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RESEARCH ARTICLE

REVISED Delineating the contours of citizen science: Development of the ECSA characteristics of citizen science

[version 4; peer review: 4 approved]

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Abstract

Background

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. Building on our previously published work that detailed findings from a vignette study used to identify the ECSA Characteristics, this paper specifically focuses on the descriptive results from that study and examines the Characteristics in relation to the ECSA 10 Principles of Citizen Science.

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

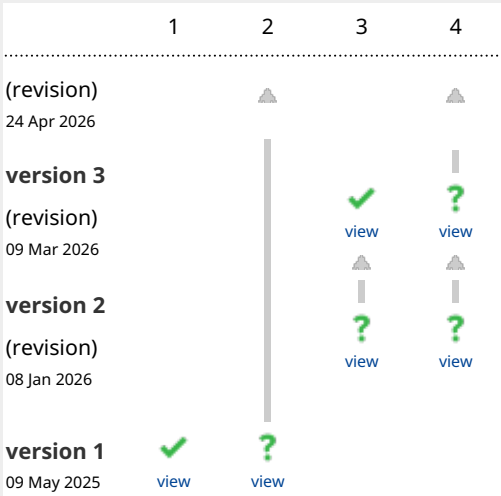
The results highlight the disciplinary distinctions as well as ambiguities surrounding various citizen science practices. In this context, it is beneficial to adopt an inclusive approach and language that allows the audience to define its own criteria depending on its needs, intended use and specific 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

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The only changes in this revised version are the inclusion of the two references recommended by one of the reviewers: ALLEA (2023) and ROSiE Consortium (2025).

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.

At the same time, a growing body of literature emphasizes that citizen science is not a single, unified mode of knowledge production but a heterogeneous set of practices shaped by distinct approaches, motivations, governance structures, and cultural contexts (Eitzel *et al.*, 2017; Shirk *et al.*, 2012; Beck *et al.*, 2024). These range from large-scale contributory projects to bottom-up, community-led initiatives, where activities may be embedded in place-based, local or traditional knowledge systems (Burton *et al.*, 2019; Cooper *et al.*, 2021). In such contexts, efforts to formalize or standardize citizen science have been questioned for potentially privileging institutional norms over alternative ways of knowing and organizing knowledge production (Jopling *et al.*, 2025). As a result, many scholars and practitioners argue for framings that prioritize inclusivity and flexibility, enabling citizen science to be supported and recognised in its full diversity rather than evaluated against a single, prescriptive set of criteria (Hacking *et al.*, 2024; Haklay *et al.*, 2021).

Overall, the wide range of activities, 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 strengthen support structures and legitimacy of the field in all its diverse forms and modalities (ECSA, 2025; AAPS, 2025; ACSA, 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). These organisations and initiatives have both raised the profile of citizen science and produced resources, guidance, platforms, and frameworks that contribute to shaping the understanding of the field and offer practical support for its practice and evaluation.

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, 2023), ecology (Hager & Haywood, 2025; Hoggart, 2021) and biodiversity (Cigliano *et al.* 2021), science and technology studies (Schrögel & Kolleck, 2018), social science (Duží *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). Taken together, these organizational and global initiatives complement a growing body of scholarly work that has traced the historical development, scope, and evolution of citizen science, providing insights into the diversity of practices, motivations, and governance approaches in the field. 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). While these developments reflect growing institutional recognition of citizen science, they also highlight an ongoing tension between efforts to provide shared guidance and the need to preserve openness to diverse, context-specific practices and participant-defined objectives.

Given this evolution, the wide range of topics and domains in which citizens engage in knowledge production, as well as the tension between inclusiveness and attempts to institutionalize the field, 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 consists of two main parts. First, we summarize the methodology used in our previously published study (Haklay *et al.*, 2021) to provide context for the descriptive results presented here, and outline the additional process we followed to derive the ECSA Characteristics from the existing literature, which was not covered in the earlier study. Second, we identified gaps and limitations in the ECSA 10 Principles that could hinder their practical application due to ambiguity. We present a table listing the 10 Principles and critically analyze these limitations and examine how the ECSA Characteristics can address them by providing additional context and clarity, facilitating the effective implementation of both the Principles and Characteristics, and offering more concrete guidance for use across a variety of citizen science projects.

