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Citizen Science: A Reflection on New Ways to Communicate Science

Theoretical framework: science communication

The relationship between science, technology, and society is become both increasingly interlinked and relevant. Communication is thus becoming even more essential for the functioning of contemporary democracies (Jasanoff, 2017). The practice of communicating and disseminating science knowledge can be defined as the social activity that effectively makes science a public good (Cerroni & Simonella, 2014). Science communication aims to reach various types of non-experts (Nowotny, 1981) and also to define the relationship between scientists, researchers, and citizens (Bucchi & Trench, 2014).

A part of science communication outreach takes place in written form in books and newspapers. Another part is oral communication that takes place during science festivals, lectures, and seminars, and on radio and television. A third part is web-based communication, which has become an inevitable element in contemporary science communication. Indeed, the Internet, during the period of its own evolution, has become the media environment that has most revolutionised science communication (Crescentini & Padricelli, 2023). As a result of the "socially-distributed" redefinition of the validity, trustworthiness, and authoritativeness of scientific knowledge, today's digital technologies have lowered the boundary between science and pseudoscience. At the same time, digital technologies provide increased opportunities for representatives of science to experiment with new forms of disseminating science knowledge (Scamuzzi & Tipaldo, 2015). Scientific communication skills not only benefit scientists but also help them to interact with the public and contribute to broader societal goals (Akin et al., 2021). In recent years, we have witnessed the mobilisation of scientists and research institutions intervening in public debate through information, communication, and citizen involvement initiatives (Saracino, 2020). This is in part because "the public space has been transformed by focusing on citizens as repositories of the structures and processes of democracy as control of power, delegation of the popular will, public discussion, and public opinion" (Mazzoleni, 2004, p. 17). Here we are thinking, for example, of the definition of the communication interaction scenario within the policy context, which can be decisive especially when the media not only question science policies but also the relationship between expertise and policy-making (Bucchi, 2010).

The system of scientific process attributes a strong developmental component to the communication of science, which is composed of the ways in which scientists convey the results of their work to others (Greco & Silvestrini, 2009): hence, the necessity of the daily work of scientists to be fully integrated into the so-called knowledge society (Cerroni & Simonella, 2014). On one hand, it is necessary for scientists to communicate with scientists belonging to different scientific communities, and, on the other hand, with institutions, companies, politicians, civil society, opinion leaders, technicians, and citizens. Beyond different levels of analysis of communicative phenomena and the coherent models that delineate the relationship between science, scientists, and various audiences (Jasanoff, 1997), studies of scientific communication generally agree that "the role of the mediator is a central variable in the regulation of meaning-making processes, capable of orienting exchanges between the sender and the receiver towards results that are by no means obvious, even with equal message content" (Scamuzzi & Tipaldo, 2015, p. 68). The communication of science should therefore be seen as a vital part of the public sphere, with its purpose being not only to entertain but also to equip and empower citizens (Davies, 2022). Currently, "a scientist is socially valued if he or she manages to reduce the distance that is often created between subjects surrounded by an aura of knowledge and ordinary mortals. In this perspective, we grasp the need for a close relationship between science and society, between experts and the public in a process of engagement" (Pellegrini, 2018, p. 33).

For there to be citizen participation on ethically sensitive issues, we must consider the cultural and social attributes of those who decide to act and interact with experts. This concept, amplified in the model on which this paper focuses, considers forms of interaction in the category of CS that have recently been gaining relevance (Horst et al., 2017).

Citizen science: definitions and reflections

Public participation in the field of science and technology is primarily driven by citizen empowerment and democratic engagement (Bucchi, 2006), but also by the need to address technical-scientific controversies. Today citizens are increasingly interested and open to understanding and intervening in matters related to science and technology that

directly concern them. Because of this, many scholars do not limit their work to the dissemination of knowledge through the media, but also make use of new approaches such as CS which represents the contemporary frontier between science and society.

The term CS refers to projects that involve both professional scientists and amateurs in the process of collecting, evaluating, and/or calculating various scientific data (Kostadinova, 2011). CS can therefore be defined as "the active participation of the public in scientific research." It involves voluntary collaboration aimed at the systematic collection and analysis of data, and leads to the development of knowledge in various fields of study that are part of the human-social, technological, and natural domains.

