Citizen science and science communication: toward a more inclusive pattern?

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Abstract

Despite research calls in citizen science and science communication for more participatory approaches, practical attempts are uncommon. This practice insight focuses on a significant barrier to adopting a participatory approach — the lack of inclusion. In this project, I identified the barriers and determinants of inclusion through a literature review, and then I developed and tested a framework applicable to participatory science communication projects to determine if projects recognise and address inclusion considerations. I successfully tested the framework using reports from a European citizen science project. By considering inclusion criteria as essential for participatory science communication, this framework may help practitioners account for inclusion considerations during the design and monitoring stages of the project cycle.

Keywords Citizen science; Social inclusion

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Introduction

Researchers call for more meaningful participation between scientists and non-scientists [Hecker, 2022], to help deal with the increasing complexity of societal problems [Irwin, 2008] and to create better policies [e.g., Giardullo, 2023].

Scholars have introduced the term "participatory science communication" [e.g., Giardullo et al., 2023] to capture how citizen science (CS) and science communication (SciComm) projects are used as mechanisms for bringing scholars and practitioners together with citizens to discover meaningful results that can transform our societies. The aim is to shift the paradigm from public understanding of science to a more integrated framework, where non-scientists are not mere recipients of top-down messages but take part in projects and the knowledge production process [Giardullo et al., 2023]. However, this paradigm shift is difficult to find in practice. Indeed, projects have tended to consider communication as a disseminating activity [Giardullo et al., 2023], thus overlooking the need to build such an integrated framework.

Shifting towards the actual participation of non-scientists in these projects is a demanding task. Besides allowing their horizontal participation, this shift aims to enable everyone to act in different stages of the research process. A two-way commitment between the scientific community and lay society should be envisaged [Campos, 2022; Giardullo et al., 2023], thus creating a hybrid space where theory and practice, and scientists and non-scientists meet [Campos, 2022]. However, several threats can endanger this process, in particular, the lack of inclusion of certain communities. Many studies have recognised that participants tend to be white adults with high income and education levels [see, for example, Cooper et al., 2021; Lewenstein, 2022; Paleco, García Peter, Salas Seoane, Kaufmann & Argyri, 2021]. This lack of diversity deepens the gap between those who participate in (and benefit from) these activities and those who do not. For instance, Paleco et al. [2021] analysed how inclusion is addressed in CS projects by evaluating, for example, gender and diversity among participants. They argue that projects must be grounded in local concerns and designed to respect and respond to the diversity of community membership. Cooper et al. [2021] argue that the use of the contested term "citizen science" could also affect approaches to inclusion. From their perspective, the focus should be on strategic planning to advance accessibility, justice, equity, diversity, and inclusion.

In this practice insight, I intend to shed light on the inclusion issue by developing and testing a framework for recognising and addressing topics associated with its lack. To this end, the literature on science communication is analysed from an intersectional viewpoint [for example, Paleco et al., 2021] to identify barriers and determinants of inclusion. Then, based on this review, a framework is developed and tested through a case study — a European CS project. This article contributes to practice by presenting a framework to help practitioners assess their progress towards achieving goals related to inclusive science communication in these types of projects. It can be used to encourage discussions at the start of these projects and prompt constant reflection on the efforts made when carrying out these activities.

ACTION, the case study of this article

ACTION[1] (participatory science toolkit against pollution) was a three-year programme that ended its activities in January 2022. It included throughout Europe ten research and third-sector organisations, universities, institutes, small businesses, and 16 citizen science pilots — some selected through an open call. It intended to create a CS project that moved toward a more participatory, inclusive, citizen-led one from a mostly scientist-led process. ACTION applied a CS approach to tackle environmental pollution. It created guidelines to help democratise the scientific process and allow anyone to realise a CS project. Given the clear potential of this CS project, ACTION was used as a case study to test the framework developed. To do so, I conducted an analysis of documents produced from this large, complex, multi-partner case study and evaluated if these recognised and addressed threats to inclusion. More in detail, the following section describes the method employed: Directed qualitative content analysis. By keeping in mind that with this method there is a deductive use of the literature, directed qualitative content analysis helped identify themes from the SciCom literature, create the evaluation framework, and then test it using the ACTION project.