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 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

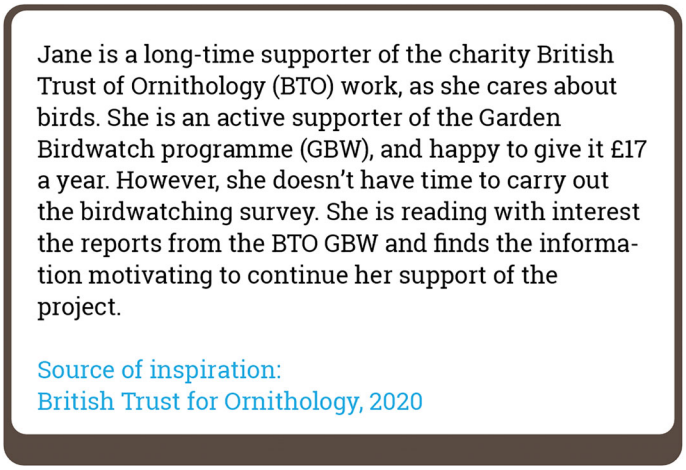

Figure 1. Example of a vignette used in the study (Vignette 3).

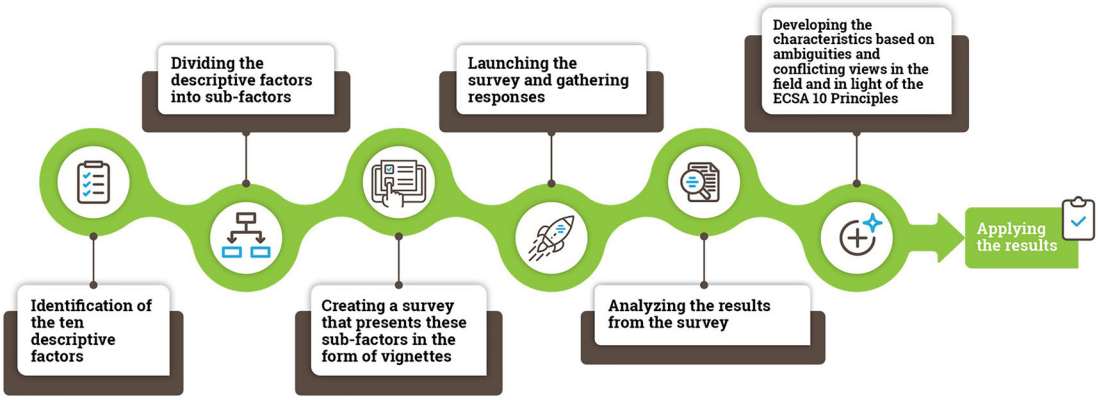

Figure 2. An overview of the methodological process used in the study.

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:

- 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).
- 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).
- The ECSA's Characteristics of Citizen Science: Explanation Notes (Haklay *et al.*, 2020d), which provide a more detailed explanation of the aforementioned Characteristics.
- 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 ethical responsibility of the project owner. Finally, we note that unpacking the core concepts can be particularly challenging in ambiguous areas such as the

