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Bridging citizen science and science communication: insights from a global study of science communicators

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A large study of science communicators around the world was conducted as part of the GlobalSCAPE research project. All participants in the study indicated some level of science communication experience, with more than 11% choosing "citizen scientist" as one of their identities. This paper provides an overview of how science communication and citizen science are two independent fields of research and practice that have opportunities for overlap and mutually beneficial outcomes, particularly in terms of the practices of those working in areas of public engagement with science. In addition, qualitative results are presented regarding the experience of being a science communicator for those who identified as citizen scientists. The paper also showcases the first empirical insights from the GlobalSCAPE project, which exemplifies how international research collaborations can be used to explore the challenges and opportunities faced by those individuals working in science communication and citizen science.

KEYWORDS

science communication, citizen science, Science with and for Society (SwafS), GlobalSCAPE, research projects, correlation analysis, identity, European Commission

1 Introduction

Citizen science and science communication have become increasingly important fields of research and practice in recent years, as society faces unprecedented challenges that require new techniques and tools grounded in scientific understanding (Bucchi, 2017; Ryan et al., 2018; Skarzauskiene and Mačiulienė, 2021). Climate change, emerging infectious diseases, and rapidly changing new technologies are all challenges that are global in scale and benefit from the involvement of citizens as partners in research and innovation (Wamsler and Brink, 2014; Meentemeyer et al., 2015; Cappa et al., 2022). Citizen science is an approach to scientific

research that involves members of the public in the research process, including data collection, analysis, and interpretation. Science communication, on the other hand, is the practice of sharing scientific information with non-experts and engaging public audiences in discussion and debate about scientific topics.

The need for effective citizen science and science communication has never been greater, with the COVID-19 pandemic highlighting the importance of collaboration and the incorporation of diverse perspectives as society began to seek accurate and timely information to inform their decisions (Andrews-Fearon et al., 2020; Katapally, 2020; Massarani et al., 2020). Together, citizen science and science communication can play a critical role in giving citizens greater access to scientific information and the ability to participate in scientific decision-making processes. However, understanding the relationship between these two fields, and the role of those who bridge the gap between them, is crucial to maximising their impact and addressing their shared challenges.

1.1 Citizen science: public participation in science

Citizen science can be a theoretical or practical approach to research as well as being a field of research in its own right (Kullenberg and Kasperowski, 2016; Heigl et al., 2019; Roche et al., 2020). Citizen science has long been considered to hold vast potential for helping society (Irwin, 1995; Lewenstein, 2022) and, as well as being a distinct field of enquiry (Jordan et al., 2015), has increasing prominence in areas such as astronomy, ecology, meteorology, and medicine (Lewandowski et al., 2017). While the term "citizen science" broadly applies to scientific research that involves people who do not identify as professional scientists (Bonney et al., 2009; Silvertown, 2009), the theoretical context of the individual terms "citizen" and "science" can vary greatly depending on a range of factors and circumstances (Eitzel et al., 2017; Haklay et al., 2021). Although the issue of terminology has been present in the field of citizen science since the beginning, it has been hotly debated recently with discussions held at the major science communication and citizen science conferences in 2023 (Roche et al., 2023). One of the central issues of the terminology debate—the distinction between citizen science and community science and how the "citizen" term can be insensitive to marginalised communities (Ellwood et al., 2023; Lin Hunter et al., 2023)—culminated in the US-based but globally-reaching Citizen Science Association changing its name to "the Association for Advancing Participatory Sciences". While there is no doubt that inclusion needs to be improved in the field (Cooper et al., 2021), some citizen science scholars have suggested that the field can be made more inclusive without resorting to abandoning a term that has gradually been gaining in scientific and political credibility in recent years (Haklay, 2023). These debates have bolstered the idea that communication and engagement are central to the future of citizen science.

1.2 Science communication: engaging audiences in dialogue and debate

Effective communication of scientific findings to public audiences serves to enhance public trust in science and facilitate wider public engagement in scientific research (Fischhoff and Scheufele, 2013; Schäfer, 2016; Achiam et al., 2022). Science communication is not just the "communication of knowledge from scientific experts to public audiences" (Bultitude, 2011, p. 32), but is instead a two-way exchange with public audiences, as well as a field of research and practice in its own right (Burns et al., 2003; Trench, 2008). In recent years, in tandem with the challenge of communicating science in a "post-truth society" (Iyengar and Massey, 2019, p.7656), the field of science communication has grown substantially as a discipline taught in higher education institutions around the world (Massarani et al., In Review), amid growing calls to incorporate it more substantially into science education (Bubela et al., 2009; Mercer-Mapstone and Kuchel, 2017).

Responsible science communication is as important as ever (Scheufele and Krause, 2019; Howell and Brossard, 2021; Hyland-Wood et al., 2021) with a number of prominent challenges emerging in the field. There are disparate views among scientists on the relationship between science communication and socio-political impacts and what science communication can achieve (Scheufele, 2014; Fähnrich, 2017; Besley et al., 2018; Fähnrich et al., 2020). For example, while "historically science communication has been predicated on the assumption that ignorance is the basis of a lack of societal support for various issues in science and technology"—the so-called 'deficit model' of science communication (Simis et al., 2016, p. 401)—research has demonstrated that science communication is far more complex than the deficit model would suggest, with models of dialogue and participation being integral to the responsible public communication of science (Davies, 2008; Horst and Michael, 2011). The motivation for science communication can sometimes be conflated with objectives spanning from education to promotion and are often lacking in meaningful evaluation (Jensen, 2014; Weingart and Joubert, 2019). The people involved in science communication are often based in universities and research or education organisations and can be researchers, scientists, communication professionals, educators, students, volunteers, or freelancers, among other roles (Davies and Horst, 2016; Weingart and Guenther, 2016). The few studies that have explored the people involved in science communication have demonstrated the richness of the topic and how the broad range of backgrounds and experiences of the people involved make it ripe for further study, especially given how the availability and accessibility of funding and support for science communicators can greatly affect their work (Koivumäki and Wilkinson, 2020; Besley et al., 2021).

