



RESEARCH ARTICLE

REVISED

Delineating the contours of citizen science:

Development of the ECSA characteristics of citizen science

[version 2; peer review: 1 approved, 2 approved with reservations]

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First published: 09 May 2025, 5:128

<https://doi.org/10.12688/openreseurope.19411.1>

Latest published: 08 Jan 2026, 5:128

<https://doi.org/10.12688/openreseurope.19411.2>

Abstract

Background

Open Peer Review

Approval Status

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2

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version 2

Citizen science is increasingly recognized as a valuable scientific approach across disciplines, contexts, and research areas. However, its rapid expansion and diverse methodologies make it challenging to establish a single definition or universal criteria for what constitutes citizen science. This paper introduces the *ECSA Characteristics of Citizen Science*, offering a nuanced exploration of the field to support stakeholders, including policymakers and research funders, in understanding and applying citizen science effectively.

Methods

We developed the ECSA Characteristics through a vignette study, a survey method that captures diverse perspectives on complex topics. We then reviewed the ECSA 10 Principles of Citizen Science, a broad framework for best practices in citizen science, to identify its gaps and limitations, showing how the ECSA Characteristics can help address them.

Results

The results highlight the disciplinary distinctions as well as ambiguities surrounding various citizen science practices. Two challenges exist when defining citizen science. A very strict definition could exclude valuable practices, hindering innovation and discouraging public participation. Conversely, a loose definition might make it difficult for specific audiences to apply it effectively in their own contexts. Therefore, it is beneficial to adopt an inclusive approach and language that allows the audience to define its own criteria depending on its needs, intended use and specific circumstances.

Conclusions:

The ECSA Characteristics were developed in a spirit of openness; identifying areas with diverse and even conflicting views was central to this practice. We recommend their use as a whole set and contend that no one area or characteristic is more important than the other. They should be considered as a toolkit with examples that can guide efforts towards defining citizen science for a specific context and purpose. They are built on the ECSA 10 Principles, addressing some of their gaps and limitations, while at the same time acknowledging the need to update and improve the 10 Principles based on developments in the field.

Plain Language Summary

Citizen science is increasingly recognized as a valuable method in various research fields, but its definition remains challenging due to the diversity of approaches and practices. This paper introduces the "ECSA Characteristics of Citizen Science", which outline key elements

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of citizen science projects. It also connects these Characteristics to the ECSA 10 Principles of Citizen Science, which provide guidance on best practices. Additionally, the paper examines how different groups, such as policymakers and research funders, understand citizen science and highlights the differences in practices across disciplines. A strict definition of citizen science may limit creativity and participation, while a broad one could make it difficult to apply in specific contexts. The paper recommends a flexible, inclusive approach that allows different actors to define citizen science according to their own needs and contexts.

Keywords

citizen science, ECSA 10 Principles of Citizen Science, citizen science terms and definitions



This article is included in the [Horizon Europe](#) gateway.



This article is included in the [European Research Council \(ERC\)](#) gateway.



This article is included in the [Horizon 2020](#) gateway.

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Competing interests: No competing interests were disclosed.

Grant information: This project has received funding from the European Union's Horizon 2020 and Horizon Europe research and innovation programme under grant agreement No 824580 (The Platform for Sharing, Initiating, and Learning Citizen Science in Europe [EU-Citizen.Science]); 101058509 (European Citizen Science [ECS]); 824711 (Developing metrics and instruments to evaluate citizen science impacts on the environment and society [MICS]); 101131696 (Curating, Replicating, Orchestrating, and Propagating Citizen Science across Europe [CROPS]); 101133983 (Empowering citizens in collaborative environmental compliance assurance via monitoring, reporting and action [more4nature]); and 101086421 (Enhancing Citizen Observatories for healthy, sustainable, resilient and inclusive cities [CitiObs]). Additionally, the project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme Grant Agreement No 694767 (Extreme Citizen Science: Analysis and Visualisation [ECAVis]).

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How to cite this article: FRAISL D, Haklay M, Hager G *et al.* **Delineating the contours of citizen science: Development of the ECSA characteristics of citizen science [version 2; peer review: 1 approved, 2 approved with reservations]** Open Research Europe 2026, 5:128 <https://doi.org/10.12688/openreseurope.19411.2>

First published: 09 May 2025, 5:128 <https://doi.org/10.12688/openreseurope.19411.1>

REVISED Amendments from Version 1

This revised version of the manuscript includes additional text in the introduction documenting the evolution of citizen science from the publication of the ECSA 10 Principles in 2015 to the present. We also highlight relevant (systematic) review papers that examine the evolution of citizen science from various thematic perspectives. Additionally, we have streamlined the Methods section, particularly the description of the vignette survey, and now refer readers to the relevant publication for further details. Finally, we have added text to the conclusions section that reflects on the evolution of citizen science and explains briefly how future developments can be accommodated by our framework. All these revisions were made to address the reviewer comments.

Any further responses from the reviewers can be found at the end of the article

Introduction

The term “citizen science”, coined independently in the mid-1990s by Alan Irwin and Rick Bonney, is inherently ambiguous. Irwin used the term to describe a form of science that includes knowledge produced and held by citizens, which is valued and respected alongside expert knowledge (Irwin, 1995). Bonney (1996) highlighted the active participation of volunteers and non-experts in data collection as a demonstration of civic service, enabling research that would not be possible without public participation. Subsequently, citizen science has grown and become established as an approach for knowledge production, accelerated by various technological and societal trends, including the rise of the internet, smartphones and low-cost sensors, and growing access to education (Fraisl *et al.*, 2022; Pateman *et al.*, 2021; Roser & Ortiz-Ospina, 2016). There are many parallel traditions of public involvement in science resulting in the emergence of diverse terms and definitions, such as community science, participatory action research, crowdsourcing, volunteered geographic information and citizen-generated data (Beck *et al.*, 2024; Conrad & Hilchey, 2011; Eitzel *et al.*, 2017; MacDonald, 2012; Shirk *et al.*, 2012; Sieber & Haklay, 2015). Concurrently, efforts have been directed toward building a single definition or common criteria for all these activities (Heigl *et al.*, 2019), although there is also recognition that this might be difficult (Auerbach *et al.*, 2019; Heigl *et al.*, 2019). More recently, Cooper *et al.* (2021) discussed the efforts to “rebrand” citizen science as “community science” in the United States as the term “citizen” can be considered as a barrier to inclusion. The authors suggested that conversations should focus on approaches and practices that foster inclusion, rather than a name change.

Overall, the wide range of definitions and terminologies reflect the rapid and ongoing evolution of citizen science as a research field. Since the mid-2010s, the number of initiatives, scientific publications, research topics and policy recognition has grown significantly. For example, in 2015, the White House forum “Open Science and Innovation: Of the People, By the People, For the People”, the launch of CitizenScience.gov and the