[1] This section is taken from the ACTION toolkit [Thuermer, 2022].

Methods

Since the ACTION project was already completed at the time of data collection, I used the final publications produced from the project as the primary data sources for the document analysis. In total, ACTION issued 51 research reports [ACTION project, 2023]. These were manually scanned by reading their titles and abstracts from the website. Based on this manual scanning, the criteria used to include or exclude publications from this study were aligned with the scope of this project; in other words, whether publications had a link with the inclusion issue in CS and SciCom projects. Therefore, the documents included in this study were the following:

- D5.4 Initial Guidelines and Tools for Community Engagement and Monitoring [Janssen, Groen & Wittmayer, 2020]: A guideline for community engagement and monitoring,
- D5.5 Final Guidelines and Tools for Community Engagement and Monitoring [Janssen & Wittmayer, 2022]: An outline of the strategies CS projects can use to increase community participation,
- Participatory Science Toolkit Against Pollution [Thuermer, 2022]: The resource for implementing a CS project in the ACTION way,
- Brainstorming Inclusion Workshop [Austen, 2021]: Materials used to identify opportunities and include missing stakeholders in the project design.

Although document analysis can occur according to different procedures, directed qualitative content analysis was employed. This method follows a deductive approach starting from existing theories or other frameworks. Thus, in light of the literature review on science communication, it represented the most apt method to use.

Before proceeding with the study, preliminary steps were taken for the so-called arrangement phase [Elo & Kyngäs, 2008]. Since the objective was to understand whether and to what extent the problems associated with lack of inclusion in citizen science were recognised and addressed in the project, this study used individual themes as units of analysis. In this way, it was possible to look at what the documents expressed in terms of relevance to the scope of this article, regardless of the length of the text fragment.

After having determined these aspects, I followed the steps described by Mayring [2014] to define a category system from the literature review. I defined a coding guideline and conducted a material run-through of the documents. I revised the categories and coding guidelines based on the run-through. Then, I conducted a final working through the material and the document analysis.

The first and second steps (i.e., the definition of the category system from the literature review and the definition of the coding guideline) are now presented. Given the aim of this practice insight to develop and test a framework for promoting inclusion, which could be used to assess the contributions of projects towards this goal, I reviewed the existing literature on science communication from

an intersectional viewpoint. From this analysis, I identified the main barriers and determinants of inclusion to develop the framework. It is necessary to underline that some important aspects may appear to be missing from the framework, such as cultural gaps. However, they are either included within other barriers/determinants or they were not identified through the literature review. Aligned with the approaches taken in other research [e.g., Humm & Schrögel, 2020], I distinguished barriers and determinants as material and non-material. Finally, I split barriers and determinants based on their focus on communities or projects/communicators. Following Tables 1, 2, 3 and 4, each code was defined according to what had emerged in the systematic literature review. The *italic style* was used when barriers and determinants focused on both communities and projects/communicators.

Table 1 provides a list of themes drawn from the existing literature that relate to barriers that have been considered to impede community or community member involvement in science communication-related projects. Of particular note are the lack of science capital, wrong self- and outside perceptions, and science identities. According to the first, science communication practices do not include the different knowledges that communities hold and can bring to the table. The second looks at the identity that people from disadvantaged contexts are assigned or align with, which affirms that science is not for them.

Table 1: Definition of Coding Guidelines for Barriers in Communities.

Barriers in communities	Definitions
Lack of infrastructures and opportunities	Lack of local SciComm opportunities in the neighbourhood [e.g., Habibi Doroh & Streicher, 2021; Humm, Schrögel & Leßmöllmann, 2020; Rocha, Massarani, Abreu, Inacio & Molenzani, 2020]
Difficult socio-economic contexts	People of disadvantaged background who do not have time and/or resources to participate (e.g., due to shift work) [e.g., Dawson, 2018; Humm et al., 2020; Habibi Doroh & Streicher, 2021]
Lack of informal experiences	Lack of clubs in schools (e.g., STEM disciplines) and role models from the neighbourhood [Keith & Kerr, 2022; Humm et al., 2020]
Lack of a common language	Communicators and practitioners can not understand each other (e.g., native vs non-native speakers, usage of a scientific language, lack of cultural expressions and metaphors) [e.g., Humm & Schrögel, 2020; Habibi Doroh & Streicher, 2021; Humm et al., 2020; Taylor & Dewsbury, 2018; Rocha et al., 2020]
(emotional) distance	People feel that they are not taken seriously due to culture views and practices of the socially dominant [Humm et al., 2020; Dawson, 2018]
Lack of science capital	Lack of different experiences, knowledge, and understandings of science [e.g., Canfield & Menezes, 2020; Dawson, 2018; Archer, Dawson, DeWitt, Seakins & Wong, 2015; House of Commons, Science and Technology Committee, 2017]