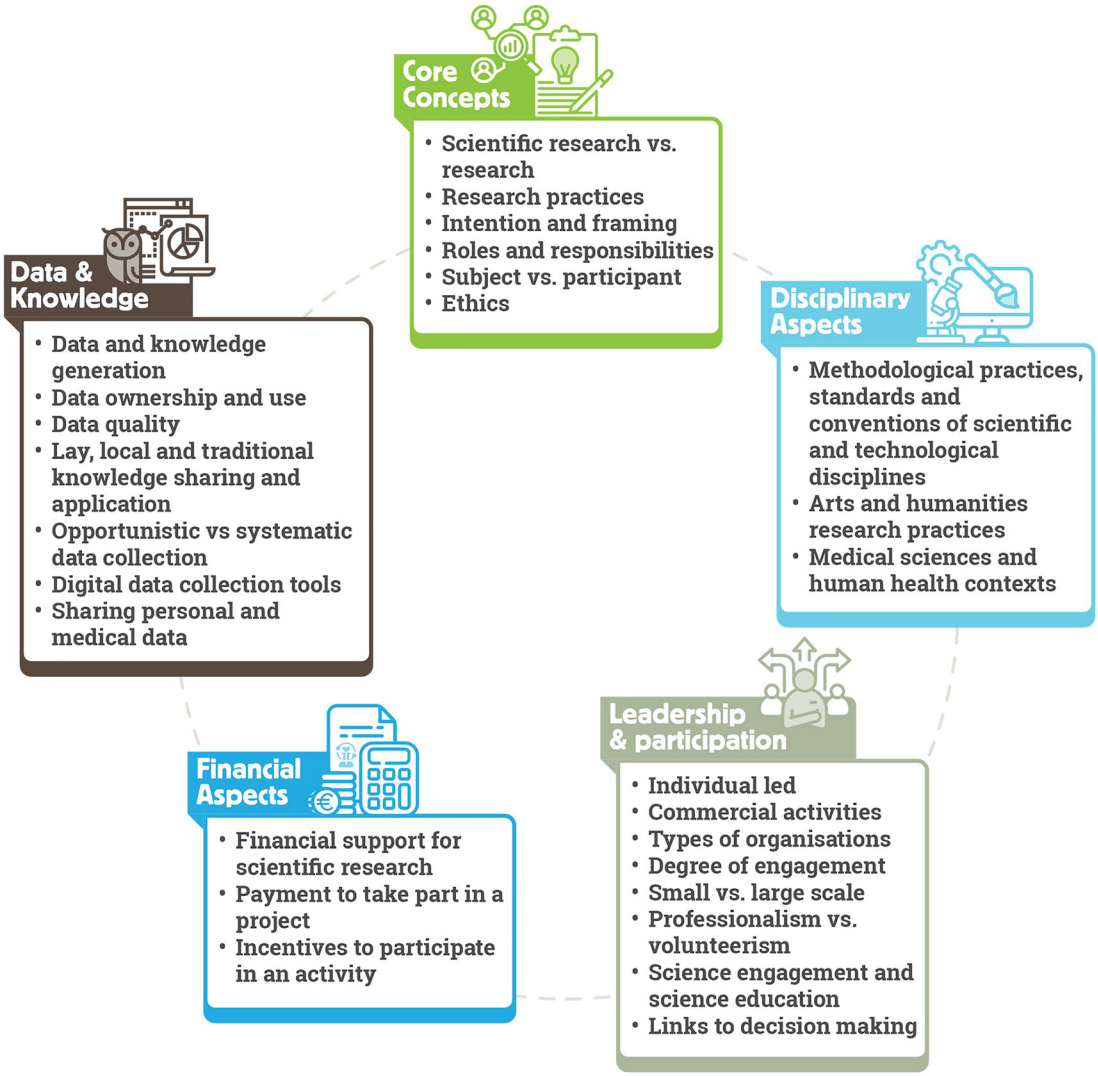

Figure 3. ECSA Characteristics structured in five key areas.

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 wellbeing. 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 of 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 by Haklay et al. (2021) have been transformed into explanatory outcomes that can

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.	• 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.	• 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.	• Not clear what "genuine scientific outcome" means; • Overemphasis on "science"; • Outcome examples do not reflect the potential diverse outcomes.	• "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.	• "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.	• 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.	• 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.	• 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.	• Providing feedback to the participants may have ethical and legal implications related to data ownership, sharing and use.	• 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.	• The limitations and biases need clarity.	• 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).