Federal Crowdsourcing and Citizen Science Toolkit drew significant attention and spurred new activity across and beyond the United States (Congress.gov, 2015; usa.gov, 2025). In the same year, Europe’s Ten Principles of Citizen Science established best practices for the field (ECSA, 2015). Professional associations, including the European Citizen Science Association (ECSA), the Association for Advancing Participatory Sciences (former Citizen Science Association) in the United States, the Australian Citizen Science Association and other relevant networks elsewhere, have since expanded capacity, convened conferences, and developed guidance to further professionalize the field (AAPS, 2025; ACSA, 2025; ECSA, 2025). A global initiative has also emerged through the Citizen Science Global Partnership, launched around the 2017 UN Environment Assembly and formalized as a legal entity in 2022, to coordinate citizen science efforts for sustainable development (CSGP, 2022). Major international organisations have also elevated citizen science in their frameworks. UNESCO’s 2021 Recommendation on Open Science explicitly recognizes citizen and participatory science (UNESCO, 2021) and various UN programmes have backed global citizen science initiatives (Fraisl *et al.*, 2023a; Fraisl *et al.*, 2023b; Fraisl *et al.*, 2025). Domain specific journals, such as Citizen Science Theory and Practice (Ubiquity Press, 2025) and Community Science (Wiley, 2025), now offer reputable outlets for disseminating scholarly work and methodological advancements. Visibility has further increased through special issues on citizen science and the SDGs (Fraisl *et al.*, 2023c), ecology (Hager & Haywood, 2025; Hoggart, 2021) and biodiversity (Cigliano *et al.*, 2021), science and technology studies (Schrögel & Kolleck, 2018), social science (Duži *et al.*, 2022), cities (Brovelli *et al.*, 2025), and Earth Observation (Fritz & Fonte, 2016; Fritz & Fonte, 2019). In Europe, successive EU “Citizen Observatory” programmes (Hager *et al.*, 2021a) and newer Horizon Europe efforts like Urban ReLeaf (2025) and CitiObs (2025) take a comprehensive, socio technical approach, linking citizen participation and data with policy uptake. In parallel, global platforms such as Zooniverse, eBird/Merlin, and iNaturalist now pair massive volunteer communities with AI methods, illustrating powerful forms of human machine collaboration (CornellLab, 2025; iNaturalist, 2025; Zooniverse Team, 2025). Thematic global initiatives, such as Global Mosquito Alert, demonstrate how national and regional efforts can be networked internationally to tackle shared risks (UNEP, 2017). In parallel, scholars have begun tracing the development of citizen science over decades and through analytical and topical lenses. These studies examine, for example, the diversity and evolution of ecological and environmental citizen science (Pocock *et al.*, 2017), the historical development of citizen science with special attention to its legal and governance dimension (Berti Suman & Alblas, 2023), shifting academic interpretations of the concept (Hacking *et al.*, 2024), distinct research strands that employ citizen science approaches (Kullenberg & Kasperowski, 2016), and the trajectory of the field within education (Wu & Benaglia, 2024).

Given this evolution and the wide range of topics and domains in which citizens engage in knowledge production, reaching

consensus on a single definition of citizen science remains difficult. Yet, defining a set of common characteristics can help to identify which activities should be considered as citizen science in its broader sense and to provide a framing for assessing the impacts of such activities. Such a set of characteristics can be beneficial, or even necessary, for stakeholders such as the European Commission that would like to support citizen science activities (European Commission, 2022) but need guidance on identifying them. National citizen science platforms that feature citizen science projects such as the Austrian “Österreich forscht (Austria is researching)”, German “BürgerSchaffenWissen (Citizens create knowledge)” or Swedish “Medborgarforskning (Citizen Science)” also need to decide which projects they catalogue and curate (Bürger schaffen Wissen, 2024; medborgarforskning.se, 2024; Österreich forscht, 2024). Such stakeholders have varying motivations and objectives for defining citizen science in a more context-specific way, for example, to support policies in a specific domain or national level priorities in a defined research area (OEAD, 2024). Therefore, it is imperative to embrace the plurality of objectives, needs, and views of different stakeholders to identify common characteristics that can help answer the question “is this citizen science?”.

The ECSA Characteristics of Citizen Science (“the ECSA Characteristics”), the focus of this paper, extend the ECSA 10 Principles of Citizen Science (“the ECSA 10 Principles”) (ECSA, 2015; Robinson *et al.*, 2018) that are best practice guidance rather than a definition and target mainly practitioners than funders. For the purposes of a broader range of stakeholders, such as policymakers, funders, communities, and scientists new to citizen science seeking to apply these principles in practice, the ECSA 10 Principles are considered too vague to provide adequate guidance for judging proposed citizen science activities or funding applications (Fraisl *et al.*, 2020b). Additionally, they pay insufficient attention to bottom-up practices such as community-driven initiatives underrepresented in academic science (Parrish, 2022; Wehn, 2021). Hence, there is a need for guidance through an inclusive set of characteristics of citizen science projects and activities that stakeholders can choose from to make decisions, develop criteria for evaluation, or apply in other practical contexts such as impact assessment (Dörler *et al.*, 2022). The ECSA Characteristics were developed as a tool to assist defining citizen science within specific contexts and to complement the ECSA 10 Principles. The ECSA Characteristics differ from the ECSA 10 Principles in that they are responsive to each unique context rather than representing a complete set of principles or criteria that initiatives must fulfil.

The aim of this paper is to critically reflect on the ECSA Characteristics, exploring how ambiguities in citizen science practice can be helpful in embracing the plurality of citizen science. Building on our previously published work, which detailed the findings from a vignette study that was used to identify these Characteristics (Haklay *et al.*, 2021), this paper specifically focuses on the descriptive results from that vignette study. Different from the previous publication, in this

paper, we also examine the Characteristics in relation to the ECSA 10 Principles of Citizen Science. We present current and potential applications of ECSA Characteristics along with their opportunities and limitations. Finally, we provide examples of contexts in which the ECSA Characteristics can be particularly helpful, demonstrating how they can supplement and address the shortcomings of the ECSA 10 Principles.

Method

The methodology and results used in this study are described in detail in our previously published study by Haklay *et al.* (2021). Here, we summarize this methodology for providing context to the descriptive results presented, and additionally outline the process we took to go from the existing literature to ECSA Characteristics.

We developed the ECSA Characteristics through a vignette study, a form of survey used in healthcare and social studies to allow the extraction of diverse perceptions on complex issues (e.g., Brauer *et al.*, 2009; Taylor, 2006). A vignette study refers to short stories that describe specific circumstances for participants to respond to. Figure 1 is an example of a vignette used in this study. A complete list of 50 vignettes, including clearly recognized citizen science examples, controversial cases where respondents expressed divergent views, and a discussion of how these practices align with or fall outside the common definitions of citizen science, is published in Haklay *et al.* (2020a).

This study should be viewed in the context of the wider methodological process used in this research from the production of vignettes to the development of the ECSA Characteristics (Figure 2).

The first step included the identification of different dimensions related to citizen science: “descriptive factors”. We identified 10 descriptive factors based on existing typologies in the literature (Haklay, 2013; Pocock *et al.*, 2017; Shirk *et al.*, 2012; Strasser *et al.*, 2018; Wiggins & Crowston, 2011), and the ongoing debate among citizen science practitioners

Jane is a long-time supporter of the charity British Trust of Ornithology (BTO) work, as she cares about birds. She is an active supporter of the Garden Birdwatch programme (GBW), and happy to give it £17 a year. However, she doesn't have time to carry out the birdwatching survey. She is reading with interest the reports from the BTO GBW and finds the information motivating to continue her support of the project.

Source of inspiration:
British Trust for Ornithology, 2020

Figure 1. Example of a vignette used in the study (Vignette 3).

