

A methodological approach to co-design citizen science communication strategies directed to quadruple-helix stakeholders

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Abstract

Citizen Science (CS) can help change the paradigm of science communication. To test this, 38 ongoing CS projects from Italy, Portugal and Spain have been selected by the H2020 NEWSERA project to act as pilots in the development of communication strategies, specifically targeting stakeholders in the quadruple helix. The projects, together with stakeholder representatives and science communication and journalism professionals participated in a series of workshops — #CitSciComm Labs — where communication strategies were co-designed, using adapted design-thinking methods. The innovative methodological approach is hereby presented and can be an inspiration for others willing to implement improved communication strategies to target different stakeholders.

Keywords

Citizen science; Science communication: theory and models

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Introduction

The way science and the remaining society interact is constantly evolving and new opportunities for dialogue and collaboration continuously emerge. In fact, one of the most striking developments at the turn of the 21st century was the growing interest in initiatives aimed at engaging society in scientific activity, a paradigm shift from the previous emphasis on issues of public understanding of science. A good example, is the importance given by the European Commission to the implementation of Open Science within the EU framework programme for research and innovation, Horizon 2020, clearly advocating the involvement of citizens in decisions on science and technology in order to better align the goals, processes and results of research and innovation with the values, needs and expectations of society [European Commission, 2016]. In parallel, science-informed decisions are also gaining momentum in advanced democracies [EU-Citizen Science, 2021]. As such, citizen science (CS) can play a key role on how researchers and innovators

engage with society, and how they contribute to common concerns around digital literacy, data justice, and participatory governance [Maccani et al., 2020].

CS is both an aim and enabler, often linked with outreach activities, science education or the public engagement with science as a way to promote Responsible Research and Innovation [European Commission, 2016]. It has the potential to cover a wide range of topics and scientific fields through multiple practices [Bonney et al., 2009], from contributory (citizens participate mainly as data collectors), to collaborative (citizens may help refine the project design, analyze data, disseminate findings), or co-designed CS (citizens work together with academic scientists and other stakeholders and are usually involved in most, if not all phases of the research process) [Haklay, 2013].

As a result, reliable scientific data is co-produced and can be used by the quadruple helix (4H) stakeholders (civil society, academia and scientific community, policymakers, industry and SMEs) [Carayannis and Campbell, 2010], to address societal, environmental and economic challenges [Lepczyk et al., 2020]. CS projects have thus a huge potential when it comes to the communication of science, evidence and data, as they have the opportunity to engage at very different levels with all the aforementioned stakeholders [Elorza et al., 2021; Hecker et al., 2018; European Committee of the Regions et al., 2016].

However, the implementation of CS faces many challenges and barriers, including scientific recognition, citizen engagement, data quality, communication strategies, demonstrated impact, project sustainability and funding [European Commission, Directorate General for Research and Innovation, 2022].

Focusing specifically on the communication of CS projects, it is fundamental to understand what processes may hinder, challenge or drive any communication efforts to pave the way for advancing communication strategies that reach wider audiences. This requires considering different aspects such as the definition of clear objectives, the variety of stakeholders groups, the selection of key communication channels, formats, messages and actions, as well as considering other variables, such as inclusion and gender [European Commission, Directorate-General for Research and Innovation, 2020; Giardullo, Arias et al., 2021; Paleco et al., 2021]. For instance, in the case of civil society, CS projects may want to increase or maintain engagement and have difficulties in reaching underrepresented groups, whereas in the case of policymakers, CS projects may need to reach them to inform public policies based on citizen-generated evidence, but encounter a lack of awareness of CS itself; other projects may want to address academics for wider acceptance of their results and find a lack of trust in their data, or be willing to reach industries to help building exploitation models, contributing to their sustainability, but find a barrier caused by a lack of a common “language” [Elorza et al., 2021; Gunnell et al., 2021].

Due to the complex nature of CS projects, an iterative approach to communication strategies is essential, which can be adjusted to the different phases of implementation (participants’ recruitment, data collection, analysis, dissemination, etc.), depending on the level of engagement sought and the specific objectives, and during the projects’ lifetime (and possibly beyond) [Roche, Bell et al., 2020]. Time, budget or lack of professionalization can also pose barriers to the effective implementation of communication strategies [Wagenknecht et al., 2021].

Moreover, it is necessary to consider that currently the science communication

ecosystem is also undergoing dramatic changes, becoming more complex due to the emergence of new channels, such as social media, new actors, such as influencers, or new data visualization tools [Weitkamp et al., 2021; Kennedy et al., 2020].

Participatory and co-design methodologies may help bridge the gap between CS projects and their target audiences and achieve a higher level of innovation in the process of defining their communication strategies. This can be attained by bringing together interdisciplinary groups including, for example, science communicators and data journalists, and providing guidance through a problem-resolution process, fostering creativity and offering the possibility to structure conversations around specific information, such as communication expectations or actions [Curedale, 2016; McKercher, 2020]. This is possible because co-design methods are intended to combine different types of knowledge into a shared experience, allowing to visualize certain aspects, which would not be possible by other means [Gray, 2022; Masferrer, 2019; Spinuzzi, 2005].

