 2.1 The Museo di Storia Naturale della Maremma (Natural History Museum of Maremma, Italy) displays the Ten Principles of Citizen Science in their 'Citizen Science Corner' gallery to inspire visitors to participate in local projects. (Source: © Andrea Sforzi)

Box 2.2. Case study: How the Ten Principles of Citizen Science informed a US policy brief

Dr Lea Shanley

The US Federal Community of Practice for Crowdsourcing and Citizen Science (CCS) is a self-organised grassroots group of more than 350 federal employees representing 60 federal organisations. It seeks to expand and improve the US government's use of crowdsourcing, citizen science and public participation techniques to enhance agency missions and to improve scientific and societal outcomes.

In 2015, the CCS leadership worked closely with the White House Office of Science and Technology Policy to help shape a policy memo that would guide and encourage the use of these open science and innovation approaches across the federal government. Drawing from the Ten Principles of Citizen Science, the CCS leadership incorporated three core principles into the text of the memo. The memo (Office of Science and Technology Policy 2015) was released on 30 September 2015 as part of the White House's Forum on Citizen Science (Gustetic, Honey & Shanley 2015), co-organised by the CCS.

The principles detailed in the memo emphasised openness, accessibility, meaningful participation and recognition for contributions to ensure that the use of citizen science and crowdsourcing 'is appropriate and leads to [the] greatest value and impact' (Office of Science and Technology Policy 2015). The White House memo directs agencies to adhere to three principles, summarised as:

- *Data quality*: Data collected are credible, usable and fit for purpose;
- *Openness*: Datasets, code, applications and technologies used are transparent, open and available to the public, consistent with applicable intellectual property, security and privacy protections; and
- *Public participation*: Participation should be fully voluntary, volunteers should be acknowledged for their contributions and should know how their contributions are meaningful to the project and how they, as volunteers, will benefit from participating.

the Ten Principles have been used in a wide variety of settings, including to inform further development of best practice guidelines for citizen science (including League of European Research Universities 2016; see also Wyler & Haklay in this volume), on Wikipedia to set out ethical considerations in citizen science (Wikipedia 2017), in public-facing museum displays about citizen science (figure 2.1) and to inform government policy, as in the case study of a US White House policy memo described in box 2.2.

Implementing the Ten Principles of Citizen Science: Successes and challenges

The Ten Principles of Citizen Science are intended to both support and challenge the citizen science practitioner community. Whilst some Principles are implemented within every citizen science project, others are more challenging to incorporate and require a greater investment of time and resources to fulfil. This section examines each Principle in turn, assessing the extent to which the citizen science community is currently meeting it and identifying where there are opportunities to improve practice. The chapters in this volume explore many of these themes in greater depth.

1. Citizen science projects actively involve citizens in scientific endeavour that creates new knowledge or understanding.

At the heart of all citizen science projects is the involvement of citizens in real scientific endeavour. Whilst this Principle refers to scientific endeavour in particular, there are many 'citizen science' projects focusing on other disciplines including the arts, geography and social history (see www.zooniverse.org/projects for a range of examples; and see also Mahr et al. in this volume). With many thousands of projects active globally (SciStarter [2017] lists over 1,500 projects) this represents millions of citizen scientists (Roy et al. 2012; Theobald et al. 2015). These impressive levels of participation notwithstanding, citizen science initiatives tend to be less successful at engaging communities that are historically underrepresented in science, including (but not limited to) certain minority ethnic groups and people from lower socioeconomic backgrounds (Pandya 2012; West, Pateman & Dyke 2016; West & Pateman 2016; see also Peltola & Arpin; Haklay; both in this volume). Significant opportunities remain to collaborate with a greater diversity of participants that are truly

reflective of wider society and that also bring new and different knowledge (Danielsen et al. in this volume). Guidance on how project leaders may approach this is emerging (Pandya 2012; Ruzic et al. 2016), and new formats can be found to engage in person (Gold & Ochu in this volume) or through digital technologies (e.g., Novak et al. in this volume). The widening participation agenda is not unique to citizen science and is likely to require a range of long-term changes to be successful, including (but not limited to) greater flexibility in the range of opportunities available, for example, time commitment and prior skills required (see Haklay in this volume), new approaches to publicity and recruitment of participants, language translation of project materials and more participatory project development to ensure project activities and community priorities are better aligned (West & Pateman 2016).