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Table 1. *Continued*

Principles	Gaps	Characteristics
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.	• 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.	• 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).
8. Citizen scientists are acknowledged in project results and publications.	• There is no clarity about the privacy and ethical aspects of such an acknowledgment or what it actually refers to.	• 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.	• Overemphasis on "science" and data quality rather than the fitness-for- purpose of data.	• 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.	• No clarity on how these legal and ethical issues can be taken into consideration.	• Specific sections on legal and ethical issues related to various aspects of citizen science are presented (Core Concepts & Data and Knowledge).

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.

Our findings show that the emphasis on non-strict definitions and the plurality of citizen science initiatives reflected in the ECSA Characteristics is well aligned with a substantial body of literature that identifies heterogeneity as a defining and productive feature of the field. Previous studies have highlighted that citizen science encompasses a wide range of approaches, traditions, governance models, and participation practices, shaped by local social, cultural, and institutional contexts, and that attempts to impose universal or rigid definitions risk marginalizing valuable forms of practice (Eitzel *et al.*, 2017; Shirk *et al.*, 2012; Cooper *et al.*, 2021). This literature argues for flexible frameworks that enable comparability and shared learning while preserving contextual adaptability, a perspective that underpins the design of the Characteristics and reinforces their potential relevance beyond European policy and research context.

ECSA Characteristics were initially intended to support policy actors, funders, researchers, and practitioners as a guiding 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 current and past applications, the ECSA Characteristics 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. To support this, a quality criteria framework 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. The quality framework combines top-down and bottom-up approaches: the top-down component includes minimal overarching criteria, which are required criteria for relevance and standard metadata, and a suggested criterion encouraging engagement with the ECSA 10 Principles, followed by specific and supporting criteria assessing aspects such as access, readability, content, applicability, and format quality. Resources must meet at least 50% of the relevant specific criteria to be included, while supporting criteria provide additional guidance without affecting the rating. The bottom-up component engages the community, allowing them to upload, rate, and comment on resources, ensuring inclusivity and responsiveness to diverse needs. By clarifying ambiguities in the 10 Principles and providing context-sensitive guidance, the ECSA Characteristics enable moderators and stakeholders to evaluate resources effectively while accommodating the diversity of citizen science practices (Fraisl *et al.*, 2020b).

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.

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

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 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. Any such effort would require a genuinely inclusive approach, with strong socio-cultural and geographical representation, particularly from the Global South. 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, as reflected in recent literature and relevant frameworks (ALLEA, 2023; ROSiE Consortium, 2025; Fortson *et al.*, 2024; Fraisl *et al.*, 2025).

Conclusion

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 complement the ECSA 10 Principles by providing greater specificity, contextual grounding and practical guidance, supporting their clear interpretation, easier application, and the resolution of their ambiguities.

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 single set of criteria. Rather than proposing a fixed definition, this paper contributes a set of Characteristics that acknowledge plurality while offering structured guidance. By providing characteristics that embrace diverse practices and activities, the ECSA Characteristics can support various stakeholders, such as funders, scientists or practitioners that are new to the field, in understanding the richness of citizen science practices, and in adapting criteria to specific contexts.

Our findings recognize common practices within citizen science, including environmental and ecological projects centered on data contribution, as well as established approaches rooted in the social sciences, humanities, and grassroots co-creation of knowledge. The framework we propose is flexible enough to accommodate future developments in citizen science, while remaining grounded in core principles aimed at ensuring the highest ethical standards.

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 toward the fulfilment of this goal by articulating how the ECSA 10 Principles can be interpreted, extended, and applied across varied citizen science contexts, supporting both coherence and diversity within the field.

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/).