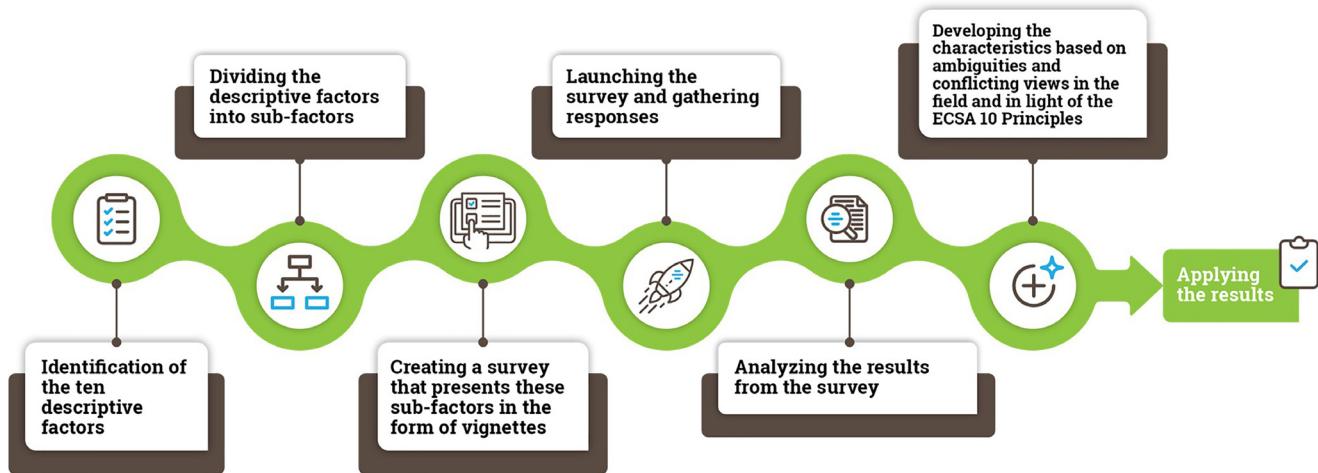


Figure 2. An overview of the methodological process used in the study.

and researchers (Auerbach *et al.*, 2019; Heigl *et al.*, 2019) to address controversial issues within citizen science. For example, public participation is a clear requirement for a citizen science project, but uncontroversial so not listed among the ten factors.

In the second step, we divided the ten descriptive factors into 61 sub-factors. A complete set of factors, sub-factors and vignettes used in the study are presented in Supplementary Material 1.

The sub-factors covered issues over which there is some debate in literature and collective experience in the field. For example, the hypothesis-driven experimental (rather than observational) nature of “the Great Grow Experiment” (Burton *et al.*, 2019) for regenerative growing practices is generally accepted to be citizen science. However, projects where participants receive a (micro) payment for data collection (Reddy *et al.*, 2010) or where data are harvested from social media are widely debated.

The third step involved the creation of a survey presenting the sub-factors in the form of vignettes. In total, we created 50 vignettes (see Figure 1 for an example). The use of 50 vignettes is the result of the co-occurrence of several of the 61 sub-factors in single vignettes rather than each vignette representing a single sub-factor. In the survey, respondents were asked to indicate the degree to which a vignette can be classified as a citizen science activity on a scale from 0 to 100 (Liu & Conrad, 2016). Respondents were also requested to rate their level of confidence for their answer for each vignette with the option to explain their decisions.

The fourth step involved survey launch (12 December 2019) on SurveyMonkey. Respondents were recruited through an open social media call (Twitter, LinkedIn and Facebook) and emails to the citizen science mailing lists. More than 330 responses resulted in over 5100 vignette ratings, corresponding to between 90–110 responses per vignette.

In step 5, we analyzed the data, agreed on the structure of the ECSA Characteristics document and discussed respondent comments for each vignette.

Finally, in step 6, we turned results from the analysis into the ECSA Characteristics with consideration of the ECSA 10 Principles. This involved formulating 50% and higher agreement among respondents for each vignette found to be a case of citizen science, and less than 50% agreement for cases found not to represent citizen science, drawing attention to the ambiguities in each case. For example, the degree to which Vignette 3 (Figure 1) was considered as citizen science was 8.90%. We formulated the ECSA Characteristic related to this, using explanations received from respondents as a basis:

Financial support for scientific research. Pure financial support to a project, such as crowdfunding, subscription fees and donations, is not considered citizen science, as no participation in any phase of the scientific research takes place. Careful consideration of the consistency with citizen science should be made if the financial contribution is a prerequisite to a form of participation in the scientific research phase of the project.

To develop a comprehensive set of Characteristics based on the ambiguities and conflicting views from the field, an inclusive process for design and implementation of survey and result production was instigated. Anyone who expressed interest was invited to participate in the study and at any point during the process. Additional efforts to reach out to diverse disciplines and fields where citizen science is prominent were made through networks of the co-authors. This ensured a wide range of perspectives from those using and developing citizen science were considered. Inclusivity was fostered through an international open call to the citizen science and science communication communities. Additional measures to ensure inclusiveness included active consideration of diverse audiences outside the citizen science practitioner and researcher

community, such as policymakers and funders, and their potential needs in terms of applying citizen science in their field of work. This was crucial to ensure that established research organizations, Civil Society Organizations (CSOs) and other actors involved in starting and implementing citizen science were represented while creating the ECSA Characteristics. Inclusivity was also ensured while preparing vignettes. The vignettes featured examples of diverse citizen science practices and close attention was paid to the use of inclusive terminology throughout, to reduce the perception that words like “science” or “research” excluded any stakeholder groups, disciplines, fields or initiatives.

We developed the ECSA Characteristics with future applications in mind. Growth in the field of citizen science is opening up new areas, activities, and interactions between people, science, and technology, such as Artificial Intelligence (Franzen *et al.*, 2021; Ponti & Seredko, 2022), to which the ECSA Characteristics should be applicable. The ECSA Characteristics should also be applicable in a modular way; responsive to unique contexts rather than a set of criteria that initiatives must fulfil to be considered citizen science.

We produced the ECSA characteristics as two separate documents. The first document, *ECSA’s Characteristics of Citizen Science*, is succinct so that it is practical and easy to follow by a wide range of audiences, including policymakers, funders, researchers, and the general public. The second document, *ECSA’s Characteristics of Citizen Science: Explanation Notes*, provides context for the production of the first document and describes the link between the ECSA 10 Principles and the ECSA Characteristics. We also included information and guidance on how the ECSA Characteristics can be interpreted and used, as each characteristic constitutes a topic in its own right.

The first full draft of the ECSA Characteristics was shared through an open call to gather feedback and broader engagement and discussion, both regarding the characteristics, and the process of their identification. The document remained open for feedback for around three weeks (February 2020). We then incorporated received feedback and finalized the aforementioned ECSA Characteristics documents.

We published the ECSA Characteristics and their explanation notes openly on the Zenodo repository in April 2020 (Haklay *et al.*, 2020d), followed by several promotion activities including an ECSA Webinar (Haklay *et al.*, 2020b) and a session at the Austrian Citizen Science Conference (Hager *et al.*, 2021b). We then published a scientific paper including a detailed description of our methodology for developing the ECSA Characteristics (Haklay *et al.*, 2021).

Following this process, we identified the gaps and limitations in the ECSA Principles, which could hinder their practical application due to their ambiguity. We also examined how Characteristics can help address these gaps by providing additional context and clarity, facilitating the effective implementation of both the Characteristics and Principles, and

offering more concrete guidance for their use in a variety of citizen science projects.

Results

As mentioned previously, this paper builds upon several key documents:

1. A peer-reviewed paper presenting the findings from an analysis using the vignette method to identify the ECSA Characteristics of Citizen Science (Haklay *et al.*, 2021).
2. The ECSA’s Characteristics of Citizen Science, made publicly available immediately after the completion of this work to serve as a resource for the community to identify what constitutes citizen science (Haklay *et al.*, 2020c).
3. The ECSA’s Characteristics of Citizen Science: Explanation Notes (Haklay *et al.*, 2020d), which provide a more detailed explanation of the aforementioned Characteristics.
4. The ECSA 10 Principles of Citizen Science (ECSA, 2015), created as core principles to guide good practice in citizen science. However, their broad and vague nature makes it challenging to translate them into specific, actionable guidance for different contexts, hindering effective implementation and the development of concrete guidelines.

While the findings of this study are based on these key documents, here, we present a novel contribution to the field by outlining the Characteristics themselves, providing context for the documents referenced in points three and four. Additionally, this study addresses the ambiguities and analyze the gaps within the ECSA Principles concretely and explain how the Characteristics can help address them.

ECSA Characteristics consist of five areas concerning the disagreements regarding what constitutes citizen science: (i) core concepts, (ii) disciplinary aspects, (iii) leadership and participation, (iv) financial aspects, and (v) data and knowledge. Figure 3 provides an overview of Characteristics covered in these areas.

