Chapter 1
Editorial: The Science of Citizen Science Evolves

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What Is Citizen Science?

Citizen science broadly refers to the active engagement of the general public in scientific research tasks. Citizen science is a growing practice in which scientists and citizens collaborate to produce new knowledge for science and society. Although

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citizen science has been around for centuries, the term citizen science was coined in the 1990s and has gained popularity since then. Recognition of citizen science is growing in the fields of science, policy, and education and in wider society. It is establishing itself as a field of research and a field of practice, increasing the need for overarching insights, standards, vocabulary, and guidelines.

In the process reflecting citizen science and its practices, many questions arise. How old is citizen science? What is the difference, if any, between citizen science, participatory science, post-normal science, civic science, and crowd science? Is citizen science just a new political term in order to obtain funding? Some critics view citizen science as a renewed neoliberal approach to exploit citizens by making them work for free when data is a key asset of our century. These questions may not be fully answerable, but they surely deserve considered debate. These questions are a prime example of the need to maintain a lively discourse around citizen science, with as many practitioners as possible, and then bring together in a single book all these perspectives. Therefore, the present volume aims to offer to those who are new to the field of citizen science an overview of the different aspects of citizen science and the current developments and discussions in the field. The large number of chapters is an illustration of how diverse the citizen science world is and how many different aspects need to be considered when delving into the field.

This book attempts to handle in a holistic manner all dimensions of citizen science, starting with a detailed understanding of the concepts, of science, research, and knowledge. The ambition of this book is to provide a complete picture of citizen science, including the always important ethical aspects, as well as its controversial links with commercialisation and social outcomes as well as the application of different definitions as outlined by Haklay et al. in chapter 2. Cultural differences are also at stake, as seen in the Europe-wide understanding of citizen science, described by Vohland et al. in chapter 3.

The European Citizen Science Association (ECSA) has characterised citizen science (Haklay et al. 2020) based on the *ECSA 10 Principles of Citizen Science* for good practice (Robinson et al. 2018). This work provided the reference to build the different chapters in this book, addressing questions of power relations, data ownership, and political impact. The book aims to contribute to the good practice of citizen science in order to develop citizen science as an acknowledged and broadly practiced approach in universities, other research institutes, and civil society organisations. The scientific and epistemological benefits of citizen science for different disciplines are also addressed and critically reflected upon, mainly in the first part of the book. The second part of the book focuses on the societal impact of citizen science, with regard to policy, learning, and triggering (social) innovation. The tools and instruments that are appropriate to support and mainstream citizen science are elaborated in the third part of the book.

The Emergence of the COST Action Research Network

The present volume largely incorporates the research network of the COST (Cooperation in Science and Technology) Action CA15212 *Citizen Science to Promote Creativity, Scientific Literacy, and Innovation throughout Europe* and includes additional authors in order to provide a complete and coherent scholarly book on citizen science.

A European Union (EU)[1] programme, COST includes tools for networking to improve scientific excellence and scientific integration in Europe. It started in 1971 and has supported the development of the European Research Era (ERA) in two key areas: (1) scientific excellence and innovative power and (2) inclusiveness. COST has 38 member countries, and Israel is a cooperating partner (Fig. 1.1).

The main tool in COST are Actions, which are networks that are supported by funding for travel costs for workshops and training schools, and also scientific exchanges which are called Short Term Scientific Missions (STSM). The member countries nominate the members of each Management Committee (MC) – the key decision-making body of each Action. The vision of COST is to support innovative,

Fig. 1.1 European Union member countries during the key phase of COST Action CA15212 (the UK left the EU on 1 February 2020) and member countries of COST. Except for Moldova and Iceland, all COST countries are members of CA15212. Country data: World Bank Official Boundaries; COST data from www.cost.eu