1.3 Potential synergies between citizen science and science communication

Citizen science can benefit from effective science communication. Clear communication of the goals and outcomes of citizen science projects can help to increase participation rates, especially among groups that are traditionally underrepresented in science (Bonney et al., 2009; Dickinson et al., 2012; Gunnell et al., 2021). Effective communication can also help to ensure that the data collected by citizen scientists are accurate and reliable (Kosmala et al., 2016; Balázs et al., 2021). Ideally, the findings from citizen

science projects can be communicated back to the participants and wider public audiences, contributing to a more informed society and a more participatory approach to science (Dickinson et al., 2010; Hecker et al., 2018). Indeed, there is an argument that "communication in citizen science is always science communication" (Wagenknecht et al., 2021, p.1).

Citizen science also has the potential to enhance science communication. By involving public audiences in scientific research, citizen science can provide a platform for public engagement with science that is not always accessible through traditional methods of science communication, offering a way for individuals to contribute to scientific research and to have a stake in the scientific process, leading to greater public ownership of scientific knowledge (Bonney et al., 2016; Gunnell et al., 2021). The collaborative nature of citizen science can also lead to the development of new knowledge and innovative ways to address scientific problems (Haklay, 2013; Vohland et al., 2021). By exploring these potential synergies, it may be possible to develop more effective approaches to science communication that can help to build public trust in science and promote wider public participation in scientific research (Golumbic et al., 2020; Magalhães et al., 2022).

1.4 GlobalSCAPE: a global study of science communicators

From 2018–2020, the European Commission, through a funding call in the Science with and for Society (SwafS) pillar of Horizon 2020, the world's largest multinational research funding programme (Abbott, 2020), invited large-scale research proposals to take stock and re-examine the role of science communication (European Commission, 2020; Roche et al., 2021a). This was the first dedicated research funding call (rather than a "Coordination and Support Action") of its size offered by the European Commission for science communication research, and saw a total of eight projects funded (CONCISE, RETHINK, QUEST, TRESCA, NEWSERA, ParCos, ENJOI, and GlobalSCAPE), with an overall investment of almost €10 million (European Commission, 2022; Roche et al., 2023). These "SwafS-19" Projects (as they become known due to being the 19th topic in the final SwafS funding programme) were tasked with bringing together "journalists and science communicators, researchers, civil society groups, industry experts and policymakers," the so-called "quintuple helix" of stakeholders, to "examine issues such as quality of science communication, trust in science, and the mitigation of the spread and impact of misinformation, disinformation and fake news" (European Commission, 2022, p. 2). The NEWSERA project, for example, specifically focused on integrating citizen science and science communication in Europe and demonstrated that citizen science projects often interpret communication as more of dissemination activity without harnessing its potential for deeper engagement (Magalhães et al., 2022; Giardullo et al., 2023).

As the last of the eight SwafS-19 projects to commence from the (to-date) final research funding call from the European Commission in the specific area of science communication research, GlobalSCAPE had a responsibility to extend beyond the "disparate and fragmented" landscape of European science communication (Davies et al., 2021, p. 5) to attempt to take into account the experiences of science communicators around the world. This paper shares some of the first insights from the GlobalSCAPE project, which employed an innovative methodology comprising a longitudinal diary study of science communicators around the world to collect data on the challenges and opportunities they face as they navigate a rapidly changing field. There has been little consideration of the people who work across both citizen science and science communication, and how the experiences of such individuals may be investigated and better understood. The key question this paper seeks to answer is whether projects such as GlobalSCAPE can provide insights into the role of science communicators and if there is any overlap with citizen science. Given that science communication and citizen science can be powerful tools for providing opportunities for engagement with, or participation in, scientific research, together they have vast potential to reach beyond individual scientific disciplines to attract wider public participation in scientific research, address societal challenges, build greater trust between science and society, and promote more democratic science.

2 Methods

At the beginning of the GlobalSCAPE study, a baseline survey was developed to understand the backgrounds of potential participants before inviting them to enrol in the full longitudinal diary study. The findings of this paper are based on the data collected from that baseline survey. Ethical approval for the study was granted by a research ethics committee at the coordinating university, Trinity College Dublin.

The baseline survey was developed to include a wide range of profile questions about the science communicators, along with demographic information such as age and gender. It was first piloted with a sample of 23 participants from four continents, recruited by project partners using convenience and purposive sampling (Etikan et al., 2016; Obilor, 2023), to provide feedback on the clarity of the survey questions. The piloting stage included follow-up questions as the participants completed each step in the survey and, based on this feedback, each question and set of response options was tweaked and validated to generate the final version of the questions used in the baseline survey. The questions developed in the baseline survey—including their original versions, the edits and tweaks suggested by participants in the piloting stage, and the final versions of the questions used—are publicly available in the European Commission's open access repository, Open Research Europe (See Jensen et al., 2022). The data gathered from this piloting stage (excluding answers to open-ended questions to ensure data privacy) are also publicly available and can be accessed through Zenodo (See Jensen et al., 2021).

The baseline survey, and the recruitment emails, were made available in nine languages: Arabic, Chinese, English, French, German, Italian, Portuguese, Russian, and Spanish. To ensure the robustness and consistency of the recruitment emails, survey questions, and survey responses, a forward-backward translation methodology was used (Degroot et al., 1994). For each language, two different translators were involved: one translated the text forward from the original language to the target language and the other translator translated the text from the target language back into

the original language. Any discrepancies between the forward-backward translated text were then discussed between the translators to find consensus.