Core concepts refer to conceptual issues regarding citizen science. This covers topics including the use of the terms *science* and *research*. The term *science* may result in the perceived exclusion of activities in the fields of humanities, arts, and engineering, as well as grassroots and community-driven initiatives, which can meet all the expectations of scientific practices. We, therefore, use the term *scientific research as* inclusive of all domains of activity, and highlight that citizen science research and practice should follow the protocols and practices of the disciplines to which they belong, to ensure rigor. An additional core concept of citizen science activities is that different actors may be involved in addition to professional scientists and participants, such as community leaders, facilitators, authorities, and other stakeholders. All actors must be made aware of their roles and responsibilities, which is the

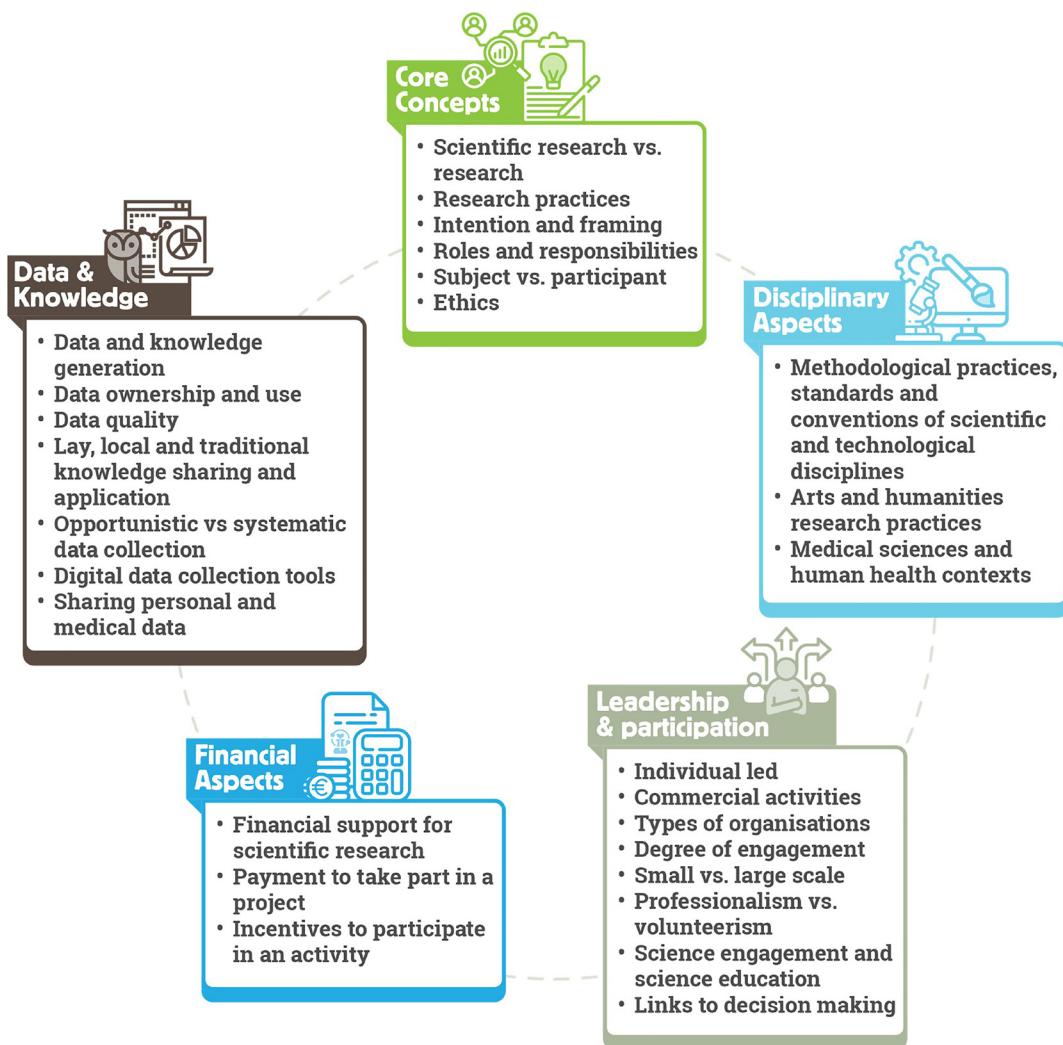


Figure 3. ECSA Characteristics structured in five key areas.

ethical responsibility of the project owner. Finally, we note that unpacking the core concepts can be particularly challenging in ambiguous areas such as the difference between *subject* and *participant* in the context of the medical or social sciences. We recommend that researchers identify and clearly communicate their perception and framing of the term *participant* and be transparent regarding practices, as essential to the ethical aspects of the citizen science activity.

Disciplinary aspects relate to the varying methodologies, standards and common practices applied to the design and running of citizen science projects. For example, requirements related to data management, including quality assurance and quality control processes, may be different for the natural sciences when compared to community-led practices to improve well-being. Additionally, some areas of research can be particularly prone to ambiguity. For example, in the arts and humanities,

approaches can be more interpretive than descriptive. Therefore, it is important to pay attention to the body of best practice relevant to those research fields and seek to implement them in citizen science projects referring to those domains. We also highlight varying approaches to personal information sharing in citizen science practices. Collection of personal data may be a prerequisite of some activities, such as in the health domain, but may be avoided in projects exploring highly sensitive issues such as gender-based violence. In all cases, it is essential that activities comply with data privacy rules and regulations in the country or countries in which the project operates, and ensure participant safety, security and wellbeing.

The degree of participant engagement from passive to active, the scale of the project from small to large, and the type of organisation leading the project such as grassroot organisations, NGOs, public authorities or academic institutions, are all

examples of topics covered under the *leadership and participation* category. Here, we highlight special concerns regarding commercial organisations in citizen science. Examples include data collection through sensors, health monitoring devices and mobile applications. In such cases, it is important to understand how data are used and shared before considering the activity as *citizen science* or *not citizen science*. We recommend applying the ECSA 10 Principles as generic guidance and ascertaining transparency of a project to better understand whether such activities align with the practice of citizen science. For the degree of engagement, active participation that requires the cognitive attention of participants is favored over limited participation such as in volunteered computing projects, where the participation is focused on the participant downloading software to donate their computing power. However, such projects can also be considered citizen science depending on whether the participants are well informed regarding the purpose and process of the research undertaken and how their participation will contribute to that purpose and process.

Financial aspects of the ECSA Characteristics include aspects such as donations or payments to participate in a project (for example through membership fees) and conversely payments to participants as incentives. Purely financial contributions from a 'participant' to a project through donations or subscription fees without further engagement is not considered citizen science. However, this needs to be evaluated on a case-by-case basis, as projects may still align with the ECSA 10 Principles and the ECSA Characteristics in other ways – for example, if a project requires payment for participation such as purchasing equipment from the project owner to enable data collection. Another ambiguous case widely discussed among the citizen science community is that of financial incentives for participants. In such cases, the local context of the project should be considered, as well as the nature of the task and the contribution of the participants. For example, in some projects, compensation of participants for their time and efforts is appropriate due to their economic situation. In such cases, financial payments need not alter project objectives or convert participants into professional project staff members.

Data and knowledge refer to themes from data quality and ownership to sharing of personal and medical data, and how data and knowledge generation issues influence an activity. Here, we emphasize that within citizen science, various forms of data and knowledge generation exist, and that disciplinary contexts and standards must be evaluated, including the data quality requirements. For data ownership and use, citizen science is considered closely linked to open science, including open data sharing and full transparency in ownership. However, sharing of sensitive information and data, such as indigenous data or Traditional Ecological Knowledge (TEK) (Shanley, 2015), the location of endangered species or personal health measurements in medical health research require special considerations (Carroll *et al.*, 2020; Fraisl *et al.*, 2022; UNESCO, 2021). Here, we also consider a range of different methods

used for data collection in citizen science activities. In some projects, participants are required to use standard protocols to share observations, while in others they are asked to report data opportunistically at random sites and time intervals or self-report on their personal circumstances or experiences. All these approaches can qualify as citizen science depending on the aims and the context of the project, as well as the fitness for purpose of the data.