CS projects are often top-down initiatives directed by researchers in which professional scientists enlist the help of volunteers to gather or analyse data. When the term CS entered the lexicon in the early 1990s, it emerged from two very different sources. First, researchers at the Cornell Lab of Ornithology in New York used the term to describe a process in which volunteers passionate about birdwatching shared observations and data about birds with biologists conducting scientific research. The activities of these citizen-scientists were generally confined to data collection for projects conceived by professional scientists. Second, the same term was used as the title of a 1994 book written by sociologist Alan Irwin in the United Kingdom. Irwin's interpretation of CS was that expert researchers could attend to the needs and concerns of citizens by drawing upon the knowledge possessed or developed by the citizens themselves (Irwin, 1994). This interpretation invokes a scientific paradigm in which research conducted by professional scientists is deeply connected to the needs and activities of public communities. After all, science can be considered "the heir to an uninterrupted lineage of organic forms of knowledge acquisition, reaching back in time to the origin of life on earth" (Ziman, 2002, p. 20). From the 1990s to the present, CS projects have aimed not only to share data and scientific information, but also to raise awareness and involve citizens in current issues such as pollution or the effects of climate change. According to the scholar Muki Haklay (2013), the term CS encompasses a wide range of participatory levels such as: crowdsourcing where citizens are asked

to participate with ideas, proposals, and opinions in the realisation of a project, problem-solving, or data analysis; hacker spaces (a term referring to hybrid spaces) in which citizens have the opportunity to cross-fertilise, design, and share their knowledge, and; citizen sociolinguistics, a practice in which social groups share their own idioms, linguistic facts, and the functioning of verbal language. In these and other ways, CS enables scientists and citizens to become co-producers and co-discoursers acting jointly to broaden the understanding of problems, to seek possible solutions to overcome them, and to participate in the decision-making process (Kythreotis et al., 2019). This is not mere public engagement, but catalytic and transformative policy-making actions (Kythreotis et al., 2019) in which citizens are directly involved in the process. The sociologist of science Sheila Jasanoff (2003) introduces the concept of civic epistemology whereby scientists and citizens as subjects are engaged in the ongoing process of acquiring scientific knowledge that is then certified by the scientists themselves. According to Jasanoff, scientific knowledge needs to be expanded through the involvement of citizens, which is considered a necessary condition for residing in the risk society (Beck, 1989). Thus, it becomes imperative to create a context in which citizens are encouraged to activate experiences, skills, and competences to make valuable contributions to problem-solving (Cerroni & Simonella, 2014). During these initial decades, CS primarily focused on data collection and on its definition in terms of epistemology, objectives, and networking. More recently, it has come to be considered a paradigm that supports the blurring of the boundary between society and scientific research by involving the general public in using scientific tools and methods to address socially relevant issues.

In this manner, science is becoming more inclusive with and for members of the social community, allowing for the sharing of practices and experiences. Scientists can benefit from the assistance of citizens and their knowledge of specific topics or fields, while individuals from non-academic scientific backgrounds have the opportunity to participate and "learn from within" in the process of generating scientific knowledge (Campos et al., 2021). Therefore, CS should be seen as an innovative phenomenon that is builds on the rich history of amateur science worldwide. It has the potential to generate significant discoveries and shape the trajectory of various lines of research (Chari et al.,

2019). Furthermore, given the recent advancement of digital technologies, the online dissemination of scientific data, and the use of specialized digital tools, CS can be explored by various disciplines in and outside the academic world, and can also provide active citizenship and digital skills to both young people and adults.

Research methodology and objective

CS is an approach that fosters citizen empowerment and contributes to reshaping the nature of research in the context of Responsible Research and Innovation (RRI) (Sutcliffe 2011; Wickson and Carew, 2014). Moreover, it allows for a reconsideration of the relationship between science and everyday life as experts directly engage with the needs of communities, and non-experts are involved in data collection and sometimes analysis. This represents a new model for the co-production of knowledge aimed at the understanding of phenomena that operate on both micro (local) and macro (global) scales (Crain et al., 2014; Kullenberg & Kasperowski, 2016).

The aim of this contribution is to encourage reflection on the innovation that CS can bring to science communication. What is the relationship between CS and science communication? Can CS be considered a source of innovation in the communicative relationship between experts and non-experts? In order to answer these questions, this paper will use qualitative research techniques, starting with a review of recent scientific literature, and then focus on the context provided in a series of interviews.