After the piloting stage, data collection for the baseline survey was implemented through a campaign to share the survey with science communicators around the world. Once again, convenience and purposive sampling was employed. In addition, however, snowball sampling (Handcock and Gile, 2011) was utilised as the project consortium shared an online version of the survey with their networks who, in turn, made their own referrals to science communicators. The GlobalSCAPE consortium included two universities (Trinity College Dublin and Leiden University), a research company (Qualia Analytics), an academic publishing company (Springer Nature), and two networks—Ecsite, the European network of science centres and museums, which offers the largest annual science engagement conference in Europe (Roche et al., 2018; Mignan and Joubert, 2022), and SciDev.Net, the leading science and technology journalism organisation for global development (Dickson, 2004; Massarani, 2004). Utilising these global networks, invitations were sent to science communicators in November 2021 and the survey was closed at the end of 2022 with over 900 respondents. The majority of participants were from Africa (29%), Europe (25%), and Asia (15%), with smaller levels of participation from North and South America and Oceania.

3 Results

3.1 Citizen science in global science communication

Relevant aspects of respondents' background and experience with science communication were a key focus of the study. Specifically, respondents were asked, *"Are you involved in communicating about science or research with people who are not scientists or researchers?"* The majority of respondents (n = 762, 81.5%) were actively involved in such public communication activities, while a smaller percentage only engaged occasionally (n = 137, 14.7%), and 3.9% (n = 36) did not engage at all. The key question, *"Do you consider yourself a science communicator?"* garnered 879 responses, with 87% indicating *"Yes"* or *"Sometimes"*. Building on this, the survey asked if people identified with a number of possible labels for their role as science communicators. 1712 responses were obtained from 963 participants. The most common role reported was *scientist or researcher* (n = 342, 35%), followed by *science writer or journalist* (n = 315, 33%), *science teacher or educator* (n = 253, 26%), and *science communication researcher* (n = 196, 20%). Less than 12% (n = 108, 11.2%) identified themselves as a *citizen scientist*. Of the respondents who identified as a *citizen scientist*, most respondents (n = 92, 87.6%) confirmed being actively involved in science communication. A Chi-square test assessing the relationship between gender and citizen scientist identification revealed no statistically significant effect ($X^2(2) = 3.760$, $p = .152$). There was no statistically significant relationship between age band and citizen scientist identification ($X^2(6) = 10.876$, $p = .092$). There was also no difference between those with a university degree (96%; n = 90) and those who did not have a degree (4%; n = 4) among those who indicated identifying as a citizen scientist (n = 94) ($X^2(3) = 0.89$, $p = .829$).

3.2 Correlation analysis: citizen scientist and other identities

The correlation between identification as a citizen scientist and other roles like volunteer in science communication, science teacher or educator, science performer, science communication researcher, and scientist or researcher was analysed (Table 1). These variables are discussed below in descending order based on the amount of variance explained by each statistically significant correlation. The strongest correlation identified was between the roles of citizen scientist and volunteer in science communication (r = 0.209, n = 963, $p < 0.001$). This relationship was statistically significant and accounted for 4.36% of the variance in the sample. This suggests that those who identify as citizen scientists are also likely to engage in voluntary science communication activities, or *vice versa*. The shared role indicates that citizen scientists are proactive in engaging with their communities, often working on a voluntary basis to translate and communicate scientific information.

Next, a significant relationship was found between the roles of citizen scientist and science teacher or educator (r = 0.141, n = 963, $p < 0.001$), accounting for 1.98% of the variance. This implies that citizen scientists often play an educational role, facilitating understanding of scientific concepts within their communities, or that some science educators and teachers identify as citizen scientists. This could involve informal citizen science education efforts, such as hosting workshops or giving talks, or more formal roles like teaching science in schools or other educational settings. The role of a citizen scientist also showed a significant correlation with that of a science performer (r = 0.112, n = 963, $p = 0.001$), which explained 1.25% of the variance. Science performers use theatrical or artistic means to communicate science to the public, and this link suggests that some citizen scientists might use similar, non-traditional formats to engage audiences with scientific content. A positive correlation was identified between the roles of citizen scientist and science communication researcher (r = 0.100, n = 963, $p = 0.002$), accounting for 1.00% of the variance. This suggests that some citizen scientists have research-oriented roles, studying the efficacy and methods of science communication.

Finally, a significant, yet slightly weaker correlation emerged between the roles of citizen scientist and scientist or researcher (r = 0.097, n = 963, $p = 0.003$), accounting for 0.94% of the variance. This indicates that a fraction of citizen scientists are also professional scientists or researchers, straddling the line between professional scientific investigation and community-based science communication.

3.3 Qualitative results: science communicators identifying as citizen scientists

Analysing the experiences of science communicators who identified as citizen scientists in the baseline survey offers rich insights into their multifaceted roles, challenges, and rewards. These individuals play a vital role in translating scientific concepts into digestible information, fostering scientific literacy. A thematic analysis (Braun and Clarke, 2021) was carried out on the responses from the 11.2% of science communicators who identified as citizen

TABLE 1 Correlation matrix for science communicator roles. This table demonstrates that in the baseline survey of science communicators (N = 963), the 11.2% who identified as citizen scientists identified with other roles to varying degrees of significance. "Volunteer in science communication" and "Science teacher or educator" were most significant.

Correlations										
Role		Variables								
		Public engagement professional	Science performer	Volunteer in science communication	Science museum or centre professional	Science communication researcher	Science teacher or educator	Scientist or researcher	Science writer or journalist	Science or research communicator
Citizen scientist	Pearson Correlation	−0.010	.112**	.209**	0.042	.100**	.141**	.097**	−0.023	−0.022
	Sig. (2-tailed)	0.907	0.001	0.001	0.194	0.002	0.001	0.003	0.476	0.804

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

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scientists. This involved coding the responses to an open-ended option in the survey for respondents to give their views on being a professional science communicator (Jensen et al., 2022) and identifying the themes that emerged from those answers in order of frequency (Jensen and Laurie, 2016). Seven key themes emerged: responsibility and engagement, passion for dissemination, continuous learning, simplification and accessibility, creative and contextual communication, perseverance amid challenges, and the fundamental importance of promoting scientific literacy. Examples of these seven main themes, in descending order of frequency mentioned, are presented below.