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Open Peer Review

Current Peer Review Status: ✔ ✔ ✔ ✔

Version 4

Reviewer Report 05 May 2026

https://doi.org/10.21956/openreseurope.25414.r72985

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✔ **Isabelle Bonhoure**
University of Barcelona, Barcelona, Catalonia, Spain

No further comment to make.

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.

Reviewer Report 27 April 2026

https://doi.org/10.21956/openreseurope.25414.r72982

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✔ **Petteri Laihonen**
University of Jyväskylä, Jyväskylä, Finland

Thank you for the response, my concerns have now been fully addressed.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Co-creative Citizen Science in Applied Language Studies, Participatory Research

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.

Version 3

Reviewer Report 18 March 2026

https://doi.org/10.21956/openreseurope.25044.r70827

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Shane Orchard
University of Canterbury, Christchurch, New Zealand

The revised version (v3) now incorporates a number of changes in response to reviewer feedback which have improved the manuscript.

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.

Reviewer Report 17 March 2026

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Petteri Laihonen
University of Jyväskylä, Jyväskylä, Finland

I have read the revised version 3, and I have found that the common concerns with other reviewers have been addressed. However, I still found that some important recent literature on research ethics I suggested have been ignored without a response.
I still think that both the
ALLEA (2023) The European Code of Conduct for Research Integrity – Revised Edition 2023. Berlin.
and the
The ROSiE General Guidelines on Responsible Open Science (version 2.0; 2025) should be

consulted. (Refer to reference no.1&2)
The ALLEA (2023) code of conduct has most importantly been revised to include Citizen Science and includes the category "participant" not just "research subject". Furthermore, the ROSIE guidelines address many of the same questions discussed in the article. In general including these two sources could improve the discussions on the ethical dimensions of citizen science in the article. At present the article makes frequent reference to ethics, but fails to specify its definition or interpretation behind such statements as in the conclusions: "The framework we propose is flexible enough to accommodate future developments in citizen
science, while remaining grounded in core principles aimed at ensuring the highest ethical standards." For the reader it remains unclear what the "highest ethical standards" might be?

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Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Co-creative Citizen Science in Applied Language Studies, Participatory Research

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 19 Mar 2026

Dilek FRAISL

We sincerely thank the reviewer for taking the time to evaluate the manuscript again and for noting that their comments have largely been addressed, with the exception of the inclusion of their recommended literature. We would like to clarify that Version 3 of the manuscript was submitted before we received this reviewer's initial report. The reason many of the reviewer's comments were already addressed is that another reviewer raised very similar points, which we incorporated during that revision. As a result, Version 3 did not yet include the specific literature suggested by this reviewer. We have now revised the manuscript accordingly and added the two references strongly recommended by the reviewer. We agree that these additions significantly strengthen the paper by incorporating relevant and recent literature on the topic.

Competing Interests: No competing interests were disclosed.

Version 2

Reviewer Report 17 February 2026

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Petteri Laihonen
University of Jyväskylä, Jyväskylä, Finland

I read this article with great excitement, since it is a very helpful companion for researchers with experience in Citizen Science like me. The expansion of CS projects in the past ten years have brought about serious tensions around the definition of Citizen Science. Many researchers, me included, have noticed that especially in the academic world, there is hardly much agreement on either who is meant by "citizen" and what "science" entails nor what the relationship between the two can or should be.

The authors, curiously representing research institutions and including no "citizens", address many of the acute issues faced by researchers conducting CS projects. The answers the article brings forth are mostly laudably open, responsible, flexible and inclusive, perhaps bringing back those researchers to the field and ECSA that have already decided to use other term for their projects than CS.

The main concern with the article is that it is framed as an empirical research article, whereas it reads more as a discussion note to already previously analyzed data. To address this, **I would suggest cutting the parts already presented elsewhere on the 10 Principles or the Characteristics, and focus on the new analysis and results.** That being said, the article certainly takes the discussion further and thus is a very needed encouraging contribution to the discussions of the "devilish" details of Citizen Science work globally.