[1] https://www.cost.eu/

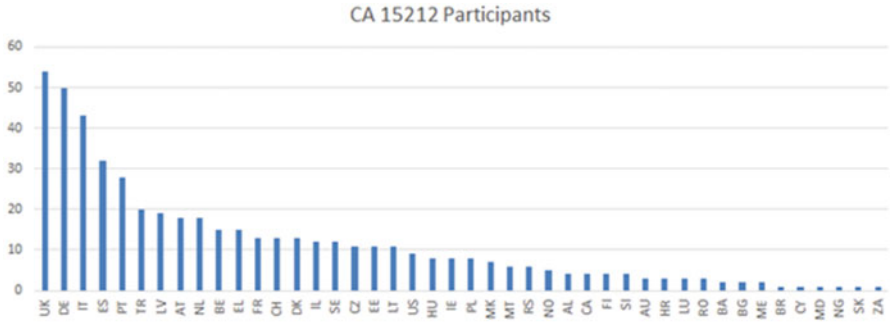

Fig. 1.2 Number of participants in the COST Action CA15212, ordered by country affiliation (internal administrative data – E-Cost, 14 February 2020)

interdisciplinary, and new topics, which might be high risk because they are not yet established in the scientific mainstream (COST 2016). COST Actions can be a valuable tool to increase and deepen networks and, through enhanced knowledge flow, support innovations (Morone et al. 2019).

Therefore, a COST Action seemed an appropriate tool to advance the reflections on the different dimensions of citizen science which emerged in the ECSA working groups. Subsequently, driven by Marisa Ponti, Claudia Göbel, and Katrin Vohland, a proposal was developed that resulted in the COST Action CA15212.[2] This COST Action addresses the relationship between citizen science and topics such as policy, education, research quality, and data standards. COST, as an instrument of the European Commission (EC) to support European excellence and coherence, has its own dynamics.

A recent study revealed an important function of COST: allowing especially women, young researchers, and researchers from so-called Inclusiveness Target Countries (ITC; see Box 1.1), to join new networks (Knecht et al. 2019). This is reflected in our COST Action. While the development of CA15212 was based on members of ECSA and its working groups, finally, participants from 43 countries contributed (Fig. 1.2). Within the last few years, the network has expanded into the Baltic states, as well as into Eastern and southern Europe, as described in more detail in chapter 3.

Box 1.1: Inclusiveness Target Countries (ITC)
ITCs, or *widening countries*, are those countries whose performance in science and technology was below 70% of the European average (EC 2019), based on a 2013 pan-European comparison of indicators. They included *research and development intensity*, measured as a percentage of expenditure of the gross

(continued)

[2] https://cs-eu.net/

Box 1.1 (continued)
domestic product (GDP); economic impact of innovation, for instance, measured by the number of patents; and *research excellence*, as indicated by highly cited publications using Scopus data and the number of top scientific universities and other organisations (EC 2013). Within the framework of the COST Action, ITCs receive tailored support and have certain privileges, for instance, funding to attend conferences (ITC Conference Grants).

This network also led to the pan-European capacity building platform EU-Citizen.Science, which emerged in response to an EC call to understand citizen science, its functions, preconditions, and quality criteria.

Part I: Citizen Science as Science

Until recently, citizen science has been recognised mainly in the natural sciences and local history. The contributions of citizens to science often remained hidden, as citizen scientists were seldom (co)authors or appeared in the methods or acknowledgements; only their data was visible (see Cooper et al. 2014). With a strong tradition of academia in Western societies, the increasing accessibility of digital tools and data, and the growing visibility of citizen scientists, the number of publications increased. A search of the ISI Web of Knowledge revealed 2625 publications of which 1028 could be attributed to European first authors (Fig. 1.3). The UK had the earliest citizen science publications and the highest number of publications. This may be due to the fact that citizen science is an English term and does not need to be translated, but also to the UK's long tradition of learned associations and other forms of citizen science.

The expansion of citizen science has resulted in debate about the scientific qualities of the contribution of citizens. This does not pertain only to data quality, but is linked to the scientific idea itself. In the majority of cases, citizens contribute data to an established research question, which leads to statements from scientists such as 'you don't get eureka moments' (Riesch and Potter 2014, p. 8). In fact, science does not only mean contributing to a specific question, but a deep knowledge of the whole field, its methods, its history, its literature, its discourses. This takes time, for which scientists are paid, and citizen scientists are not.

Therefore, the first part of this book addresses how citizen science has become a part of modern science and considers the issues around integrating its methods, models, and results into conventional ways of thinking in the different branches of scientific practice.