Responsibility and Engagement. Citizen scientists feel deeply tied to their communities, enhancing their commitment to science communication. They aim to foster dialogue that improves public understanding of science. One respondent said, *"Being able to inform without causing a stir in society."* Another respondent added, *"I think about responsibility when it comes to being a science communicator in the day-to-day experience."*

Passion for Science Dissemination. Respondents frequently highlighted their enthusiasm for science and dedication to sharing it with others. They are driven by the goal of making knowledge about science accessible. One participant encapsulated this view: *"My day-to-day experience as a science communicator is fulfilling. Reaching out and impacting lives is rewarding."*

Continuous Learning. Staying updated on scientific research is crucial to their role. This continuous learning helps them deliver accurate, timely information to public audiences and aids their personal and professional growth. One respondent stated, *"Being updated and knowledgeable about the latest scientific work."*

Distillation and Accessibility. The difficulty of converting complex science into understandable language is a significant challenge but an integral part of their role. They find making scientific knowledge accessible both challenging and fulfilling. A respondent summarised this challenge: *"Transform topics, sometimes complex, into simpler contexts."*

Creative and Contextual Communication. The respondents emphasised the importance of finding effective communication channels and methods that resonate with their audience. This involves creativity and understanding their audience's context. One respondent mentioned, *"Finding different channels to be able to communicate science or engage persons not related to scientific activities, in a way promote citizen science."*

Challenges and Perseverance. Despite their passion, citizen scientists face hurdles like public resistance to scientific findings and underappreciation of their work. One respondent encapsulated these challenges: *"Frustration. In general, [. . .] all the people who refuse to listen to facts or the particularly irritating people who shout 'wrong' or 'fake news' whenever I discuss the science behind complicated socio-political issues with them."*

4 Discussion

4.1 GlobalSCAPE findings and limitations

The findings offer a detailed examination of individuals who identify as science communicators and citizen scientists, unveiling the intersections and relationships among various roles within the landscape of science communication. Notably, the identification as citizen scientists was found among 11.2% of respondents, indicating that an overlap exists between the fields of science communication and citizen science. The correlational analysis revealed that these individuals are highly likely to engage in other roles, particularly as volunteers in science communication, science teachers or educators, science performers, science communication researchers, and scientists or researchers. While these correlations are statistically significant, they explain only a relatively small percentage of the total variance, implying that the identities and roles within the field of science communication are multifaceted and diverse.

Although previous studies have found links between citizen science and sustainability (Fritz et al., 2019; Fraisl et al., 2020; Skarzauskiene and Mačiulienė, 2021), and citizen science and education (Roche et al., 2020; Kloetzer et al., 2021; Quinnell et al., 2023), GlobalSCAPE is the first large-scale study of its kind to explore the link between science communication and citizen science in terms of the international cadre of science communicators. While an overlap between science communicators who bridge both disciplines was demonstrated, there were also limitations to the study. Although the number of science communicators who chose *citizen scientist* as part of their professional identity in the GlobalSCAPE survey is an interesting insight, the question was a close-ended question that invited participants to select their identities from a predefined list. That list was validated, with the rest of the questions at the piloting stage, but it still somewhat reduced the significance of the response rate compared to if the same number of participants had chosen that option in an open-ended question.

It is also not clear if each of the science communicators identifying as a citizen scientist were following the same definition of what a citizen scientist is. While the forward-backward translation methodology was used to bolster consistency among the different languages, for any high degrees of complexity there remain limitations to how uniform the understanding of the terminology can be in different languages (Ozolins et al., 2020). Although individuals whose practices relate to science are more likely to be clear on citizen science definitions (Roche et al., 2021b), there is still a chance that those identifying as a citizen scientist might be using a different understanding of what constitutes citizen science. While this complicates any extrapolations drawn from their choice, it is also an aspect that is endemic to citizen science research in general, with the complexity and variety of views, perceptions, and understandings of the terms "citizen science" and "citizen scientist" one of the few constants in the field of citizen science (Eitzel et al., 2017; Haklay et al., 2021; Haklay, 2023).

4.2 Implications

Science communicators who identify as citizen scientists exhibit a deep sense of responsibility and engagement, driven by a passion for science and a commitment to continuous learning. Despite challenges in translating complex scientific concepts into accessible language and navigating public resistance, their perseverance underscores the importance they place on science communication. This is especially important as citizen science

has ample capacity for transdisciplinarity and for integrating the natural, physical, and health sciences with the humanities and social sciences (Pykett et al., 2020; Tauginiene et al., 2020). Citizen science has been highlighted as means of harnessing non-traditional data sources to contribute to the Sustainable Development Goals of the United Nations (Fritz et al., 2019; Fraisl et al., 2020). For the people who bridge citizen science and science communication, there remain obstacles to be overcome. Citizen science does not always give due consideration to the perspective of participants (Phillips et al., 2019), there are enduring challenges with terminology, inclusion, and access to participation (Cooper et al., 2021), and there is even the potential for communities to be exploited under the guise of citizen science (Roche and Davis, 2017; Roy and Edwards, 2019). However, despite these hurdles, it is the vast potential of citizen science to reach beyond individual disciplines and attract wider public participation in scientific research that could be most beneficial in helping to tackle societal challenges.