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Table 1: *Continued from the previous page.*

Barriers in communities	Definitions
Lack of support from family and neighbourhood	Lack or negative involvement of parents and neighbourhoods [Keith & Kerr, 2022]
Negative familiarity	Feelings of fear and insecurity due to lack or negative familiarity (e.g., at school) [e.g., Archer et al., 2015; Humm et al., 2020]
Wrong self- and outside perception and science identities	The type of identity that people wear when dealing with science (e.g., "this is not for me") [e.g., Keith & Kerr, 2022; Humm et al., 2020]

Table 2 provides a list of themes drawn from the existing literature that relate to barriers for projects and communicators, which render them unable to include communities and their members in science communication-related projects. Noteworthy is the openness paradox. Indeed, when projects require greater participation among community members, practitioners should be aware of the skills and knowledge that participants need to partake in and perform tasks.

Table 2. Definition of Coding Guidelines for Barriers in Projects and Among Communicators.

Barriers in project/communicators	Coding guidelines
Lack of long-term relationships	Usage of one-off activities, lack of information sharing and collaborating [e.g., Cvitanovic, Cunningham, Dowd, Howden & van Putten, 2017; Humm & Schrögel, 2020]
Lack of evaluation	Lack of assessments of inclusion efforts [e.g., Matias, Dias, Gonçalves, Vicente & Mena, 2021, 2021]
Lack of funding	Lack of support to be effective and efficient through knowledge, training, practice, and peer networks [Canfield & Menezes, 2020]
Lack of a common language	Communicators and practitioners can not understand each other (e.g., native vs non-native speakers, usage of a scientific language, lack of cultural expressions and metaphors) [e.g., Humm & Schrögel, 2020; Habibi Doroh & Streicher, 2021; Humm, Schrögel & Leßmöllmann, 2020; Taylor & Dewsbury, 2018; Rocha, Massarani, Abreu, Inacio & Molenzani, 2020]
The openness paradox	The more open the project, the more prior knowledge and initiative the participants need [Humm & Schrögel, 2020; Wagenknecht et al., 2021]

Table 3 provides a list of themes drawn from the existing literature that relate to determinants considered to facilitate community or community members' involvement in science communication-related projects. Of particular note is the need to include in these projects topics aligned to communities' interests, bearing in mind that participants do not have to embrace practitioners' cognitive frameworks.

Table 3. Definition of Coding Guidelines for Determinants in Communities.

Determinants in communities	Coding guidelines
Everyday life topics	Topics chosen according to an audience's interests, experiences, and knowledge [e.g., Habibi Doroh & Streicher, 2021; Humm & Schrögel, 2020]
Cultural norms of the community	Keeping in mind the role of cultural norms, values, and beliefs [Keith & Kerr, 2022]

Table 4 provides a list of themes drawn from the existing literature that relate to determinants for projects and communicators, supporting the inclusion of communities and their members in science communication-related projects. Of particular note is interrogation/reflection, which focuses on the need for practitioners and scholars to recognise the systems in which science is embedded and its consequences at large for science itself and society.

Table 4. Definition of Coding Guidelines for Determinants in Project and Among Communicators.