Chapter 4 is about the philosophy of citizen science and how it facilitates the generation of knowledge by those who have an interest in the topic, but are not

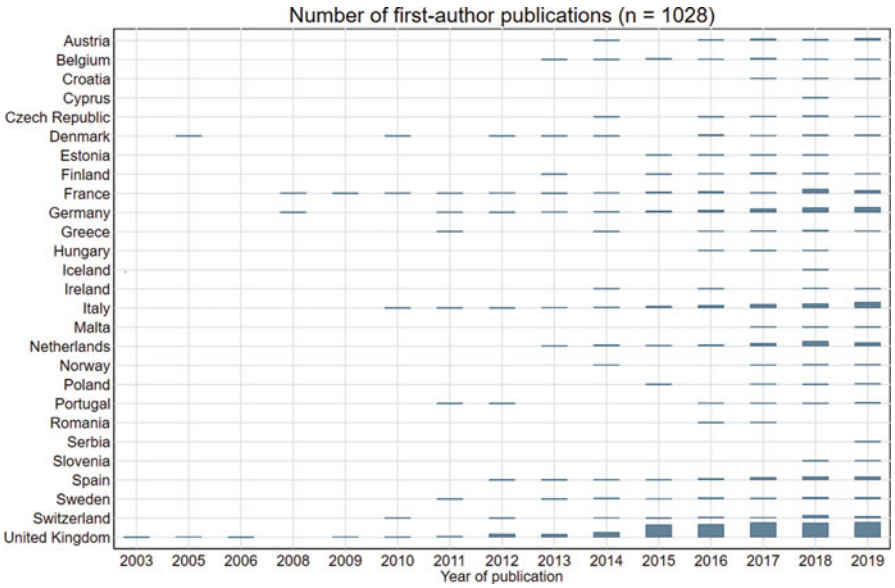

Fig. 1.3 Records for the topic 'citizen science' with a European first author; (n = 1028), retrieved from ISI Web of Knowledge, 8 November 2019

necessarily professional scientists. This leads to several issues in governing science, especially when *knowledge as a commons* is seen as a public good.

The first part of the book also highlights the different aspects of the natural sciences, the humanities, and the social sciences. In chapter 5, citizen science is viewed against the background of the natural sciences: observing and understanding phenomena, testing hypotheses, and performing experiments. Different research approaches and *citizen engagement* are described in terms of their challenges. Chapter 6 introduces the role of citizen science in the humanities as *citizen humanities*, in which citizens are involved in the activities of cultural heritage institutions and tapping local knowledge. Here the challenges are participant retention and the adaptation of new digital technologies. Chapter 7 notes that the underlying approaches in citizen science are already present in the social sciences and introduces the term *citizen social science*, elaborating on its epistemic foundations and its key issues.

Technology also plays an important role in the advancement of citizen science as a science. It advances the way data is collected and how it is processed, analysed, and integrated with other data. The first part of the book, therefore, introduces a selection of techniques relevant for citizen science and highlights key issues that play a role in the interaction of human users with technology and citizen-generated information. Chapter 8 discusses how data quality is perceived amongst different stakeholders and participants and explains how the validity and reliability of citizen-generated data can be ensured, thus providing recommendations for project implementers. In chapter 9, a conceptual model is proposed to achieve a common understanding and

representation for citizen science projects, their participants, and their outcomes. Based on international standards of data interoperability, this model is designed for information sharing amongst citizen science projects. Chapter 10 provides an overview of *machine learning* techniques that can be deployed to support citizens in analysing big data by classifying data and predicting results. The chapter raises issues around trusting these methods and how to acknowledge citizens who provide input to the machine learning process.

When it comes to scientific collaboration in citizen science, there is a variety of participatory methods and stakeholder objectives that do not necessarily align with those in conventional scientific collaboration. Chapter 11 presents, with the help of four case studies, the concept of *co-creation* and posits that the citizen science process should be flexible and adaptive throughout a project. For this, an infrastructure is needed that supports communication, tooling, and decision-making. More cross-disciplinary science is discussed in chapter 12, in which citizen science, health, and environmental justice intersect in both observational and interventional studies. Considering environmental justice aspects in citizen science activities can result in disagreements, which bring the need to reconcile discrepant project aims, data-sharing conditions, and the involvement of commercial activities. The authors place citizen science in the context of neoliberalism, and the degree of accountability of individuals, as they discuss the challenges of different participation models.