The implication of these findings is that training and support mechanisms for these citizen scientists should prioritise skills in translating complex concepts, managing public resistance, and continuous learning. Moreover, their deep sense of commitment and passion underscores the need for greater recognition and appreciation of the role of citizen scientists in bridging the gap between science and society. The findings presented in this paper shed light on the multi-faceted nature of science communication roles around the world, and the diverse avenues through which citizen scientists engage with public audiences. Their commitments extend beyond a singular role, manifesting in various facets of science communication, thus enhancing the current understanding of the dynamism in this field. The findings also underscore the importance of recognising and harnessing the potential of these individuals. As the correlations demonstrate, the people who are both citizen scientists and science communicators often identify as volunteers and/or educators. These individuals help bridge citizen science and science communication and, in doing so, contribute to closing the gap between scientific research and public audiences. These citizen scientists are navigating multiple roles and challenges. Their passion for science, commitment to their communities, and sense of responsibility drive them to disseminate complex scientific knowledge in an accessible and engaging manner. Despite the challenges they face, their work is underpinned by the view that fostering public engagement with science is paramount.

Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Trinity College Dublin Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

JR: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing–original draft, Writing–review and editing. EJ: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing–original draft, Writing–review and editing. AJ: Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing–original draft, Writing–review and editing. LB: Writing–original draft, Writing–review and editing. MH: Writing–original draft, Writing–review and editing. AT: Project administration, Writing–original draft, Writing–review and editing. CB: Project administration, Resources, Writing–review and editing. JC: Project administration, Writing–review and editing. SC: Project administration, Resources, Writing–review and editing. KD: Project administration, Writing–review and editing. JK: Project administration, Writing–review and editing. LM: Project administration, Writing–review and editing. JP: Project administration, Writing–review and editing. PR: Project administration, Writing–review and editing. FS: Project administration, Writing–review and editing.

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Conflict of interest

Authors CB and SC were employed by the Company Ecsite. Author JK was employed by the Company Springer Nature. Author LM was employed by the Company SciDev Net. Author JP was employed by the Company Wiley.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Abbott, A. (2020). Farewell to europe's Horizon 2020. *Nature* 588 (7838), 371. doi:10.1038/d41586-020-03516-6

Achiam, M., Kupper, J. F. H., and Roche, J. (2022). Inclusion, reflection and co-creation: responsible science communication across the globe. *J. Sci. Commun.* 21 (4), E1. doi:10.22323/2.21040501

Andrews-Fearon, P., Götz, F. M., and Good, D. (2020). Pivotal moment for trust in science – don't waste it. *Nature* 580 (456), 456. doi:10.1038/d41586-020-01145-7

Balázs, B., Mooney, P., Nováková, E., Bastin, L., and Jokar Arsanjani, J. (2021). "Data quality in citizen science," in *The science of citizen science*. Editors K. Vohland, A. Land-Zandstra, L. Ceccaroni, R. Lemmens, J. Perelló, M. Ponti, et al. (Cham, Switzerland: Springer Nature), 139–157. doi:10.1007/978-3-030-58278-4_8

Besley, J. C., Dudo, A., and Yuan, S. (2018). Scientists' views about communication objectives. *Public Underst. Sci.* 27 (6), 708–730. doi:10.1177/0963662517728478

Besley, J. C., Garlick, S., Fallon Lambert, K., and Tiffany, L. A. (2021). The role of communication professionals in fostering a culture of public engagement. *Int. J. Sci. Educ. Part B* 11 (3), 225–241. doi:10.1080/21548455.2021.1943763

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., et al. (2009). Citizen science: a developing tool for expanding science knowledge and scientific literacy. *BioScience* 59 (11), 977–984. doi:10.1525/bio.2009.59.11.9

Bonney, R., Phillips, T. B., Ballard, H. L., and Enck, J. W. (2016). Can citizen science enhance public understanding of science? *Public Underst. Sci.* 25 (1), 2–16. doi:10.1177/0963662515607406

Braun, V., and Clarke, V. (2021). *Thematic analysis: a practical guide*. United Kingdom: SAGE.

Bubela, T., Nisbet, M. C., Borchelt, R., Brunger, F., Critchley, C., Einsiedel, E., et al. (2009). Science communication reconsidered. *Nat. Biotechnol.* 27 (6), 514–518. doi:10.1038/nbt0609-514

Bucchi, M. (2017). Credibility, expertise and the challenges of science communication 2.0. *Public Underst. Sci.* 26 (8), 890–893. doi:10.1177/0963662517733368

Bultitude, K. (2011). "The why and how of science communication," in *Science communication*. Editor P. Rosulek (Pilsen: European Commission), 31–58.

Burns, T. W., O'Connor, D. J., and Stocklmayer, S. M. (2003). Science communication: a contemporary definition. *Public Underst. Sci.* 12 (2), 183–202. doi:10.1177/09636625030122004

Cappa, F., Franco, S., and Rosso, F. (2022). Citizens and cities: leveraging citizen science and big data for sustainable urban development. *Bus. Strategy Environ.* 31 (2), 648–667. doi:10.1002/bse.2942

Cooper, C. B., Hawn, C. L., Larson, L. R., Parrish, J. K., Bowser, G., Cavalier, D., et al. (2021). Inclusion in citizen science: the conundrum of rebranding. *Science* 372 (6549), 1386–1388. doi:10.1126/science.abi6487

Davies, S. R. (2008). Constructing communication: talking to scientists about talking to the public. *Sci. Commun.* 29 (4), 413–434. doi:10.1177/1075547008316222

Davies, S. R., Franks, S., Roche, J., Schmidt, A. L., Wells, R., and Zollo, F. (2021). The landscape of European science communication. *JCOM J. Sci. Commun.* 20 (03), 1–19. doi:10.22323/2.20030201

Davies, S. R., and Horst, M. (2016). *Science communication: culture, identity and citizenship*. Cham, Switzerland: Springer Nature.