The ECSA Characteristics in relation to the ECSA 10 Principles on Citizen Science

The ECSA 10 Principles provide a foundational framework for citizen science, outlining best practices across key areas, such as participant engagement and data management. The ECSA Characteristics complement these Principles, addressing some of their gaps, which arise from their inherent ambiguity and broadness. For example, the first principle emphasizes the importance of actively involving citizens in scientific endeavors. However, the definition of "active involvement" remains unclear. Does simply downloading an app to contribute spare computing power to a research project constitute active involvement or is more hands-on participation necessary, such as submitting plant observations through a mobile app? The ECSA Characteristics highlight the varying degrees of involvement in citizen science, ranging from equal partnership between participants, scientists and other stakeholders to cases where participant contributions mainly involve gathering data or providing computing resources. The Characteristics emphasize the importance of participant awareness regarding their contribution, including in cases where the data they produced is used indirectly or for secondary purposes, such as reusing images shared on social media. Table 1 provides a full list of ECSA 10 Principles, outlining their identified gaps as exemplified by the ambiguity of "active involvement", and demonstrating how the ECSA Characteristics can help to address these gaps.

Discussion

With the publication of the ECSA Characteristics, we have provided conceptual boundaries and guidance that are aimed at assisting others in developing a domain specific definition. Since their publication, the Characteristics have become a valuable resource for the field of citizen science because they have been made publicly available (Haklay *et al.*, 2020c). They serve as a crucial complement to the ECSA 10 Principles, providing concrete guidance for best practice in citizen science beyond the broad and generic ECSA 10 Principles. Although the ECSA Characteristics have been openly accessible and widely used in the field, as discussed in this section, the findings presented in this paper are novel. They explain how the statistical results from our previous work have been transformed into explanatory outcomes that can help various stakeholders, such as researchers, research funders, and policymakers, to effectively interpret and make informed decisions regarding what constitutes citizen science and what falls outside the scope of this field.

ECSA Characteristics were initially intended to support policy actors, funders, researchers, and practitioners as a guiding

Table 1. The ECSA 10 Principles, their gaps and how the ECSA Characteristics can help address these gaps.

Principles	Gaps	Characteristics
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 leader and have a meaningful role in the project.	<ul style="list-style-type: none"> • No clarity on what “active” involvement means; • Overemphasis on the “scientific” aspect of citizen science; • Not clear what “new knowledge or understanding” means; • The role of citizens does not reflect the diversity in the field. 	<ul style="list-style-type: none"> • Varying degrees of engagement are highlighted with concrete examples and specific recommendations (Leadership and Participation); • The use of the term “science” is clarified drawing attention to the risk of excluding some citizen science activities (Core Concepts). • Different forms of knowledge generation are described (Data and Knowledge); • The potential roles of citizens, scientists and other actors are covered (Core Concepts).
2. Citizen science projects have a genuine science outcome. For example, answering a research question or informing conservation action, management decisions or environmental policy.	<ul style="list-style-type: none"> • Not clear what “genuine scientific outcome” means; • Overemphasis on “science”; • Outcome examples do not reflect the potential diverse outcomes. 	<ul style="list-style-type: none"> • “Genuine scientific outcome” is clarified (Core Concepts); • How to interpret “science” is explained (Core Concepts); • Various potential outcomes and objectives of citizen science projects are clearly laid out (Core Concepts & Leadership and Participation).
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, e.g., to address local, national and international issues, and through that, the potential to influence policy.	<ul style="list-style-type: none"> • “Benefit” does not capture the contentious nature incentives for example, although it is a very debated topic in citizen science; • Does not include the diverse set of actors that are/can be involved in a citizen science activity. 	<ul style="list-style-type: none"> • Incentives are covered (Financial Aspects); • Multiple actors that can be involved in citizen science and their roles and responsibilities are discussed (Core Concepts).
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.	<ul style="list-style-type: none"> • Implications of participation in one or multiple stages of the project may create confusion such as when the engagement is limited to downloading a software for data collection. 	<ul style="list-style-type: none"> • Participation aspects are discussed, including the conditions in which minimal engagement occurs, and relevant recommendations are provided (Leadership and Participation).
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.	<ul style="list-style-type: none"> • Providing feedback to the participants may have ethical and legal implications related to data ownership, sharing and use. 	<ul style="list-style-type: none"> • The issues related to feedback and ethical and legal implications are discussed and the link to the importance of data ownership and use is made (Data and Knowledge).
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.	<ul style="list-style-type: none"> • The limitations and biases need clarity. 	<ul style="list-style-type: none"> • Potential limitations and biases specific to citizen science are highlighted along with the recommendations on how to address them (Leadership and Participation & Data and Knowledge).
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.	<ul style="list-style-type: none"> • Data sharing practices are not covered in sufficient detail and potential ethical and legal aspects are not clear; • No clarity on what the security and privacy concerns can be. 	<ul style="list-style-type: none"> • Data sharing is discussed in detail both in the context of sensitivity based on disciplines such as medical sciences and open science requirements, as well as their ethical and legal aspects (Core Concepts, Disciplinary Aspects & Data and Knowledge).

Principles	Gaps	Characteristics
8. Citizen scientists are acknowledged in project results and publications.	<ul style="list-style-type: none"> There is no clarity about the privacy and ethical aspects of such an acknowledgment or what it actually refers to. 	<ul style="list-style-type: none"> The ECSA Characteristics include a short statement about the ethical aspects of citizen science, and indirectly address this. However, since the participation in publication is not a source of controversy, the ECSA Characteristics do not address publications directly.
9. Citizen science programs are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.	<ul style="list-style-type: none"> Overemphasis on "science" and data quality rather than the fitness-for-purpose of data. 	<ul style="list-style-type: none"> How the term "science" should be interpreted is clarified (Core Concepts) and the data quality and fitness-for-purpose of data are discussed (Data and Knowledge).
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.	<ul style="list-style-type: none"> No clarity on how these legal and ethical issues can be taken into consideration. 	<ul style="list-style-type: none"> Specific sections on legal and ethical issues related to various aspects of citizen science are presented (Core Concepts & Data and Knowledge).

framework for consideration when assessing, funding, designing, and implementing citizen science activities, but in reality, their use and application can be much wider.

In terms of applications of the ECSA Characteristics, they have been used in the EU-Citizen.Science platform and the Measuring the Impact of Citizen Science (MICS) projects funded by the European Commission ([eu-citizen.science, 2023](#); [Parkinson et al., 2022](#)). They have supported the development and content of the EU-Citizen.Science website by providing basis and guidance for identification of good quality resources and projects related to citizen science featured on the platform. In EU-Citizen.Science, a quality criteria framework for citizen science resources was created to define and share good quality resources in Europe and beyond. The first overarching criterion of this framework is to assess whether a resource submitted by a user, for feature on the platform, is related to citizen science, for which the ECSA Characteristics provide guidance. All resources and projects featured on the EU-Citizen.Science platform go through this quality criteria framework, including the use of the ECSA Characteristics along with the ECSA 10 Principles.

Within the Measuring Impact in Citizen Science project, funded by the European Commission, the ECSA Characteristics framework has guided the development of measurable indicators for citizen-science impact assessment. This operationalizes the ECSA Characteristics, making them applicable in quantitative studies ([Parkinson et al., 2022](#), [about.mics.tools], and [Table 2](#)).

Additionally, the 50 vignettes developed in the study and based on a defined set of ten descriptive factors, have proven to be a valuable open educational resource, as a basis to discuss different types of citizen science. They have, for example, been used to engage students to reflect on citizen science as part of the "Citizen Science" course taught at University College

London, and by the "Taking Citizen Science to Schools" Research Centre of the Technion/University of Haifa. Therefore, the application of the ECSA Characteristics can contribute to the educational curriculum of the next generation of researchers.