Literature review

Alan Bryman (2012, p. 110) states that "the process of literature review is an uncertain path of discovery, in the sense that one can never know in advance where it will lead". It allows the researcher to understand what is already known about a topic and to identify gaps in the research. In this way, the consultation and systematisation of recent scientific contributions on the topic of CS helps to ensure that research work is well-conceived and more likely to be successful. As far as the link between CS and science communication is concerned, it is useful to use a literature review to first reconstruct this connection. In Eu-

rope, the connection can be traced back at least to the 1980s when the Royal Society produced a report entitled "The Public Understanding of Science", which was interpreted as a "better understanding of science that can be a significant factor in promoting the welfare of the nation, raising the quality of public and private decisions and enriching the life of the individual" (Irwin, 1994, p. 16). However, the results produced by the projects that were carried out showed little interest in actual scientific topics and too low a level of "scientific literacy". The results were strongly criticised on many levels, which is why the Public Understanding of Science model was ultimately referred to as a "deficit model". As Massimiano Bucchi and Federico Neresini (2008), both sociologists of science, explain, the deficit model was defined as such because it relied on a linear communication structure based on a top-down relationship according to which "scientific communication assumes that knowledge is fixed and transferable from the scientist (the sole holder of certified knowledge) to the citizen" (Cerroni & Simonella, 2014, p. 141).

During the 1990s, a number of studies emphasising the emergence of new forms of interaction between scientists and the lay public (Bucchi, 2003), sought to overcome the assumption that the general public is incapable of understanding science as conceived and generated by the scientific community. The aim of these new forms of interaction was to develop a pact between science and society that would better reflect the current needs and values of society (Leshner, 2003). Such a pact would be achieved through activities linked to an interacting pattern of science communication around public engagement, the underlying assumption being that "public engagement can, in general, be described as any activity in which a specific role is envisaged for citizens or stakeholders in research and innovation processes" (Ravn & Mejlgaard, 2015, p. 8). This implies that society itself would be involved in the research process through various methods, including events open to the public, communication projects, science education courses for schools, and participatory democracy initiatives. In this way, public engagement becomes a process of dialogue and participation between the public and organisations that make decisions that have an impact on people's lives. It becomes a method for organisations to build trust and consensus, and also to obtain information and feedback from the public. One of the main criticisms that has been levelled at this model

is that its proponents, rather than pursuing the goal of the involvement of and deliberative debate with as large a proportion of citizens as possible, often use it to influence public opinion in order to avoid conflicts over controversial issues (Bucchi & Neresini, 2008). In fact, the growth of science education does not prevent the questioning of scientific and technological advances. For this reason, politicians and scientists have found it necessary to adopt other types of democratic approaches. The approach used by CS projects, in particular, should be seen as an effort to go beyond the characteristic model of public engagement as it places a strong emphasis on the role and rights of citizenship in order to restore public confidence in science and technology and thus to invigorate science communication. In this sense, CS can make science more accessible and engaging for a wider public. According to Wagenknecht et al. (2021), CS is a transdisciplinary approach that responds to the current science policy agenda by supporting open science and drawing on a range of science communication tools.

In CS, communication and research are viewed as areas that need to intersect through the entire scientific process, not just at certain points or at the end of the project. According to Wagenknecht et al. (2021), science communication in CS projects has two objectives: the first is to ensure the success of a project, and the second is to improve citizens' awareness and understanding of diverse scientific issues and to motivate them to take action on these issues. Effective scientific communication is synonymous with attracting participants and ensuring that volunteers are given the information and tools they need to make a meaningful contribution. In order to be effective, communication with a specific group should take place during all phases of the project (Mcleod et al.,1999) and adapt to the actors and contexts involved. Magalhães et al. (2022) believe that that there is no one-size-fits-all approach to CS projects and communication strategies toward stakeholders. According to Giardullo et al. (2023), the key advantage of CS is its ability to broaden the range of stakeholders involved in scientific research at many levels. The tendency exists to interpret communication as only a dissemination activity, rather than as a tool that can promote appropriate encounters based on communication with potential participants. More than just communicating science through public involvement, CS also enables science to be actually done (Hoover,