Degroot, A. M., Dannenburg, L., and Vanhell, J. G. (1994). Forward and backward word translation by bilinguals. *J. Mem. Lang.* 33 (5), 600–629. doi:10.1006/jmla.1994.1029

Dickinson, J. L., Shirk, J., Bonter, D., Bonney, R., Crain, R. L., Martin, J., et al. (2012). The current state of citizen science as a tool for ecological research and public engagement. *Front. Ecol. Environ.* 10 (6), 291–297. doi:10.1890/110236

Dickinson, J. L., Zuckerberg, B., and Bonter, D. N. (2010). Citizen science as an ecological research tool: challenges and benefits. *Annu. Rev. Ecol. Evol. Syst.* 41, 149–172. doi:10.1146/annurev-ecolsys-102209-144636

Dickson, D. (2004). Science and technology communication for development. *PLoS Biol.* 2 (1), e11. doi:10.1371/journal.pbio.0020011

Eitzel, M. V., Cappadonna, J. L., Santos-Lang, C., Duerr, R. E., Virapongse, A., West, S. E., et al. (2017). Citizen science terminology matters: exploring key terms. *Citiz. Sci. Theory Pract.* 2 (1), 1–20. doi:10.5334/cstp.96

Ellwood, E. R., Pauly, G. B., Ahn, J., Golembiewski, K., Higgins, L. M., Ordeñana, M. A., et al. (2023). Citizen science needs a name change. *Trends Ecol. Evol.* 38 (6), 485–489. doi:10.1016/j.tree.2023.03.003

Etikan, I., Musa, S. A., and Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *Am. J. Theor. Appl. statistics* 5 (1), 1–4. doi:10.11648/j.ajtas.20160501.11

European Commission (2022). "Empowering citizens in the public discussion of science," in *CORDIS Results Pack on science communication: a thematic collection of innovative EU-funded research results* (Luxembourg: Publications Office of the European Union). doi:10.2830/389864

European Commission (2020). *Horizon 2020 - work programme 2018-2020: science with and for society*. Available at: https://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-swfs_en.pdf (Accessed June 20, 2023).

Fähnrich, B., Riedlinger, M., and Weitkamp, E. (2020). Activists as "alternative" science communicators—exploring the facets of science communication in societal contexts. *J. Sci. Commun.* 19 (6), C01. doi:10.22323/2.19060301

Fähnrich, B. (2017). Science diplomacy: investigating the perspective of scholars on politics–science collaboration in international affairs. *Public Underst. Sci.* 26 (6), 688–703. doi:10.1177/0963662515616552

Fischhoff, B., and Scheufele, D. A. (2013). The science of science communication. *Proc. Natl. Acad. Sci.* 110 (3), 14031–14032. doi:10.1073/pnas.1312080110

Fraisl, D., Campbell, J., See, L., Wehn, U., Wardlaw, J., Gold, M., et al. (2020). Mapping citizen science contributions to the UN sustainable development goals. *Sustain. Sci.* 15, 1735–1751. doi:10.1007/s11625-020-00833-7

Fritz, S., See, L., Carlson, T., Haklay, M., Oliver, J. L., Fraisl, D., et al. (2019). Citizen science and the United Nations sustainable development goals. *Nat. Sustain.* 2 (10), 922–930. doi:10.1038/s41893-019-0390-3

Giardullo, P., Neresini, F., Marín-González, E., Luís, C., Magalhães, J., and Arias, R. (2023). Citizen science and participatory science communication: an empirically informed discussion connecting research and theory. *J. Sci. Commun.* 22 (2), A01. doi:10.22323/2.22020201

Golumbic, Y., Baram-Tsabari, A., and Fishbain, B. (2020). Engagement styles in an environmental citizen science project. *J. Sci. Commun.* 19 (06), A03. doi:10.22323/2.19060203

Gunnell, J. L., Golumbic, Y. N., Hayes, T., and Cooper, M. (2021). Co-created citizen science: challenging cultures and practice in scientific research. *J. Sci. Commun.* 20 (5), Y01–Y17. doi:10.22323/2.20050401

Haklay, M. (2023). "C*Sci 2023 and the new name of the (US) citizen science association," in *GIScience, citizen science and environmental information*. Po Ve Sham – Muki Haklay's personal blog.

Haklay, M. (2013). "Citizen science and volunteered geographic information: overview and typology of participation," in *Crowdsourcing geographic knowledge*. Editors D. Sui, S. Elwood, and M. Goodchild (Cham, Switzerland: Springer Nature), 105–122. doi:10.1007/978-94-007-4587-2_7

Haklay, M., Dörler, D., Heigl, F., Manzoni, M., Hecker, S., and Vohland, K. (2021). "What is citizen science? The challenges of definition," in *The science of citizen science*. Editors K. Vohland, A. Land-Zandstra, L. Ceccaroni, R. Lemmens, J. Perelló, M. Ponti, et al. (Cham, Switzerland: Springer Nature), 13–33. doi:10.1007/978-3-030-58278-4_2

Handcock, M. S., and Gile, K. J. (2011). Comment: on the concept of snowball sampling. *Sociol. Methodol.* 41 (1), 367–371. doi:10.1111/j.1467-9531.2011.01243.x

Hecker, S., Luckas, M., Brandt, M., Kikillus, H., Marenbach, I., Schiele, B., et al. (2018). "Stories can change the world — citizen science communication in practice," in *Citizen science. Innovation in open science, society and policy*. Editors S. Hecker, M. Haklay, A. Bowser, Z. Makuch, J. Vogel, and A. Bonn (London, U.K.: UCL Press), 445–462. doi:10.14324/111.9781787352339

Heigl, F., Kieslinger, B., Paul, K. T., Uhlik, J., and Dörler, D. (2019). Toward an international definition of citizen science. *Proc. Natl. Acad. Sci.* 116 (17), 8089–8092. doi:10.1073/pnas.1903393116

Horst, M., and Michael, M. (2011). On the shoulders of idiots: Re-thinking science communication as 'event. *Sci. as Cult.* 20 (3), 283–306. doi:10.1080/09505431.2010.524199

Howell, E. L., and Brossard, D. (2021). Mis) informed about what? What it means to be a science-literate citizen in a digital world. *Proc. Natl. Acad. Sci.* 118 (15), 1–8. doi:10.1073/pnas.1912436117