The vignettes were also used on several multiple occasions at conferences to facilitate in depth discussion on the nuanced understandings of citizen science ([Hager & Kieslinger, 2020](#); [Hecker et al., 2021](#)). During one such discursive workshop, it became apparent that robust judgement of whether something should be considered citizen science depends on the completeness and quality of information available across all 10 descriptive factors. The debates also suggested nuanced dependencies across factors, with different perceived weights meaning that citizen science classification could change in relation to different factor combinations ([Hager et al., 2021b](#)). This further underlines the complex interplay of considerations when characterizing citizen science in this way, and why there remains potential for disagreement and confusion.

In terms of potential applications, the ECSA Characteristics can be used in studies where the citizen science landscape is analyzed. For example, in their mapping of citizen science contributions to the UN Sustainable Development Goals (SDGs) Global Indicator Framework, [Fraisl et al. \(2020a\)](#) reported on the difficulty of citizen science classification for a given project, highlighting cases where authors had disagreement. Similarly, in a subsequent study, Characteristics served as the foundation for determining whether a project qualifies as citizen science ([Fraisl et al., 2023b](#)). Additionally, exploration of citizen science in distinct disciplines and areas of application, such as health, can help guide the framing of research that requires citizen science classification for projects and initiatives. In such cases, ECSA Characteristics provide guidance, especially due to their special focus on the areas of ambiguity. Moreover, researchers new to the field, who

Table 2. An example of the quantification of the ECSA Characteristics as MICS indicators.

ECSA Characteristics of citizen science	MICS indicators
Data and knowledge generation. Citizen science, scientific, academic and policy-oriented research can include different forms of data and knowledge generation, including novel data generation, creation of new analyses, or production of new knowledge in written and other forms. The knowledge produced in such projects should aspire to disciplinary standards, such as appropriate data quality and quality assurance, the peer review of project publications and materials, or policy-relevant evidence that is fit for decision-making.	What forms of knowledge does the project as a whole create? New data (quantitative or qualitative) New analyses (including existing approaches applied to new data) New methodologies (e.g., for data collection, participant engagement, education) New concepts or theories None of the above I don't know

want to implement citizen science as a practice in their research, represent another critical audience. For example, UK Research and Innovation (a national funding body) promoted a call for proposals explicit in the aim of introducing new researchers to citizen science (Natural Heritage Science Forum, 2023; UKRI, 2019). Another example is the role they have played in facilitating the implementation of the UNESCO Recommendation on Open Science (UNESCO, 2021). The recommendation outlines the close relationship between the Open Science movement and citizen science, and the role of citizen science in opening up the scientific process (Wehn *et al.*, 2020; Wehn & Hepburn, 2022).

Another potential application is the use of ECSA Characteristics by national citizen science platforms and networks such as the Austrian, German, and Swedish platforms (Heigl *et al.*, 2020; Swiss Citizen Science Principles Working Group, 2022). As part of the ECSA Working Group “Citizen Science Networks”, owners of these platforms and others developed a set of criteria for the specific purpose of project selection for their platforms (Dörler *et al.*, 2022). The ECSA Characteristics can support their activities in refining the criteria on which citizen engagement projects, activities, and resources fall under the category of citizen science, as their work is intended to be a living resource, evolving as the field grows, similar to the ECSA Characteristics.

The ECSA Characteristics can also assist funders and decision makers in identifying citizen science activities for their respective funding and policy decisions. Public and philanthropic funders alike are increasingly aware of the role and potential of citizen science to address societal challenges associated with basic and applied research, and development interventions. Similarly, decision makers in public authorities at different governance levels are frequently approached by, involved in, or initiate citizen science activities themselves, but with a similar lack of background on citizen science. In such cases, the ECSA Characteristics can provide a set of guidelines for these actors to define citizen science based on their needs and context.

Finally, the ECSA Characteristics can assist grassroots, community-led initiatives in deciding to frame their initiatives as citizen science, which can help them rebrand, structure or

improve their activities for communication and dissemination, fundraising, advocacy and other purposes.

ECSA Characteristics address many limitations of the ECSA Principles, as presented in the Results section and in Table 1. However, one limitation of the ECSA Characteristics is that, despite the effort, they may still be vague for use by communities that require global definitions and methodologies. For example, the UN Statistics Division (UNSD), other UN and international agencies, and the National Statistical Offices around the world seek to mobilize new sources of data to track progress towards the SDGs. These groups have difficulties in “defining” citizen science and its relevant aspects to unlock its potential for SDG monitoring due to the diversity of terms, methodologies and applications. However, for successful official monitoring, global definitions and globally agreed methodologies for data collection are needed to ensure global-level comparisons. The broad and all-inclusive approaches necessary for the development of the field of citizen science make it challenging to address the needs of these official statistics communities. On the other hand, non-strict definitions can also help these authorities to work with the citizen science initiatives at a local and national level, and to address their context- and locality-specific data gaps and needs, which may not be covered in the global methodologies of the SDGs or international frameworks (Fraisl *et al.*, 2022; Fraisl *et al.*, 2023a). In such cases, it may be helpful for these communities to work with experts who can support the interpretation and use of the ECSA Characteristics in a given context.

Another limitation is that the ECSA Characteristics, like the ECSA 10 Principles, are inherently Europe-centric, as suggested by their name. Although efforts have been made to ensure that the development process has been inclusive and consider diverse geographies as outlined in the methodology section, the fact that EU-Citizen.Science project, which supported the development of the ECSA Characteristics, was funded by the European Commission and involved primarily European partners, means they may still retain a European focus. However, similar to how the Australian CS Association adapted the ECSA 10 Principles to their local context (ECSA, 2015), comparable efforts could be made for the Characteristics. Moreover, recent discussions among the co-authors of

this paper have considered expanding the ECSA 10 Principles and Characteristics to a global framework that considers the unique local contexts of different regions, with the aim of establishing regularly updated global guidelines for best practice in citizen science. This effort could be led by a Community of Practice formed by the Citizen Science Global Partnership (CSGP, 2022), which leads similar efforts such as the Citizen Science and Open Science Community of Practice (CSGP, 2024). Such an initiative is crucial given the rapidly evolving nature of the field and the fast-paced evolution of technologies such as Artificial Intelligence that directly influence citizen science project development, implementation and associated ethical considerations (Fortson *et al.*, 2024; Fraisl *et al.*, 2025).

Conclusion

Citizen science is a rapidly growing field that is transforming research while questioning and opening up established practices and processes of conceptualizing and “doing” science. The dynamism of the field makes it difficult to agree on a universal definition and a set of criteria to constitute its basis. Providing characteristics that embrace diverse practices and activities has the potential to help various stakeholders, such as funders, scientists or practitioners that are new to the field, to understand the richness of citizen science practices, and provide a basis for criteria that can be adapted for specific contexts.

Our findings reflect the evolution of the field by recognizing well-established forms of citizen science, including projects in environmental and ecological sciences where participants primarily contribute data, while also embracing emerging approaches and disciplines such as the social sciences, humanities, and grassroots co-creation of knowledge. The framework we propose is flexible enough to accommodate future developments in citizen science, and still remains grounded in core principles aimed at ensuring the highest ethical standards.

The ECSA Characteristics were developed in a spirit of openness; identifying areas with diverse and even conflicting views was central to this practice. We recommend their use as a whole set and contend that no one area or characteristic is more important than the other. They should be considered as a toolkit with examples and that can guide efforts towards defining citizen science for a specific context and purpose. They are built on the ECSA 10 Principles, addressing some of their gaps and limitations, while at the same time acknowledging the need to update and improve the 10 Principles based on developments in the field. Most importantly, the ECSA Characteristics are meant to complement the ECSA 10 Principles by providing specific examples and context to their interpretation, as well as by making their understanding and application easier, addressing their ambiguities.