2016). Lipinski (2015) recommends that discussions (and thus communication) within projects between experts and non-experts should be horizontal. Gascoigne et al. (2022) believe that this suggests a more participatory form of science communication where citizens are involved at each stage of the project right up to policy co-production. In this way, science communication combined with CS, and implemented at multiple levels, involves a shift of power and the emergence of responsible research and innovation, and thus promotes the transition from "science in society" to "science with and for society" (Gascoigne et al., 2022). Although there is little literature on the innovations and transformations that CS can bring to science communication, initial studies in the literature indicate that scientific topics do become more understandable and sometimes even enter the everyday lives of citizens. According to Wagenknecht et al. (2021), CS often leads to successful science communication because it promotes a view of teaching and learning that is different from traditional perspectives in science communication. In particular, it opens up the research process to external actors, and thus communication takes place between heterogeneous actors from different contexts. With CS, science communication moves away from the traditional model of unidirectional knowledge transfer toward a participatory mode of sharing scientific knowledge and co-creating information (Wagenknecht et al., 2021). This process involves different groups collaborating and sharing new and sometimes surprising information with each other, and creates new perspectives on communication. For example, CS can help build trust between the public and science because it supports the idea of science as a social activity. This can help create a society that is more aware of science and more committed to solving scientific problems. Norström et al. (2020) emphasise the importance of well-implemented science communication in fostering a two-way exchange of information, or co-production of knowledge.

It is also important to emphasise that digital innovations have allowed for the greater accessibility of scientific information through the quick and easy sharing of scientific content on dissimilar online platforms. For instance, online data sharing has facilitated scientific collaboration and the growth of open notebooks, online repositories, and open access journals that disseminate scientific results (Grand et al., 2010,

Cranshaw & Kittur, 2011). Digital technologies – such as apps installed on smartphones, dedicated portals to directly submit photographs, functions that facilitate reporting activities and the sharing of measurements and observations of animal or plant species – are one of the main factors supporting the growth of projects and the increase in the number of participants in CS programmes (Haklay 2015, 2013). The adoption of open science practices allows for greater transparency and the participation of non-specialists (Catlin-Groves, 2012; Grand et al., 2010). In particular, digital communication plays a key role in CS as it enhances the connection between citizens and researchers, and their ability to share information and collaborate in the collection of scientific data. Online platforms have created opportunities for people to build relationships and exchange information quickly and efficiently (Ellison et al., 2011), and new opportunities for work and collaboration in the scientific sector (Brynjolfsson & McAfee, 2011).

Research techniques

CS promotes the development and exercise of a range of skills and responsibilities related to research for all members of society (Schade et al., 2021). Its potential value extends to scientific and socio-political implications. This has created a paradigm shift away from previous interpretations of issues related to the public understanding of science (Magalhães et al., 2022) to a different form of science communication. In order to address our research questions, we made a choice to integrate the literature review with the direct experiences of representatives of CS projects in Italy. Representatives were identified through the reasoned choice sampling of scientists identified through mapping, who became project referents. In reasoned choice sampling, participants are not chosen probabilistically but rather on the basis of certain characteristics (Corbetta, 1999).

In social science disciplines, mapping can be used to represent a range of topics including interactions among people, groups, and organisations, patterns of human behaviour, and social changes over time. It also enables the graphic representation of data or information and the dissemination of research results to a wider audience (Wasserman & Faust, 1994). In the case of this contribution, fifty projects

were identified that were active between 2019 and 2023 in Italy. Although some of them operated under the patronage of the European CS association ECSA, there is no comprehensive database of active and inactive Italian projects and their areas of research. Therefore, the list of mapped projects was provided by Citizen Science Italia. During the mapping exercise, we collected, in addition to partner institutes, information about coordinating institutes and their geographical context, and the names of the contact persons of the Italian projects identified. It was at this point in our research that we realised it would be necessary to deepen our investigations with interviews. The interview technique consists of an interaction between two subjects, an interviewee and an interviewer, for cognitive purposes, provoked and conducted by the interviewer on the basis of a questioning scheme submitted to a variable number of subjects chosen through a survey plan (Marradi & Fideli, 1996).

Twenty-three semi-structured interviews were conducted on the Google Meet platform, which allowed the researcher to go into the field without a rigid theoretical framework that might undermine new insights useful for our research (Goode & Hatt, 1962). The interview outline was designed to learn about the innovations that CS can bring to science communication. The dimensions underlying the interview outline included motives for, advantages or disadvantages of working with citizens, and also how experts interact and communicate. The importance of communication for experts, and scientists in particular, was confirmed. The media alone cannot be channels of efficient and truthful information, and there is a growing need to counter scientific illiteracy which is one of the main drivers behind the spread of fake news and anti-scientism. Each interview was transcribed in order to complete a textual corpus and then analysed. The hermeneutic approach was adopted for analysing interviews in this study. With the hermeneutic approach, meanings are externalised and transformed into objective elements within an external reality that is intersubjectively constructed (Berger & Luckman, 1974), and emerging themes are identified and delineated to which interview responses are then linked.