Part II: Citizen Science in Society

Citizen science is not just a participatory way to contribute to scientific knowledge, but also an effective way to address a wide collection of societal challenges. The explicit commitment of societal actors marks a significant difference between citizen science and most of the standard approaches in scientific research practices. Therefore, citizen science represents a collective endeavour that, in some cases, improves *science, technology, engineering, and mathematics* (STEM) formal and informal learning, while, in others, it can harness and better connect scientific evidence to policymaking, social innovation, and even social activism. Efforts to connect science to society require a flexible and adaptive set of methodologies and perspectives, which need to be deeper explored and constantly revisited.

Citizen science fosters an open and participatory approach to science, reducing the distance between science and society, and contributing to the goal of an inclusive society. Together with public and private actors, citizen scientists can play a role in developing society, improving communities, and promoting public participation. Therefore, when considering the full potential of citizen science, we should focus not only on answering scientific questions and generating valid data but also on the possible pressures, drivers, and effects on society and social innovation. Citizen science needs to continue to engage as many segments and actors in society as possible.

The second part of the book includes eight chapters that address the societal role of citizen science and its current limitations in terms of inclusion and equal participation. It also highlights which social and technological changes impact citizen science. Some of the chapters in this part of the book examine the role of citizen science in four societal realms: policy, education or learning, social innovation, and non-governmental organisations (NGOs). The rest of the chapters focus on ethics, inclusiveness, and participation, which are three fundamental democratic values on which any citizen science initiative must be based.

Chapter 13 focuses on the always challenging concept of participation by recognising the importance of considering the perspectives and experiences of citizen science participants. It discusses the gap separating researchers from citizens, where the former do not always use the data collected by the latter. The chapter also provides guidelines and recommendations for project leaders before they begin new citizen science initiatives. Chapter 14 broadens the perspective to inclusiveness. It discusses how diversity can be enhanced, with a special emphasis on the gender perspective. Since citizen science projects offer participants the opportunity to play a role in a scientific investigation, they also offer opportunities for learning about science. Citizen science provides a variety of contexts in which science learning can occur. In chapter 15, Kloetzer et al. chart forms of learning through citizen science in six *territories*, according to where learning might take place, ranging from schools to zoos and botanic gardens. While they present opportunities, they also highlight key tensions arising from citizen science projects in educational settings and look at training different stakeholders as a potential strategy to overcome some of these tensions.

As learning goes beyond personal learning, the involvement of citizens with the broad concept of social innovation is examined in chapter 16. Here, Butkeviciene et al. use three analytical dimensions – content, process, and empowerment – to examine the relationship between citizen science and social innovation in five case studies in different countries. As a result of their analysis, the authors identify opportunities and challenges for citizen science to stimulate social innovation through a specific list of projects. Citizen science can be a tool for community change by involving citizens in various forms of participatory research together with different social actors, in addition to universities and research centres.

However, in chapter 17, Göbel et al. lament the prevalent depiction of citizen science as mainly involving researchers and volunteers while neglecting the role of civil society organisations (CSOs) and failing to consider the breadth and diversity of participatory research activities citizen science includes. The authors present two case studies to illustrate how CSOs can be involved in participatory research, making it possible to transform scientific knowledge and empower social groups. Issues of the legitimacy of research conducted by CSOs and power asymmetries between CSOs and research institutions are also discussed in the chapter. There are also power asymmetries between citizens and professional researchers.

The complex relationship between citizen science and policy needs interrogating, and this is described by Schade et al. in chapter 18. The authors focus on pressing challenges concerning the relationships between citizen science and policy in the

current European policy landscape, characterised by geographical, social, and political diversity. The chapter provides a set of recommendations for possible actions to build and sustain existing relationships. Chapter 19 identifies six key pathways to environmental impact: environmental management; evidence for policy; behaviour change; social network championing; political advocacy; and community action. The attributes of projects that generate impact through the pathways are explored, and, subsequently, these impact pathways are aligned with target audiences.