Citizen science is still establishing itself as a valid scientific approach in some quarters. While this validation can be assisted through agreement on the borders of the field, this must be inclusive of diverse methods and practices and acknowledge the richness of the field and the need for its further development. The ECSA Characteristics represent an important step towards the fulfilment of this goal.

Ethical considerations

The survey adhered to data minimization practices, and the analysis did not include personal details, except where respondents explicitly requested to be associated with their contributions. Involvement in the study was based on written informed consent. All survey respondents mentioned by name have explicitly given their consent to be associated with their comments and to retain their name in the deposited file. All participants featured in the video have given their consent for its release. Data protection registration for the project was provided by the Centre for Research and Interdisciplinarity, Université de Paris.

Data availability

Underlying data

Zenodo: ECSA Characteristics of Citizen Science. <https://zenodo.org/communities/citscicharacteristics/records?q=&l=list&p=1&s=10&sort=newest>

This project contains the following extended data:

- Supplementary Material 1. (Supplementary Material – Table of Vignettes (case descriptions). <https://doi.org/10.5281/zenodo.4281293>
- Survey Data Set - Would you call this Citizen Science? <https://doi.org/10.5281/zenodo.4266684>
- Webinar on the Characteristics of Citizen Science <https://doi.org/10.5281/zenodo.3859969>
- ECSA's Characteristics of Citizen Science (<https://doi.org/10.5281/zenodo.3758668>)
- ECSA's Characteristics of Citizen Science: Explanation Notes <https://doi.org/10.5281/zenodo.3758555>

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0) (<https://creativecommons.org/licenses/by/4.0/>).

Acknowledgements

We would like to acknowledge the inputs from Lionel Deveaux, Soledad Luna, Fredrik Brounéus, Katja Heuer and Tim Woods.

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Open Peer Review

Current Peer Review Status:   

Version 2

Reviewer Report 24 January 2026

<https://doi.org/10.21956/openreseurope.23924.r68383>

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Shane Orchard

University of Canterbury, Christchurch, New Zealand

Review of 'Delineating the contours of citizen science: Development of the ECSA characteristics of citizen science'

Shane Orchard

University of Canterbury | Te Whare Wānanga o Waitaha

1. Introduction

This short comment responds to an invitation from Open Research Europe to provide a review of the paper "Delineating the contours of citizen science: Development of the ECSA characteristics of citizen science" (Version 2).

The paper is clearly oriented around the objective of further developing the notion of ESCA Characteristics of citizen science which have been the focus of previous studies and initiatives (e.g., European Citizen Science Association (ECSA) 2015; Haklay et al., 2021). In the introduction, paragraphs 3–5 set out a clear rationale for further developing the existing ECSA characteristics literature to assist the needs of a broader range of stakeholders: particularly funders, policymakers and people new to citizen science. In contrast the original ECSA '10 Principles of Citizen Science' was mainly designed to provide best practice guidance for existing citizen science practitioners (ECSA, 2015). Although the ESCA characteristics have already been published (Haklay et al., 2020a) along with a set of explanatory notes (Haklay et al., 2020b) and a scientific article that describes the methodology used for their development (Haklay et al., 2021), this paper makes a further contribution by examining the ESCA Characteristics in relation to the ECSA 10 Principles of Citizen Science and providing examples of their applications.

The study has been generally well conceived and executed to address its stated objectives. Several amendments have also been made to Version 1 of the manuscript in response to previous review comments. I am generally supportive of the suggestions made by previous reviewers and the responses made by the authors are generally appropriate. These include streamlining of the Methods section to refer readers to existing publications or supplementary materials and the provision of additional information on the evolution of citizen science. Regarding the latter, however, much of the additional information is organized around the theme of a timeline (e.g., of evolving citizen science organisations and initiatives) whereas it may be better to instead focus on the specific contributions that have been made to the theme of defining the characteristics of

citizen science. There are also a few other inconsistencies in the study's framing and interpretation of results that could further improve the paper. These are briefly summarised in the following section.

2. Specific comments

2.1 Abstract

Although the Abstract is otherwise sound, the first section (i.e., 'Background') does not clearly articulate the specific objectives for this paper in relation to previous publications on the ESCA Characteristics.

2.2 Introduction

I have some concerns around the merits of statements made in the Introduction on the role of national associations which have reportedly 'developed guidance to further professionalize the field'. Here in Aotearoa New Zealand (NZ) we prefer to use a framing around supporting and embracing the field in all its diverse forms and modalities. It can be argued that the goal of 'professionalizing' the field might actually be contrary to both the purposes and beneficial outcomes of some forms of citizen science, such as those based on local and traditional knowledge (e.g., see Jopling et al. (2024)). A further contradiction can be seen when comparing this material with the main conclusions of the paper and suggested benefits of adopting 'an inclusive approach and language that allows the audience to define its own criteria depending on its needs, intended use and specific circumstances'. The main conclusions essentially present an argument around embracing diversity in the varied forms of scientific enquiries that might be considered to fall within the definition of 'citizen science' which requires that the diverse motivations and objectives of participants are fully recognised. I therefore suggest that the Introduction could be expanded to briefly traverse the existing literature that identifies and highlights this diversity (e.g., before moving on to describe the evolution of major organisations and initiatives in this field).

Further to the above comment, the list of major national and international organisations that have arisen could be more clearly linked with initiatives and outputs that have either attempted to define the field, or offer insights for doing so (i.e., in the Introduction, paragraph 2). One option for doing this might be to wrap up this paragraph with a summary to that effect before moving on to summarise the work of scholars who have traced or commented on the development or scope of the citizen science field. This scholarly work offers a complementary perspective on the main theme of the Introduction and warrants a little more attention than currently provided (e.g., in a separate paragraph).

2.3 Methods

The study design is generally appropriate. It is largely built around the results of previous work on the ESCA characteristics. Very few additional methods are used to develop this paper; they mainly consist of tabulated comparisons and the presentation of example applications. I support the steps already taken to streamline the Methods section of this paper. However, only the very last paragraph of the Methods section contains material that is specific to this paper.

2.4 Results

The Results section presents a sufficient amount of new material to warrant this additional publication. However, I do not agree with the statement that suggests the Results provide a 'novel contribution to the field by outlining the Characteristics themselves'. Such material is already found in the original ESCA Characteristics document and supporting explanatory notes (Haklay et al., 2020a; Haklay et al., 2020b). The first part of the Results section is essentially a summary of material already presented in the abovementioned documents (particularly Haklay et al., (2020b)) and it would perhaps be appropriate to state this directly.

The second part of the Results section that presents a comparison of the 'ECSA characteristics'

against the ECSA 10 Principles of Citizen Science is relatively brief but sound in its construction. The tabulated material (Table 1) is particularly helpful and includes an analysis of gaps or ambiguities in the ECSA 10 Principles which have been addressed in the ECSA Characteristics project.

2.5 Discussion

The Discussion section provides a suitable summary of the paper but also a few inconsistencies that require further attention or explanation.

These include:

Paragraph 1 suggests that this paper explains how the statistical results from previous work have been transformed into explanatory outcomes, yet no statistical results are presented or even mentioned elsewhere in the paper. Therefore, this claim needs to be further explained or substantiated.

Paragraph 3 describes an application of the ESCA Characteristics within a quality criteria framework that is used to screen resources for inclusion on the EU-Citizen.Science website. It would be good to provide further details of the quality criteria framework to assist the reader to identify the relevant connections (e.g., in Supplementary Materials). This could also provide an opportunity to further discuss how the ECSA Characteristics work has added value over-and-above the pre-existing ECSA 10 Principles of Citizen Science; consistent with the stated objectives for this paper.

Paragraphs 7–10 of the Discussion focus on some of the current and potential applications of the ECSA Characteristics. Whilst this material is relevant it doesn't specifically address the results of this study. However, paragraph 11 onwards rounds out the Discussion nicely by returning to the comparison between the ECSA 10 Principles of Citizen Science and ESCA Characteristics.