Hyland-Wood, B., Gardner, J., Leask, J., and Ecker, U. K. (2021). Toward effective government communication strategies in the era of COVID-19. *Humanit. Soc. Sci. Commun.* 8 (1), 30–11. doi:10.1057/s41599-020-00701-w

Irwin, A. (1995). *Citizen science: a study of people, expertise and sustainable development*. London, UK: Routledge. doi:10.4324/9780203202395

Iyengar, S., and Massey, D. S. (2019). Scientific communication in a post-truth society. *Proc. Natl. Acad. Sci.* 116 (16), 7656–7661. doi:10.1073/pnas.1805868115

Jensen, E. A., Jensen, A. M., Noles, S., and Pfleger, A. (2022). Developing and testing the GlobalSCAPE science communicator diary survey: methodological pilot research findings to improve a repeated-measures survey design. *Open Res. Eur.* 2 (18), 18–25. doi:10.12688/openreseurope.14246.1

Jensen, E. A., Jensen, A. M., Noles, S., and Pfleger, A. (2021). GlobalSCAPE diary survey pilot [data set]. *Zenodo* 2021. doi:10.5281/zenodo.5706117

Jensen, E., and Laurie, C. (2016). *Doing real research: a practical guide to social research*. England: SAGE.

Jensen, E. (2014). The problems with science communication evaluation. *J. Sci. Commun.* 13 (1), 1–3. doi:10.22323/2.13010304

Jordan, R., Crall, A., Gray, S., Phillips, T., and Mellor, D. (2015). Citizen science as a distinct field of inquiry. *BioScience* 65 (2), 208–211. doi:10.1093/biosci/biu217

Katapally, T. R. (2020). A global digital citizen science policy to tackle pandemics like COVID-19. *J. Med. Internet Res.* 22 (5), e19357. doi:10.2196/19357

Kloetzer, L., Lorke, J., Roche, J., Golumbic, Y., Winter, S., and Jõgeva, A. (2021). "Learning in citizen science," in *The science of citizen science*. Editors K. Vohland, A. Land-Zandstra, L. Ceccaroni, R. Lemmens, J. Perelló, M. Ponti, et al. (Cham, Switzerland: Springer Nature), 283–308. doi:10.1007/978-3-030-58278-4_15

Koivumäki, K., and Wilkinson, C. (2020). Exploring the intersections: researchers and communication professionals' perspectives on the organizational role of science communication. *J. Commun. Manag.* 24 (3), 207–226. doi:10.1108/jcom-05-2019-0072

Kosmala, M., Wiggins, A., Swanson, A., and Simmons, B. (2016). Assessing data quality in citizen science. *Front. Ecol. Environ.* 14 (10), 551–560. doi:10.1002/fee.1436

Kullenberg, C., and Kasperowski, D. (2016). What is citizen science? A scientometric meta-analysis. *PloS one* 11 (1), e0147152. doi:10.1371/journal.pone.0147152

Lewandowski, E., Caldwell, W., Elmquist, D., and Oberhauser, K. (2017). Public perceptions of citizen science. *Citiz. Sci. Theory Pract.* 2 (1), 3–9. doi:10.5334/cstp.77

Lewenstein, B. V. (2022). Is citizen science a remedy for inequality? *Ann. Am. Acad. Political Soc. Sci.* 700 (1), 183–194. doi:10.1177/00027162221092697

Lin Hunter, D. E., Newman, G. J., and Balgopal, M. M. (2023). What's in a name? The paradox of citizen science and community science. *Front. Ecol. Environ.* 21 (5), 244–250. doi:10.1002/fee.2635

Magalhães, J., Guasch, B., Arias, R., Giardullo, P., Elorza, A., Navalhas, I., et al. (2022). A methodological approach to co-design citizen science communication strategies directed to quadruple-helix stakeholders. *J. Sci. Commun.* 21 (04), A05–A20. doi:10.22323/2.21040205

Massarani, L., Bray, H. J., Joubert, M., Ridgway, A., Roche, J., Smyth, F., et al. (2023). The distribution of science communication teaching around the globe. *J. Sci. Commun.* (In Review).

Massarani, L. (2004). *Challenges for science communication in Latin America*. Available at: https://www.proquest.com/openview/17f9eb562e219b06bfa6ff0a81b81643/1?pq-origsite=gscholarandcbl=5572319.

Massarani, L., Murphy, P., and Lamberts, R. (2020). COVID-19 and science communication: a JCOM special issue. Part 2. *J. Sci. Commun.* 19 (7). doi:10.22323/2.19070501

Meentemeyer, R. K., Dorning, M. A., Vogler, J. B., Schmidt, D., and Garbelotto, M. (2015). Citizen science helps predict risk of emerging infectious disease. *Front. Ecol. Environ.* 13 (4), 189–194. doi:10.1890/140299

Mercer-Mapstone, L., and Kuchel, L. (2017). Core skills for effective science communication: a teaching resource for undergraduate science education. *Int. J. Sci. Educ. Part B* 7 (2), 181–201. doi:10.1080/21548455.2015.1113573

Mignan, V., and Joubert, M. (2022). # ecsite2022—a festive and reflexive gathering of science communicators. *J. Sci. Commun.* 21 (6), R04. doi:10.22323/2.21060604

Obilor, E. I. (2023). Convenience and purposive sampling techniques: are they the same. *Int. J. Innovative Soc. Sci. Educ. Res.* 11 (1), 1–7.