Determinants in projects/communicators	Coding guidelines
Interrogation/reflection	Recognising the framework in which science is carried out and the identities of communities and practitioners [Achiam, Kupper & Roche, 2022; Canfield & Menezes, 2020; Dawson, 2018]
Everyday life topics	Topics chosen according to an audience's interests, experiences, and knowledge [e.g., Habibi Doroh & Streicher, 2021; Humm & Schrögel, 2020]
Cultural norms of the community	Keeping in mind the role of cultural norms, values, and beliefs [Keith & Kerr, 2022]

Step 3 concerned the 'material run-through' (refer to appendix A for the entire process). Table 5 presents a thematic analysis of the document D5.4 Initial Guidelines and Tools for Community Engagement and Monitoring [Janssen et al., 2020]. The table shows the position of relevant text fragments in the document and the reason for coding them.

Table 5. Text Coding of D5.4 Initial Guidelines and Tools for Community Engagement and Monitoring [Janssen, Groen & Wittmayer, 2020].

Page (top, middle, bottom)	Main category	Reason for coding
Page 13 (t)	Interrogation/reflection	Recognition of biases that can exacerbate inequalities and imbalances
Page 13 (m)	Everyday life topics	Citizens consider other issues more important, but the focus is not on inclusion
Page 14 (t)	Lack of long-term relationships	Recognition of their importance, but the focus is not on inclusion
Page 15 (b)	Lack of long-term relationships	Recognition of their importance, but the focus is not properly on inclusion
Page 16 (t)	Lack of a common language	Recognition of its importance, but the focus is not properly on inclusion
Page 17 (t)	Lack of funding	Recognition of its importance, but the focus is not on inclusion
Page 17 (m + b)	Difficult socio-economic contexts	Recognition of its importance, but the focus is not properly on inclusion
Page 17 (m)	Knowledge deficit model	Inadequate knowledge is a barrier to participation, but the focus is not on inclusion
Page 30 (t)	Negative familiarity	Anxiety to perform a task, as this is the cause for not participating
Page 30 (t)	Knowledge deficit model	Inadequate knowledge is a barrier to participate
Page 30 (b)	Knowledge deficit model	Citizens are a funnel, and scientists have to fill them
Page 31 (t)	Everyday life topics	Recognition of its importance, but the focus is not on inclusion
Page 31 (t)	Lack of science capital	Recognition of its importance, but the focus is not on inclusion
Page 32 (m)	Negative familiarity	They do not want school logos, but the focus is not on inclusion

Findings and discussion

Tables 6, 7, 8 and 9 show the results from carrying out Step 4, which was the revision of the categories and coding guidelines. This step required removing categories emerging from the literature review that were not found in the documents, such as considering cultural norms of communities or the openness paradox and adding another category. As for the latter, it was the knowledge deficit model, a barrier for projects and communicators. Finally, the definitions did not need to be changed.

Table 6 shows that practitioners recognised many community-focused barriers in the project, such as difficult socio-economic contexts and lack of different science capital, which negatively affected the engagement of community members. However, they failed to report other barriers, such as lack of infrastructure, lack of informal experiences and lack of support from families (see Table 1).

Table 6. Definitive Category System for Barriers in Communities.

Barriers in communities	Coding guidelines
Difficult socio-economic contexts	People of disadvantaged background who do not have time and/or resources to participate (e.g., due to shift work) [e.g., Dawson, 2018; Humm, Schrögel & Leßmöllmann, 2020; Habibi Doroh & Streicher, 2021]
Lack of a common language	Communicators and practitioners can not understand each other (e.g., native vs non-native speakers, usage of a scientific language, lack of cultural expressions and metaphors) [e.g., Humm & Schrögel, 2020; Habibi Doroh & Streicher, 2021; Humm, Schrögel & Leßmöllmann, 2020; Taylor & Dewsbury, 2018; Rocha, Massarani, Abreu, Inacio & Molenzani, 2020]
(emotional) distance	People feel that they are not taken seriously due to culture views and practices of the socially dominant [Humm, Schrögel & Leßmöllmann, 2020; Dawson, 2018]
Lack of science capital	Lack of different experiences, knowledge, and understandings of science [e.g., Canfield & Menezes, 2020; Dawson, 2018; Archer, Dawson, DeWitt, Seakins & Wong, 2015; House of Commons, Science and Technology Committee, 2017]
Negative familiarity	Feelings of fear and insecurity due to a lack or negative familiarity (e.g., at school) [e.g., Archer, Dawson, DeWitt, Seakins & Wong, 2015; Humm, Schrögel & Leßmöllmann, 2020]