Next, I will point to some specific issues for consideration to the authors:
The abstract does not clearly indicate what is the novel contribution of the paper, e.g. stating that: "This paper introduces the *ECSA Characteristics of Citizen Science",* which refers to earlier work. Please add a sentence on the unique contribution of this paper in the abstract.
The article opens with a historical narrative of CS, indicating a recent development, perhaps add a note on alternative histories, with a longer perspective, such as presented by Mahr et al. (2018).
The introduction serves already now as a valuable state of the art source of most important literature. I would still suggest adding/updating some important (re)sources and taking a note on them: (refer to 4) is included, please take note on the newer version. 2) sources on cs in the arts and humanities are not represented equally in the literature review, event though in later parts they are often referred to as critically different from e.g. the natural sciences, which would warrant the better inclusion of such sources in the introduction, too. Please add some sources in these fields if available to the authors. 3) two important recent developments in the ethics of CS could be included:(refer to 3) I also would find their inclusion in the parts referring to ethics helpful as they present the core state-of-the-art.

In the introduction I would reformulate the idea "to further professionalize the field", because it contradicts those historical accounts, where CS has been seen as an antidote to the (side effects of) professionalization of science, where the public or citizens are deliberatively excluded from the scientific research process (e.g. Mahr et al. 2018).
With these very minor concerns in mind, which can easily be addressed with a minor revision, I welcome this publication and find it a very useful contribution for the many researchers tackling the issues in defining citizen science or interpreting the 10 principles in their fields and particular contexts.

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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: Co-creative Citizen Science in Applied Language Studies, Participatory Research

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.

Reviewer Report 24 January 2026

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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 (ESCA, 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.

Author Response 09 Feb 2026

Dilek FRAISL

We thank the reviewer for the constructive and helpful feedback. Below, we summarize how each comment has been addressed.
We revised the background section to more clearly articulate the specific objectives of this paper, as suggested. In response to comments on framing, we replaced the term "professionalize" with "strengthen support structures and legitimacy of the field in all its diverse forms and modalities". We also added a new paragraph to the Introduction, following the opening paragraph, that engages with literature highlighting the diversity of citizen science practices, before moving on to the evolution of major organisations and initiatives.

Additional text was included to explicitly link key national and international organisations and initiatives to the outputs and activities through which they have contributed to delineating and shaping the field. This appears immediately after the sentence beginning "UNESCO's 2021 Recommendation on Open Science…". We also added bridging text beginning with "Taken together, these organizational and global initiatives…" within the paragraph on domain-specific journals to better connect organizational developments with scholarly work and to give greater emphasis to the academic literature.

To address the comment on the Methods section, we added an opening paragraph clearly outlining the methodology in two parts: elements building on previous work and the novel contribution of this study. This clarifies the additional methodological step taken here, specifically the identification of gaps and limitations in the ECSA 10 Principles and how the ECSA Characteristics can help address them.

Regarding the Results section, we would like to clarify our intent concerning the novel contribution of this paper. While the ECSA Characteristics were originally published on Zenodo to enable early and open access, this paper extends that work by situating the Characteristics within a peer-reviewed context and providing additional analysis and application.

In the Discussion, we clarified that the statistical results underpinning the work are reported in Haklay et al. (2021) and explicitly noted that this paper builds on those findings. We expanded the description of the quality criteria framework used on the EU Citizen Science platform. We also added a paragraph addressing non-strict definitions and plurality and included an explicit statement in the final paragraph emphasizing the need for inclusive, globally representative approaches, particularly involving the Global South.

Finally, the Conclusions were reorganized by moving the former third paragraph to the

opening of the section and refocusing the discussion on the core contribution of the paper. References to social sciences, humanities, and grassroots knowledge as “emerging disciplines” were removed, recognizing them instead as established approaches. The section was also tightened to reinforce the overall contribution and significance of the paper.

Competing Interests: No competing interests were disclosed.

Version 1

Reviewer Report 05 November 2025

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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

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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.