Ozolins, U., Hale, S., Cheng, X., Hyatt, A., and Schofield, P. (2020). Translation and back-translation methodology in health research–a critique. *Expert Rev. pharmacoeconomics outcomes Res.* 20 (1), 69–77. doi:10.1080/14737167.2020.1734453

Phillips, T. B., Ballard, H. L., Lewenstein, B. V., and Bonney, R. (2019). Engagement in science through citizen science: moving beyond data collection. *Sci. Educ.* 103 (3), 665–690. doi:10.1002/sce.21501

Pykett, J., Chrisinger, B., Kyriakou, K., Osborne, T., Resch, B., Stathi, A., et al. (2020). Developing a Citizen Social Science approach to understand urban stress and promote wellbeing in urban communities. *Palgrave Commun.* 6 (1), 85–11. doi:10.1057/s41599-020-0460-1

Quinnell, R., Motion, A., Illingworth, S., Calyx, C., Bray, H., and Borda, A. (2023). Citizen science in Australian higher education: emerging learning and research communities. *Int. J. Innovation Sci. Math. Educ.* 31 (1), 1–14. doi:10.30722/ijisme.31.01.001

Roche, J., Arias, R., Bell, L., Boscolo, M., Fornetti, A., Knutas, A., et al. (2021a). Taking stock and Re-examining the role of science communication. *Front. Environ. Sci.* 9 (734081), 1–5. doi:10.3389/fenvs.2021.734081

Roche, J., Barber, G. L., Bell, L., Brown, A., Crean, S., Darling, O., et al. (2023). Interrogating illusions of progress: citizen science, science communication, and a call for inclusive reform. *Front. Environ. Sci. Sec. Environ. Citiz. Sci.* 11. doi:10.3389/fenvs.2023.1269816

Roche, J., Bell, L., Galvão, C., Golumbic, Y. N., Kloetzer, L., Knoben, N., et al. (2020). Citizen science, education, and learning: challenges and opportunities. *Front. Sociol.* 5 (613814), 613814–613910. doi:10.3389/fsoc.2020.613814

Roche, J., and Davis, N. (2017). Citizen science: an emerging professional field united in truth-seeking. *J. Sci. Commun.* 16 (04), R01. doi:10.22323/2.16040601

Roche, J., Davis, N., Stanley, J., and Hurley, M. (2018). The annual Ecsite conference: an engagement and education forum for science museums. *J. Mus. Educ.* 43 (1), 78–82. doi:10.1080/10598650.2017.1407908

Roche, J., Ni Shuilleabhain, A., Mooney, P., Barber, G. L., Bell, L., and Ryan, C. (2021b). Citizen science in Ireland. *Front. Commun.* 6 (629065), 1–8. doi:10.3389/fcomm.2021.629065

Roy, S., and Edwards, M. (2019). Citizen science during the flint, Michigan federal water emergency: ethical dilemmas and lessons learned. *Citiz. Sci. Theory Pract.* 4 (1), 1–28. doi:10.5334/cstp.154

Ryan, S. F., Adamson, N. L., Aktipis, A., Andersen, L. K., Austin, R., Barnes, L., et al. (2018). The role of citizen science in addressing grand challenges in food and agriculture research. *Proc. R. Soc. B* 285, 20181977. doi:10.1098/rspb.2018.1977

Schäfer, M. S. (2016). Mediated trust in science: concept, measurement and perspectives for the `science of science communication'. *J. Sci. Commun.* 15 (5), C02. doi:10.22323/2.15050302

Scheufele, D. A., and Krause, N. M. (2019). Science audiences, misinformation, and fake news. *Proc. Natl. Acad. Sci.* 116 (16), 7662–7669. doi:10.1073/pnas.1805871115

Scheufele, D. A. (2014). Science communication as political communication. *Proc. Natl. Acad. Sci.* 111 (4), 13585–13592. doi:10.1073/pnas.1317516111

Silvertown, J. (2009). A new dawn for citizen science. *Trends Ecol. Evol.* 24 (9), 467–471. doi:10.1016/j.tree.2009.03.017

Simis, M. J., Madden, H., Cacciatore, M. A., and Yeo, S. K. (2016). The lure of rationality: why does the deficit model persist in science communication? *Public Underst. Sci.* 25 (4), 400–414. doi:10.1177/0963662516629749

Skarzauskiene, A., and Mačiulienė, M. (2021). Citizen science addressing challenges of sustainability. *Sustainability* 13 (24), 13980. doi:10.3390/su132413980

Tauginienė, L., Butkevičienė, E., Vohland, K., Heinisch, B., Daskolia, M., Suškevičs, M., et al. (2020). Citizen science in the social sciences and humanities: the power of interdisciplinarity. *Palgrave Commun.* 6 (1), 89–11. doi:10.1057/s41599-020-0471-y

Trench, B. (2008). "Towards an analytical framework of science communication models," in *Communicating science in social contexts* (Cham, Switzerland: Springer Nature), 119–135.

Vohland, K., Land-Zandstra, A., Ceccaroni, L., Lemmens, R., Perelló, J., Ponti, M., et al. (2021). "The science of citizen science evolves," in *The science of citizen science*. Editors K. Vohland, A. Land-Zandstra, L. Ceccaroni, R. Lemmens, J. Perelló, M. Ponti, et al. (Cham, Switzerland: Springer Nature), 1–12. doi:10.1007/978-3-030-58278-4

Wagenknecht, K., Woods, T., Nold, C., Rüfenacht, S., Voight-Heucke, S., Caplan, A., et al. (2021). A question of dialogue? Reflections on how citizen science can enhance communication between science and society. *J. Sci. Commun.* 20 (3), A13–A22. doi:10.22323/2.20030213

Wamsler, C., and Brink, E. (2014). Interfacing citizens' and institutions' practice and responsibilities for climate change adaptation. *Urban Clim.* 7, 64–91. doi:10.1016/j.uclim.2013.10.009

Weingart, P., and Guenther, L. (2016). Science communication and the issue of trust. *J. Sci. Commun.* 15 (05), C01. doi:10.22323/2.15050301

Weingart, P., and Joubert, M. (2019). The conflation of motives of science communication—causes, consequences, remedies. *J. Sci. Commun.* 18 (3), Y01. doi:10.22323/2.18030401