Table 7 shows that communicators in the project recognised many of the barriers that can negatively affect their work, such as the need to address the lack of long-term relationships and evaluation in these activities. However, they did not recognise the paradox emerging from opening this type of project (see Table 2). Moreover, related to communicator activities, an additional barrier to inclusiveness was identified through the document analysis: The "knowledge deficit model" [e.g., Gross, 1994]. Although lack of knowledge and awareness can be barriers to participation, a framing of participation in this way can be a significant barrier for

inclusion. According to this model of science communication, people need adequate (scientific) knowledge in order to participate. However, by focusing on the need for scientific knowledge, project coordinators may not recognise the added value that a given community can contribute in terms of alternative knowledge and viewpoints.

Table 7. Definitive Category System for Barriers in Projects and Among Communicators.

Barriers in project/communicators	Coding guidelines
Lack of long-term relationships	Usage of one-off activities, lack of information sharing and collaborating [e.g., Cvitanovic, Cunningham, Dowd, Howden & van Putten, 2017; Humm & Schrögel, 2020]
Lack of evaluation	Lack of assessments of inclusion efforts [e.g., Matias, Dias, Gonçalves, Vicente & Mena, 2021, 2021]
Lack of funding	Lack of support to be effective and efficient through knowledge, training, practice, and peer networks [Canfield & Menezes, 2020]
Lack of a common language	Communicators and practitioners can not understand each other (e.g., native vs non-native speakers, usage of a scientific language, lack of cultural expressions and metaphors) [e.g., Humm & Schrögel, 2020; Habibi Doroh & Streicher, 2021; Humm, Schrögel & Leßmöllmann, 2020; Taylor & Dewsbury, 2018; Rocha, Massarani, Abreu, Inacio & Molenzani, 2020]
Knowledge deficit model	The audience is an 'empty vessel' that should be filled with facts and knowledge [e.g., Gross, 1994]

Regarding determinants in communities and projects and communicators (Tables 8 and 9), practitioners recognised the importance of considering everyday life topics in projects and reflecting on the framework in which science is embedded. At the same time, they did not seem to take into account the relevance of the cultural norms of the communities with whom they wanted to work (Tables 3 and 4).

Table 8. Definitive Category System for Determinants in Communities.

Determinants in communities	Coding guidelines
Everyday life topics	Topics chosen according to an audience's interests, experiences, and knowledge [e.g., Habibi Doroh & Streicher, 2021; Humm & Schrögel, 2020]

These results are fundamental to testing the framework developed. Although the literature review identified several barriers and determinants to reaching goals of inclusive citizen science and science communication, the case study analysed did not appear to exhaustively consider inclusion and reproduced some patterns that

Table 9. Definitive Category System for Determinants in Projects and Among Communicators.

Determinants in projects/communicators	Coding guidelines
Interrogation/reflection	Recognising the framework in which science is carried out and the identities of communities and practitioners [Achiam, Kupper & Roche, 2022; Canfield & Menezes, 2020; Dawson, 2018]
Everyday life topics	Topics chosen according to an audience's interests, experiences, and knowledge [e.g., Habibi Doroh & Streicher, 2021; Humm & Schrögel, 2020]

hindered achieving goals related to inclusivity.

By starting with barriers in communities (Table 6), the documents recognised how difficult economic conditions could affect the involvement of community members, including the cost of participating [e.g., Thuermer, 2022, p. 24]. They included in two instances [Janssen & Wittmayer, 2022, p. 12; Janssen et al., 2020, p. 31] that diverse science capital, such as different experiences and understanding of science, can be beneficial in making participants more comfortable. They tried to reduce the (emotional) distance by creating a comfortable space where everyone was respected [Austen, 2021, p. 12]. Then, they acknowledged the importance of having inclusive language [Janssen & Wittmayer, 2022, p. 12] and how unfamiliarity can increase anxiety about performing a task [Janssen & Wittmayer, 2022, p. 30]. Concerning barriers for projects and communicators (Table 7), the importance of long-term relationships and networking were prioritised. It was the case, for instance, of the roadmap for diversity and accessibility [Janssen & Wittmayer, 2022, p. 12], which underlined the need to engage local organisations. The same could be said for the need to improve training and funding [Janssen et al., 2020, p. 17]. More importantly, the documents highlighted an approach that could be placed under the knowledge deficit model, as already explained. Indeed, lack of scientific knowledge and awareness were considered barriers without fully appreciating the other types of knowledge that community members had and could bring to ACTION, thus undermining the instances where science capital was mentioned.