The following is a partial list of interview subjects:

- David Bianco: I-Rosalia project referent, biologist, works at Management Authority for Parks and Biodiversity Eastern Macro-area Bologna.
- Alessandro Campanaro: contact person for the InNat (platform) and LIFE ESC360 project, researcher CREA-Council for Agricultural Research and Analysis of Agricultural Economics.
- Anna Maria Mannino: biologist, researcher at the Department of Biological, Chemical and Pharmaceutical Sciences and Technologies of the University of Palermo, contact person for the Aliens in the Sea project.
- Antonio Riontino: scientific communicator at the University of Bari, expert in eco-sustainability and marine ecologist, contact person for Nature from the Window project.
- Massimo Scandura: zoologist, associate professor at the Department of Veterinary Medicine of the University of Sassari, Mammalnet project referent.
- Stefano Scalercio: researcher at CREA-Council for Agricultural Research and Analysis of Agricultural Economics and in charge of forest biodiversity, Butterfly Monitoring Scheme project referent.
- Andrea Sforzi: zoologist, President of the Citizen Science Italia Association, director of the Maremma Natural History Museum, reference person for From Museum to Museum, Wild Cat, Nature on the Walls projects.

Analysis of interviews

Science communication and CS are two important activities that have the potential to make science more accessible and participatory. For this study, interviews were conducted with participants who are already part of the phenomenon under investigation, and thus possess direct and profound understanding due to their privileged positions (Corbetta, 1999). Specifically, the interviewees are the coordinators of Italian CS projects who have conceived and developed the projects. The first and most important conclusion drawn from the conducted interviews is that internal communication must be evaluated and emphasised be-

fore methods of scientific communication are contemplated. Internal communication is essential to ensure the proper functioning and overall success of a project. Internal communication is an ongoing process that must to be tailored to each project's requirements and its audience. With careful planning and implementation, internal communication can be a powerful tool for achieving a successful project outcome.

> "Communication is fundamental but curiously enough it is not only fundamental on the part of those who organise and implement a project as it relates to citizens' involvement but also fundamental within the project. A typical shortcoming that some projects have is that the people working on the project, to put it in a brutal way, think they are putting something together as if it were a kind of product to sell and then they go and find buyers. I mean I do a project that is aimed at a group of people and then I try to publicise it so that these people participate, but maybe I don't give enough importance to internal communication. That is: what are the expectations of the people working on the project? What are the limits? I have said that the components I need to do a citizen science project are having the scientists who know about that field, a professional communicator, a sociologist, and everyone has to do their job, and everyone contributes to setting up something that will work. If there is no dialogue or if people on the project staff are not satisfied, are not happy, are not taken into account, are not listened to, do not communicate properly and do not receive communication, a project cannot work. So there has to be a 360-degree communication, internal and external." (Andrea Sforzi)

Internal communication in CS projects refers to communication efforts between research team members, project coordinators, and participants involved in the collection and analysis of scientific data. According to many of the interviewees, communicating properly means having certain expertise and skills that experts/scientists often lack. Scientists and researchers tend to be minimally engaged in the dissemination of results and public information activities (Pellegrini & Saracino, 2016). CS can be a tool to engage in sharing, building, and designing resources and knowledge.

> "The scientist certainly has to communicate with the public, because communication is a part of our job, but, unfortunately, we are neither trained nor used to doing so. Few scientists are effective in communication. Most tend to communicate only with the scientific world. They are unable to translate the fruits of their work in a simple way and therefore fail to communicate precisely because of this inability; that is, they fail to use simple language that people can understand. And many other scientists don't communicate because they basically don't care about it. I mean maybe they don't care about publishing their studies or their careers, don't care that much about how much their studies could really affect society and improve the world. From this point of view, citizen science is a bit of a gym because launching a citizen science project forces you to communicate with the world of ordinary people and also to differentiate communication according to its type, and the profile of the audience." (Massimo Scandura)

> "I have the idea that you need communication professionals first and citizen science should not be just a little phrase that makes a project cool. I am convinced that it is a really good tool and that it should be analysed in substance, and then we need to understand what were the conditions when it worked and what were the conditions when it didn't work." (David Bianco)

The centrality of science in modern society calls for greater interaction between the scientific community and the general public, which is why science communication has become extremely important. CS is a tool that has the potential to bring improvements to this area, above all in ways that science can become available to citizens and citizens can become genuinely aware of a wide range of issues.