2. Citizen science projects have a genuine science outcome.

This is what distinguishes citizen science from pure education and outreach programmes. Citizen science projects – while also serving learning goals (see e.g., Edwards et al.; Harlin et al.; Makuch & Aczel, all in this volume) – are increasingly resulting in research publications in a wide range of discipline-specific journals, with the number of peer-reviewed publications growing rapidly year on year (Follett & Strezov 2015). Science outcomes delivered by citizen science may also include the development of scientific specimen collections, for example for natural history museums (Sforzi et al. in this volume), tracking progress towards global biodiversity targets (Chandler et al. 2017), implementing changes to science policy and achieving conservation outcomes (see Ballard et al. 2017 for examples). However, there are still some projects that do not use the data collected for scientific purposes, thereby failing to realise the scientific benefits of the project. For example, biological records collected at 15 per cent of the BioBlitz events surveyed in the UK were not passed on to recommended data repositories (Postles & Bartlett 2014). This may be due to lack of staff or financial resources to publish the findings and attain other scientific outputs, uncertainty over the quality of the data, or poor study design resulting in data unsuited to the scientific need. A strong motivation to harness the public engagement benefits of citizen science can also lead to scientific rigour being compromised (see Lakeman-Fraser et al. 2016 for a discussion of this trade-off). However, achieving and maximising science outcomes from citizen science projects is a cornerstone of this field and an essential element in maintaining trust with the citizens that participate.

3. Both the professional scientists and the citizen scientists benefit from taking part.

To be sustainable, citizen science must be mutually beneficial for all parties involved. Benefits may be wide ranging, including scientific outcomes (Shirk & Bonney in this volume), social interaction, improved well-being, career development, learning and empowerment (e.g., Bela et al. 2016; Haklay in this volume; Edwards et al. in this volume). Whilst a limited number of resources exist to support the measurement and identification of these benefits (Phillips et al. 2014; Blaney et al. 2016), a broad evidence base of the benefits of participating in citizen science for all parties is lacking. Literature examining the impacts of citizen science has focused attention on the scientific or educational impacts (see Silva et al. 2016). In order for all parties to benefit, parity or overlap in their expectations and motivations for participating is required. West and Pateman (2016) provide a review and guidance on identifying and meeting citizen scientists' motivations, and Geoghegan et al. (2016) examine the motivations of participants and other stakeholders (see also Richter et al. in this volume). These reviews indicate that the numerous motivations for participating should be considered throughout the project lifecycle; ultimately, long-term project success depends on all stakeholders reaping the benefits. Researchers from other disciplines, including those from the social sciences (see also Mahr et al. in this volume), are encouraged to collaborate with citizen science programme leaders to gather more evidence on the benefits a citizen science approach offers for all involved.

4. Citizen scientists may, if they wish, participate in multiple stages of the scientific process.

The dominant method for engaging the public in scientific research is the 'contributory' method, where the public solely collect and submit data to research projects. However, the citizen science community recognises that a multitude of benefits is likely if the public is more deeply involved in scientific research, through 'collaborative' and 'co-created' methods (for an example of the latter, see Collins 2016; see also Novak et al. in this volume). Involving participants in more stages of the research process can foster a greater sense of ownership for the participants, and benefit the research by incorporating local knowledge and expertise (Corburn 2007). However, little is published on the practice and impacts of collaborative and co-created citizen science, and additional research and sharing of evaluations in this area would be welcome. Some pressing questions

include: What do the different citizen science approaches (contributory, collaborative and co-created) achieve for science and for citizens? How can collaborative or co-created projects be run at a large scale whilst maintaining a close personal connection between the scientists and participants? And how can citizens be actively supported to participate in aspects of the scientific process beyond data collection and processing?