Regarding determinants for communities and projects and communicators (Tables 8 and 9), the documents captured reflections about why individuals participate in these projects, as in Janssen et al. [2020, p. 13]. Similarly, ACTION acknowledged the relevance of communities' everyday life topics and the consequent need for a bottom-up approach, just as the example provided by Thuermer [2022, p. 14].

Despite this recognised work by ACTION, Table 5 and appendix A show that the focus of these strategies was not inclusion but rather engagement, motivation, and, in some cases, diversity. Considering the framework for assessing progress towards inclusion goals described in this practice insight, inclusion should not be conceived as broadening access to existing pathways. Indeed, this would mean forcing marginalised people to participate in spaces that have historically excluded

them [Canfield & Menezes, 2020]. In addition, focusing on access reflects deficit model-thinking (a barrier added to this study), where people are to be blamed because they are not interested in science. Although projects can underline the importance of having participants' different experiences and knowledge of science, if their general approach considers a lack of scientific interest and knowledge as a barrier to participation, then this can overshadow approaches that privilege culture and the views of communities, and obscure the economic, political, social, and historical factors that affect inclusion.

Conclusions

The framework described in this practice insight captures many of the challenges that researchers and practitioners face when dealing with inclusion in projects involving non-scientists. In addressing these challenges to inclusion, one has to take into account many facets, from the economy to the historical field, bearing in mind that inclusion can be affected by material and non-material factors. ACTION, a large-scale CS project, has demonstrated how demanding this task is. A single case study is not generalisable, and inclusivity is highly dependent on the context and aim of the projects. This framework does not, therefore, represent a set of rules to follow in every project. However, it provides important prompts for reflection in the project development stage, and a mechanism for ongoing reflection throughout the project.

Testing the framework I have developed with the ACTION project demonstrates the need for practitioners to be open and prepared for critique. Practitioners need to be receptive to uncomfortable and at times unanticipated feedback related to their position within the science system, the types of projects they or their organisations want to design, and the communities they want to involve. For these reasons, this framework can be valuable for sparking generative discussions among communicators during the project planning phase. The framework will also help practitioners throughout the lifetime of their projects as a prompt for continuous self-reflection and a mechanism for making space for planned community member feedback, which can recognise barriers to inclusion and exploit determinants for inclusion.

Appendix A. Text coding

Table 10. Text Coding of D5.5 Final Guidelines and Tools for Community Engagement and Monitoring [Janssen & Wittmayer, 2022].

Page (top, middle, bottom)	Main category	Reason for coding
Page 12 (m)	Lack of science capital	Diverse team to be welcoming
	Lack of long-term relationships	Engage local organisations
	Interrogation/reflection	Acknowledgement of excluding dynamics
	Lack of a common language	It has to be inclusive and against barriers
	(emotional) distance from the place	Create a place where people are respected
	Lack of evaluation	Need for assessing efforts

Table 11. Text Coding of the Participatory Science Toolkit Against Pollution [Thuermer, 2022].

Page (top, middle, bottom)	Main category	Reason for coding
Page 24 (m)	Interrogation/reflection	Recognition of accessibility based on the circumstances of people's life
Page 24 (b)	Difficult socio-economic contexts	Recognition of work shifts
Page 25 (t)	Lack of long-term relationships	They talk about one-off activities, but the focus is not on inclusion
Page 27 (m)	Everyday life topics	Align interests, but the focus is not on inclusion

Table 12. Text Coding of the Brainstorming Inclusion Workshop [Austen, 2021].

Slide	Main category	Reason for coding
Slide 4	Lack of long-term relationships	Focus on diversity among stakeholders
Slide 6, 12, 16, 17	Interrogation/reflection	Focus on biases that hinder participation
Slide 12	Difficult socio-economic contexts	Cost of participating in these projects

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