> "It's clear that without communication you can't reach people, and because it's right that people should be made aware of what's going on, science has to open up. Today I have to say that a lot of progress has been made in this direction. There's a desire to open up the scientific world, research, science, and discoveries to ordinary people, to citizens, and citizen science is certainly a tool for that. With citizen science you're looking for help from citizens, but on the other hand you're opening up to citizens [...] Because the

citizen in some way is also made responsible. So, it's not just that I give you the information, but I also put you at the centre of the information. So, I give you the news, but I also put you in a position to grow culturally and in terms of awareness. And sometimes there is growth on both sides, because you realise that the citizen can give you a lot." (Anna Maria Mannino)

"Communication is a job that wants to clear that famous wall that exists between academics and citizens, and citizen science is the ideal tool because from my point of view, environmental communication was fine in the 1990s but today we are hungry for experience, no? We need to do things and so the person who comes to a conference only follows for an hour, and after that they don't follow you anymore. If, however, citizens get involved in the collection of data, and it is really an action that produces reports, data, etc., then you are really able to change some of their beliefs. Citizen science is the new weapon to change things." (Antonio Riontino).

The openness of science is currently going through a phase of reshaping and renegotiation (Dickson, 2008), in part thanks to the engagement of citizens in science and technology issues in a variety of projects around the world (Blok, 2007; Gavelin et al., 2007). In this sense, CS has begun to play a significant role in the formulation of public policies in various fields.

"It is so, so important to communicate science, especially to convince those with all the shopping bags to invest in research instead, because once citizens are involved and you open up to a larger audience of possible voters then the politician more easily opens the doors of spending. So at least from our point of view, the most important thing is that there is greater [public] awareness and that paradoxically the citizen educates the politician, in the sense from the bottom up…" (Stefano Scalercio)

"The critical issue may be that of not devoting enough time and expertise to the recruitment of and communication to volunteers. Training is fundamental and if it is not done [well], the results may be inadequate. Validation [is also important] so be careful to always validate volunteer data, to make sure they are still volun-

teers. Data must still be correct because the primary objective is scientific." (Alessandro Campanaro)

Citizens who become aware of their local area and other specific issues may have a completely different views than experts. Their knowledge can contribute or even lead to new understandings of such issues. This concept was first formulated in the field of European environmental policies in 2008 (Haklay, 2015), when it was recognised that such an approach would allow for the inclusion of citizens' perspectives in the face of global challenges.

Conclusion

The qualitative interview technique made it possible to investigate research questions, adding value to the review of relevant literature. It was clearly established that the practice of CS constitutes an approach capable of optimising the data acquisition process for researchers. However, it is also crucial to note that this approach requires a rigorous verification and validation phase in order to ensure the reliability of the information collected. In addition, CS represents a channel through which citizens can gain a deeper understanding of specific scientific issues. This learning is not only manifested through the use of active participation in practical activities but finds its fullest expression in the implementation of carefully designed communication strategies. CS, therefore, constitutes a milestone in the evolution of the relationship between the scientific and social spheres, also serving as an invaluable vehicle for scientific communication. This form of engagement allows participants not only to share their experiences and insights, but also to address a broader and more diverse audience. Through the promotion of public engagement within the dynamics of scientific research and the subsequent dissemination of the results obtained, the practice of CS and scientific communication are combined to facilitate greater understanding, awareness, and appreciation of scientific disciplines by a broad public. Science currently has one of the least intense inclusion processes when compared to other social subsystems (Burzan et al., 2008), but by advocating the need for more openness and participation in science, CS addresses some of the challenges in science communication (Wickson & Carew, 2014). At the onset of the COVID-19 pandemic,

communication played a key role in providing citizens with information and guidance on how to minimise the risk of infection. These forms of communication and involvement require openness on the part of all stakeholders, both experts and non-experts, and a commitment to the responsibilities and tasks that come with these roles (Hecker & Taddicken, 2022; Salmon et al., 2021).

CS, therefore, constitutes a practice that has the potential to reconfigure the paradigm of science communication to non-specialist audiences by employing new modes of engagement. Scientists need to communicate directly with citizens and get closer to the general public by leaving their ivory towers. At the same time, CS brings an innovative element to the empirical research conducted by scientists, both in the field and in non-experimental settings. A future area of development for this investigation could focus on the activities undertaken by participants in CS projects and their communication strategies. Such an analysis would aim to determine whether CS can constitute a key element of innovation within the science communication process.

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