5. Citizen scientists receive feedback from the project.

There are many ways of giving feedback to volunteers, for example via social media, websites, maps, e-newsletters, celebratory events, blogs and meet-ups. Good feedback brings many benefits. It shares the outcomes of the science, justifies why people spent their time on the project, encourages repeat participation (Segal et al. 2015), explains the science research in more detail, and creates a personal connection between the citizen scientists and the project/research team (Rotman et al. 2012). It is also a way of showing participants that their contribution is recognised; an important feature for many (Rotman et al. 2012). There is evidence that feedback is a motivator for more participation (Singh et al. 2014), and there is great potential for project leaders to both speed up and improve the quality of their feedback, for example, by making it more personalised. Tools such as Natural Language Generation are being developed to automate the process of giving instant, personalised feedback (see, for example, Wal et al. 2016), helping project leaders to better manage large-scale communication with participants.

6. Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled for.

Citizen-collected data are still sometimes criticised for being of lower accuracy, biased or of uncertain quality, which limits their use for many scientific purposes (see Williams et al. in this volume). However, in many cases, citizens gather data that are of equal quality to professionally collected data (Lewandowski & Specht 2015; Kosmala et al. 2016) and all data, including those collected by professional scientists, have an error rate or some degree of variation between observers. Citizen science project leaders have a responsibility to control, measure and report data quality and quality assurance procedures, to demonstrate the validity and reliability of the data (for discussion, see Williams et al. in this volume). Innovations in technology can support data validation and verifica-

tion in environmental monitoring, for example Mazumdar et al., Volten et al., Schroer et al., all in this volume. A citizen science approach, however, will not be appropriate for all research questions and the 'Choosing and Using Citizen Science' guide supports researchers in making this assessment (Pocock et al. 2014b).

7. Citizen science project data and metadata are made publicly available and where possible, results are published in an open-access format.

Citizen science is an example of open science – a movement within the academia to make science research, data and outputs accessible to all. Whilst the principles of open science are welcomed within the citizen science community (both CSA and ECSA have working groups on open data; see Smallman et al. in this volume), in practice there is still a long way to go. This situation is not unique to the field of citizen science but is found across the sciences where time, resources, infrastructure and incentives are not always available to support open-data sharing (Tenopir et al. 2011). There have been many successes in the global sharing of citizen science data (for example Chandler et al. 2017) but still too few citizen science projects give participants direct access to the resulting dataset, and few project websites clearly describe if/how data will be shared with national and international databases. Cleaning, formatting and archiving data requires resources and infrastructure, and this vital step must be planned into project timescales and funding at the outset. The time lag between data collection and the publishing of results in academic journals remains a challenge for citizen science projects where participants may have to wait several years to see the 'final results' of the project. Researchers may also have to navigate data embargoes, a lack of institutional repositories for datasets and open-access publishing fees (Tenopir et al. 2011). However, new technologies and increased availability of repositories for data and publications are making this process ever easier, and the opportunities afforded by opening up citizen science data are significant. There may also be a role for citizen science, and citizen scientists, in the wider sharing of project outputs and findings within and beyond the research community using non-traditional approaches. This could include non-science outlets such as local newspapers, NGO/association newsletters, special interest journals (e.g., gardening/angling magazines) or online communication and visualisation through story telling (Hecker et al. 'Stories' in this volume).

8. Citizen scientists are acknowledged in project results and publications.

The contributions of citizen scientists are usually recognised throughout the lifetime of a project via project communications, the awarding of badges or certificates, events and many other routes. However, this does not always carry through to more academic project outputs. Acknowledging citizen scientists in project publications and other academic outputs is relatively easy to achieve but often overlooked. The volunteer hours donated to any given project are significant and should be celebrated! Appropriate levels of acknowledgement will vary by project and participant role, but – as a minimum – a generic thank you statement covering all volunteers should be included in publications and presentations wherever possible. Acknowledging large numbers of participants individually has been known, for example Lee et al. (2014) included 37,000 co-authors in their published paper on the EteRNA project, and whilst this is a rather extreme example, acknowledging individual participants may be appropriate where they have given significant input to a project (although data protection and ethical issues should be considered when disseminating personal information of participants). Data papers listing all contributors can also be published in data journals (e.g., http://www.forschungsdaten.org/index.php/Data_Journals), which can be cited in subsequent analyses and publications.

9. Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.

Project evaluation is typically under-resourced, and as a result, some outcomes of citizen science projects are not fully identified, measured or reported (Ballard et al. 2017), despite potentially significant scientific, societal, policy, community and individual outcomes. Time constraints, a lack of established evaluation criteria (but see Kieslinger et al. in this volume) and a lack of understanding and confidence in how to conduct evaluation may prevent practitioners from collecting evidence of their successes and failures (for an example of this within environmental education, see West 2014). Training in evaluation methods and prioritisation of evaluation as part of the project delivery process would assist in collecting this evidence, as would greater interdisciplinary collaborations with academics in the social sciences and education fields to study the wider impacts and outcomes of participation in citizen science (see Mahr et al. in this volume). Research focused on the learning outcomes of citizen science is growing

and some supporting resources for project leaders already exist, including practitioner guides (e.g., Phillips et al. 2014) and academic literature, in particular the new journal *Citizen Science: Theory and Practice* (Bonney, Cooper & Ballard 2016), which provides a route for project leaders to share tools and strategies for evaluation and learning research. Societal and policy impacts are equally as important as research and education outcomes, as citizen science projects can provide substantial input to policy formulation and implementation (Nascimento et al.; Owen & Parker, both this volume). Evaluation needs to consider this adequately even though such indirect impacts may at times be hard to assess. The citizen science community should therefore be encouraged to prioritise evaluation, including sharing details of less successful ventures, because the field cannot advance rapidly and effectively without self-reflection.

10. The leaders of citizen science projects take into consideration legal and ethical issues surrounding copyright, intellectual property, data-sharing agreements, confidentiality, attribution and the environmental impact of any activities.

Involving volunteers in any activity requires careful consideration for their health and well-being, their rights as individuals and an awareness of the power balance between volunteers and other parties involved in any given project. Resnik, Elliott and Miller (2015) provide a useful framework for addressing ethical issues in citizen science, and the CSA supports a working group on ethics. Many citizen science projects involve online activity, in which participants register for an online account, submit personal details about themselves, upload and share images and other content to which they hold the intellectual property, and collaborate with others. The gathering, processing and sharing of these types of data must be approached sensitively and with an understanding of the legal and ethical implications (see also Williams et al. in this volume). This may be a particularly sensitive issue in projects that deal with medical data (see Hoffman 2014 for an analysis of the benefits and risks). Scassa and Chung (2015b) provide a useful guide for considering intellectual property rights in citizen science projects and Bowser and Wiggins (2015) address privacy issues.

Conclusion

At a time when citizen science is rapidly expanding but not yet mainstreamed within traditional research or policy processes, the Ten Principles

provide governments, decision-makers, researchers and project leaders with a common set of core principles to consider when funding, developing, implementing or assessing citizen science projects/programmes. Imposition of a top-down set of standards for citizen science would be incongruent with its naturally bottom-up, flexible nature, but the Ten Principles may nonetheless serve the same aim of promoting excellence in science research, environmental protection, and public engagement and active involvement in the scientific and policy processes. Strategic national and international developments (see box 2.2 and Richter et al. in this volume) may provide examples and lead to action plans of how policymakers could make practical use of the Principles to drive widespread support for this approach.

Reviewing the Ten Principles of Citizen Science has highlighted the enormous amount of excellent work currently underway in this sector. The appetite for sharing good practice and learning lessons from others to maximise the benefits for science, policy, society and the individuals involved is inspiring. Widening participation, maximising and reporting data quality, and ensuring data and publications are made available in open-access formats remains challenging for this field. Innovative, non-traditional approaches will be required to move beyond the current state of the art. Later chapters of this book share some of these innovations and it is hoped that the reader finds these, together with the Ten Principles, inspiring and instructive.

In a rapidly moving field, best practice, too, will evolve and develop, and in time an 11th or 12th principle may be added to this current suite. In particular, developments in the fields of ethics, technologies and open data will strongly influence views of 'best' practice in coming years. Such innovations and advances in the field of citizen science, and the new challenges and opportunities they present, are to be welcomed.

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