The noted limitations of this Europe-centric work are appropriate given the substantial attention throughout the paper to potential applications within international frameworks, or to assist global-level comparisons or initiatives. The discussion of non-strict definitions and plurality of citizen science initiatives is particularly welcome, but no effort has been made to link these perspectives back to the existing literature that highlights their importance.

The suggested opportunities around adaptation of the ECSA 10 Principles and Characteristics to other contexts and potential expansion to a global framework are also welcome and deserve further consideration. If proceeding towards a global framework of principles or characteristics along these lines it would be essential to adopt an inclusive approach with solid socio-cultural and geographical representation, particularly from the global south which is currently under-represented in many citizen science networks and initiatives.

2.6 Conclusions

The structure of this section seems a little out of place since paragraph 3 is by far the most relevant to this study (e.g., it could be moved to become the opening paragraph). Additionally, the framing of paragraph 2 is not consistent with these aspects of the field because it suggests that social sciences, humanities, and grassroots co-creation of knowledge are 'emerging approaches and disciplines'. All three disciplines actually pre-date the modern terminology around 'citizen science'. It may be better, therefore, to reorient the Conclusions towards a summary of the new contributions provided by this paper (i.e., differences between the ECSA 10 Principles of Citizen Science and ESCA Characteristics).

3. Summary

Is the work clearly and accurately presented and does it engage with the current literature?

The work is clearly presented but could better engage with the relevant literature in some sections.

NB: a typo was noted in the Discussion section subtitle: The ECSA Characteristics in relation to the

ECSA 10 Principles of Citizen Science

Is the study design appropriate and is the work technically sound?

The study design is relatively brief since it mainly relies on existing work that has already been published. However, it is appropriate for the stated task and objectives.

Are sufficient details of methods and analysis provided to allow replication by others?

Yes, all of the methods are clearly documented, particularly in supporting and supplementary materials.

Are all the source data and materials underlying the results available?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Not applicable as there are no statistical analyses in the reported results (and none are needed).

Are the conclusions drawn adequately supported by the results?

The conclusions are partly supported by the results but could be more clearly related to study objectives and its novel contributions. This also an opportunity to link the main conclusions back to existing literature that is consistent with them. There is also an interesting statement made in the Abstract that is not mentioned in the main text Results or Conclusions, as follows:

'... it is beneficial to adopt an inclusive approach and language that allows the audience to define its own criteria depending on its needs, intended use and specific circumstances.'

It would be great to incorporate this suggestion within the main text as appropriate

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Is the work clearly and accurately presented and does it engage with the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

Are all the source data and materials underlying the results available?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Not applicable

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Socio-ecology, Participatory Science

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Version 1

Reviewer Report 05 November 2025

<https://doi.org/10.21956/openreseurope.21006.r60197>

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Isabelle Bonhoure

University of Barcelona, Barcelona, Catalonia, Spain

The paper “Delineating the contours of citizen science: Development of the ECSA characteristics of citizen science” offers valuable insights by revisiting the ECSA 10 Principles (2015) considering the more recent ECSA Characteristics (2020).

The presentation of scientific work is clear and accurate, and the paper draws upon a wide range of relevant references. While the literature on definitions and terminology in citizen science (CS) is extensively reviewed, limited information is provided regarding the evolution of CS between the formulation of the ECSA 10 Principles (2015) and the present (2025). As the authors note in their conclusions, CS is a rapidly growing and dynamic field. Since 2015, it has experienced a substantial increase in the number of scientific publications and a notable diversification of research topics. Including a brief overview of this evolution—based on review papers and/or systematic literature reviews—would help readers better contextualize the current study.

The study design is sound and appropriate, and the paper brings valuable academic insights. Although the work is already solid and meaningful, its relevance could be further enhanced if the authors situated their contribution within the broader timeline of CS. When the ECSA 10 Principles were developed in 2015, CS was still a relatively new approach—at least within the European context. By the time the ECSA Characteristics were formulated in 2020, the field had already evolved, and by 2025, CS has reached a more mature stage. Making this evolution explicit within the paper would help readers better understand the context of the field and clarify the gaps the authors identify.

Furthermore, the vignette cited serves as a clear example of an activity that most survey respondents are not considering to be CS. While its analysis yields interesting insights, it could also be valuable to include an example that is clearly recognized as CS—or even a more controversial vignette where respondents expressed divergent views—to further discuss the inclusion and boundaries of certain practices within the CS framework.

The Methods section provides sufficient detail. However, since part of the information has already been published elsewhere (Haklay et al., 2021), certain parts—particularly those describing the vignette survey—could be summarized to avoid redundancy.

The source data, including formerly published articles and Zenodo reports, are fully documented and available.

The Conclusions are well supported by the results presented in the paper. As the authors note, CS is a rapidly evolving field. It could strengthen the paper if the authors elaborated in the conclusions on how their results both reflect this evolution and offer a framework flexible enough to accommodate future developments in CS, while remaining grounded in its core principles.

Is the work clearly and accurately presented and does it engage with the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

Are all the source data and materials underlying the results available?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Not applicable

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Citizen Science, Citizen Social Science

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 02 Dec 2025

Dilek FRAISL

We thank the reviewer for their positive and constructive feedback.

- To address their comments, we have expanded the introduction to describe the evolution of CS from the publication of the ECSA 10 Principles in 2015 to the present.
- We also draw attention to relevant (systematic) review papers that examine this evolution from various thematic perspectives. In addition, we have positioned our contribution within this broader developmental trajectory and clarified its continued relevance to current CS practice, including how it addresses the gaps identified.
- Regarding the vignette-related feedback, we agree that this material is both interesting and pertinent. We have therefore added a clarification and a link to the relevant publication (Haklay et al., 2021). As the examples and discussion requested by the reviewer are already detailed in that work, repeating them here would create unnecessary duplication. We chose this approach to remain consistent with the reviewer's following observation that, because parts of the material have been published previously (Haklay et al., 2021), sections, particularly those describing the vignette survey, should be summarised to avoid redundancy. We believe this strategy helps keeps clarity and focus in the current paper.
- Finally, in the methods section, we have streamlined the content, especially the description of the vignette survey, and now refer readers to Haklay et al. (2021) for full details.
- In the conclusions, we have added text reflecting on the evolution of CS and mentioning how future developments can be incorporated within our proposed framework.

Competing Interests: No competing interests were disclosed.

Reviewer Report 29 September 2025

<https://doi.org/10.21956/openreseurope.21006.r60199>

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**Dolores Mumelaš**

National and University Library in Zagreb, Zagreb, Croatia

This research article is written with clarity and coherence, providing a logical continuation of the previous study on the ECSA characteristics of citizen science. The text and its findings are supported by a solid body of relevant literature from experts in the field.

A particular strength of this work lies in its critical examination of the ECSA Principles. The study identifies existing ambiguities and gaps, and it demonstrates in a concrete manner how the

Characteristics can serve as a framework to address these challenges.

The study design is appropriate, and the work is technically rigorous. The methodology is clearly described, easy to follow, and well suited for this type of research, allowing replication. The article is further enhanced by numerous well-constructed figures that effectively illustrate the results and facilitate comprehension. In addition, all underlying data and materials are made available, which reinforces the transparency and reliability of the work.

The conclusions are clear, insightful, and valuable for advancing the field of citizen science. This is a robust and meaningful contribution to the theoretical development of the discipline. It also provides a strong foundation for future research on this topic and has the potential to stimulate further investigations in related areas.

Is the work clearly and accurately presented and does it engage with the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

Are all the source data and materials underlying the results available?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Not applicable

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Citizen science

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 02 Dec 2025

Dilek FRAISL

We thank the reviewer for this helpful feedback and positive decision.

Competing Interests: No competing interests were disclosed.