Chapter 20, the last chapter in this part of the book, links to Part III and provides a critical debate on how ethical challenges should be tackled in citizen science projects. The importance lies in keeping equitable social balances and power relations between participants and citizen science project leaders. Tauginiene et al. start this challenging discussion on theory and practice by exploring dynamic informed consent, which is capable of adapting to the emergent issues during citizen science project evolution.

Part III: Citizen Science in Practice

The third section of the book addresses the question of what is needed to initiate, develop, and successfully implement citizen science projects. The chapters discuss different tools and instruments, which in various ways contribute to the success of a citizen science project.

The heterogeneity of citizen science is particularly evident in its practical activities. If one looks at the projects and what is negotiated in them, one gets an impression of the diversity that, contrary to expectations, enriches citizen science as a method. At the same time, citizen science calls for inclusivity, which must be continuously demanded and achieved with regard to practices, content, and methodological procedures. Against this background, there are particular demands on the tools and instruments that serve the practical implementation of citizen science: guidelines, tools, platforms, and apps. Specific challenges also arise around communication – an integral part of citizen science – and the evaluation of research. Communication in the field of citizen science inevitably means more than just publishing results; if motivating potential participating citizens fails, there will be no citizen science project. If one understands citizen science as a strategy of science communication, new possibilities and horizons for discussion and dissemination open up. Addressing many and different target groups is a unique challenge for practitioners. The same is true for evaluation, which requires new methods to account for participatory approaches.

An increasing number of institutions, including government agencies and research funders, are showing an interest in the field of citizen science. This interest is often driven by a desire for positive impact, and the expectation that citizen science projects can deliver this. There is indeed a rich literature of citizen science case studies that have led to change by raising awareness and influencing management practices and policy. However, many projects have delivered limited impact

(despite often ambitious project aims) due to the lack of public uptake, lack of stakeholder interest, or insufficient data quality.

Chapter 21, on guidelines, proposes a categorisation: general guidelines and specific guidelines. Examples are assigned to this basic categorisation. Especially interesting is the practical example about the process of defining criteria for categorising citizen science resourcing. This example turns the approach around and presents a qualitative description of guidelines. Chapter 22 focuses on different kinds of citizen science platforms. The platforms addressed are those which display citizen science data and information; provide practical examples and toolkits; collect relevant scientific outcomes; and are accessible to different stakeholders, ranging from interested citizens to scientific institutions, authorities, politicians, and public media. Mobile and web apps have become mainstream in information provision. In chapter 23, the authors highlight the added value of mobile and web apps for citizen science. An overview of app types and their functionalities is provided to facilitate potential users in selecting apps based on their needs.

Chapter 24 discusses the need for successful communication and public relations in citizen science projects. For the authors, excellent communication means that people have listened, understood the content, and acted accordingly. The authors discuss examples, such as storytelling and vlogs, and address the challenges of communication. In the same way that communication has to be continuously adapted to the project content and the target groups, the evaluation of the projects has to be rethought. In chapter 25, the authors discuss a participatory approach to evaluation, which takes into account citizen science as participatory practice.

Conclusion

Citizen science adds value to many scientific activities and links epistemic outputs with societal values – ranging from personal growth and learning to social innovation and policy impact. However, there are some scientific areas where citizen science may provide fewer options for citizens to participate. Also, citizen science practices should not be seen as a way to save money in scientific research efforts, such as (environmental) data collection (Lave 2017).

Generally, though, citizen science provides – and increases its potential to provide – a wealth of untapped options for science: to increase its knowledge foundation, to increase its self-reflexivity, and to tackle sustainability challenges. This book can be used as a tool to enhance the value of citizen science, providing not only scholarly insights but also practical tools for capacity building; technical aspects; ethical issues; and relevant communication, inclusion, and evaluation matters. These capacities are necessary to elevate the quality of citizen science so that it is acknowledged in the scientific, social, and political arenas. In a concluding chapter, final thoughts are offered on the trends and the futures of citizen science to support the further development of citizen science participatory practices.

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