The NEWSERA project (<https://newsera2020.eu/>), born on the premise that “citizen science is the new paradigm for science communication”, aims to demonstrate the potential of CS to act as a powerful science communication tool to promote critical thinking, to increase trust in science communication and science at large, to strengthen the link between science, innovation and society, and to promote scientific literacy.

As such, a set of ongoing CS projects were selected by NEWSERA to act as pilots in the development of communication strategies specifically addressed to each of the 4H stakeholders, as target audiences, through a series of workshops, entitled the #CitSciComm Labs. The Labs were delivered in three different rounds, where co-design methodologies, participatory and mutual learning activities, were explored within a continuous iterative process of co-creating, implementing and validating communication strategies, considering their effectiveness and social perception.

Here, we will focus on the innovative methodology implemented in the first round of Labs, aimed at co-designing communication strategies, for each participating CS projects, alongside with 4H stakeholders representatives, science communication and journalism professionals, as well as, reflecting on lessons learned and main takeaway ideas to inspire the wider science communication and citizen science communities.

Method: the NEWSERA #CitSciComm Labs

The NEWSERA #CitSciComm Labs were conceived as co-design spaces, where ongoing CS projects, pre-selected based on a widely distributed survey [Giardullo, Citarella and Neresini, 2021] and individual interviews (unpublished data), participated as pilots, to analyze their current communication strategies, to identify challenges and opportunities for improved communication, and to co-design complex and multidirectional *ad hoc* communication strategies, including digital and non-digital ones, addressed to 4H stakeholders and evaluate their impact.

Four Labs were established, each oriented to a specific 4H stakeholder (civil society, academia and scientific community, policymakers, industry and SMEs), with different pilots participating, according to their stakeholder of interest to be addressed under NEWSERA. To simplify, from now on, the Labs will be referred to as the Citizens, Scientists, Policymakers and Industry Labs.

The #CitSciComm Labs were planned as face-to-face interactions, however, due to COVID-19 pandemics, there was a need to adapt to virtual interfaces. One of the major positive impacts this had on the process was that instead of the 4 projects initially planned, it was possible to involve, as pilots, 38 projects, from Italy (n=10), Portugal (n=12) and Spain (n=16). Consequently, the Labs were implemented online and in parallel in each country, in the local languages and in a cascade fashion, following the aforementioned stakeholder order, in what we defined as NEWSERA weeks. A final common mutual learning event (NEWSERA Friday) was set, after each Lab, in English, involving projects from the 3 countries.

A concept note was prepared for each NEWSERA #CitSciComm Lab to guide its implementation. It included the overall structure, the main objectives as well as the description of the participatory and co-design methodologies, to be applied independently, but concomitantly, in the three countries.

To incorporate different participatory and co-design methodologies, our approach included structuring the methods and techniques in a logical, useful and comprehensive way to guide each dynamic to achieve a specific goal – with appropriate time slots dedicated to each part of the session, and the selection or creation of work materials [Sanders and Stappers, 2008]. In this regard, graphic tools such as concept maps and visualization tools were chosen due to their benefits for collaborative building, facilitating conversations, providing quick and easy understanding of new concepts, replacing memory by reflective-learning, allowing thus to establish new relations between concepts and therefore new meanings, among others [Rodríguez Estrada and Davis, 2015; Romero, Cazorla and Buzón, 2017].

During the Labs, NEWSERA partners acted as facilitators, to organize the sessions, moderate them (guiding the activity, controlling the time, motivating the participants, solving doubts and conflicts, etc.) and to encourage the participants to express their thoughts and ideas. Facilitators have been used before in similar initiatives demonstrating to generate a creative and cooperative environment [Guasch, González and Cortiñas, 2019].

For each CS project taking part in each Lab, communities of practice (CoP), ie. groups of people that collaborate to find innovative solutions [Pattinson and Preece, 2014], were established, being composed by at least four members: CS pilots representatives, invited 4H stakeholders, science communication and journalism professionals and the NEWSERA facilitators.

**Execution:
co-designing
citizen science
communication
strategies**

The first round of co-creation workshops of the #CitSciComm Labs consisted of five participatory dynamics, including: S.W.O.T. analysis, utopian thinking and six thinking hats; conversion funnel and brainstorm graphic organizer; and one graphic recording session, divided into three independent and sequential sessions (Table 1).

Table 1. Schedule of the three sessions of Round 1 of the NEWSERA #CitSciComm Labs.

Session	Duration	Title	Design thinking methodologies
1 (Day 1)	15 min	Welcome and brief introduction to NEWSERA	–
	60 min	1a. Perspectives and objectives	–
	120 min	1b. Diagnosis	S.W.O.T. analysis, Utopian thinking, Six thinking hats
	30 min	Sharing, discussion and closing	–
2 (Day 2)	15 min	Brief introduction to the results of the previous day	–
	90 min	2a. Communication strategy	Conversion funnel
	90 min	2b. Defining indicators	Brainstorm graphic organizer
	30 min	Sharing, discussion and closing	–
3a NEWSERA Friday (Citizens Lab)	15 min	Brief introduction to the NEWSERA week process	–
	90 min	Presentation of the communication actions conceptualized by each project of each country	Graphic recording
	45 min	Discussion, questions and answers (Q&A) and closing	–
3b NEWSERA Friday (Scientists, Policymakers and Industry Labs)	20 min	Welcome, Icebreaker and Focus on topic of the session	–
	30 min	Virtual fishbowls around two key questions	–
	10 min	Summary of aims and activities	–
	5 min	Short break	–
	5 min	Quick energizer and introduction to group discussion	–
	30 min	Work in Groups: collaborative murals	–
	25 min	Presenting main outcomes and closing	–

For all dynamics that included participatory design thinking methodologies, a video meeting platform and the “Miro” tool (<https://miro.com>) were used to allow building interactive maps where participants could directly add their ideas during each session, simulating hands-on workshops. A map for each of the dynamics was designed, with different goals adapted to the corresponding dynamics. Moreover, the number of projects differed by country, and all projects had different agendas and time availability, so flexibility in implementing the multiple sessions was key, always trying to be consistent with the overall concept.

Flexibility in adapting the methodologies among Labs was also necessary, for example, as indicated in Table 1, for Session 3a, regarding Citizens and Session 3b, for the remaining stakeholders. In this case, we tested graphic recording to present the findings of Sessions 1 and 2 during the NEWSERA Friday corresponding to the Citizens Lab (3a), but we decided to prioritize interaction and mutual learning between the projects in the following sessions, so different dynamics were introduced (3b).

Hereby, we describe the methodological approach for each session, as indicated in Table 1.

**Session 1a:
perspectives and objectives**

The objective of the first dynamics map (referred as “Perspectives and objectives”) was to introduce the CS pilots as well as the members that constitute each CoP and it comprised a series of questions, which had to be answered by all participants. The questions were divided in 3 groups (Figure 1): those directed to the CS pilots representatives, those directed to the specific stakeholder group representatives (in this example, Citizens), and those directed to the science communication and journalism professionals that were helping in the creation of the communication strategies. These questions were slightly adapted to each Lab; so, as the example given, in the Citizens Lab we had six questions for each of the participant representative groups. For the other Labs, the questions were adapted to match their profiles, including: What is your job? / In which field do you work? / Are you familiar with CS practices?

CS Project representatives		
What is your project about?	Which is your target audience?	What type of communications actions do you use to reach your target audience?
How do you assess the success of your current communication strategy?	What kind of resources and experience in communication do you have to address the communication of your project?	What would you improve regarding the communication of your project?

Target 4H-Stakeholder group representatives		
What motivates you about the project you are involved in? (motivations, interests)	How did you find out about the project?	How active has your participation been in the project so far?
What would make you more involved?	How would you like to receive information about the project?	What would you improve regarding the communication of the project?

Science Communication and Journalism Professionals		
What is your job?	What citizenship profiles do you come across with at your job?	How do you promote active citizens participation?
Can you tell us a good communication experience to generate knowledge that involves citizens?	What aspects do you consider relevant for participatory projects to involve citizens?	What do you consider essential in the communication of projects that involve citizens?

Figure 1. “Perspectives and objectives” template that was used to introduce the CS pilots, the target stakeholder groups representatives and the science communication and journalism professionals, during NEWSERA #CitSciComm Labs’ first session.

The questions had to be briefly answered by each participant – 1 minute per question – whilst the facilitator would write the answers in sticky notes. Once all

participants had answered, there was a 10 minutes discussion. As the set of questions and the number of participants was different among the Labs and the different CS pilots, the time saved on this task was allocated to the other dynamics.

Thereafter, participants were divided into breakout rooms, with groups of 6 to 8 people, in order to focus specifically on each of the CS projects involved, while promoting higher individual participation and increased interaction among peers.

Session 1b: diagnosis

The second dynamic consisted of an adapted S.W.O.T. analysis that included an utopian thinking perspective and the six thinking hats approach, which we designated as “Diagnosis”. Its main goal was to define internal and external variables that can affect the communication strategies of each CS project, as well as detect opportunities for improvement, considering the available resources and specific objectives and characteristics of each project.

Participants were asked to fill a map formed by five rectangular areas corresponding to the S.W.O.T. dimensions (Figure 2): (i) Strengths, (ii) Weaknesses, (iii) Opportunities, (iv) Threats, and finally (v) Wishes. This exploratory phase originates from the need to identify and distinguish explicitly different categorisation dimensions of processes or structures [Leiber, 2017]. The S.W.O.T. analysis was introduced to identify internal strengths and external opportunities to be leveraged by a given project to accomplish their objectives, whilst detecting the internal weaknesses and external threats that need to be mitigated [Leigh, 2010]; The “Wishes” section was introduced as a novel item in order to stimulate discussion, considering the perspectives emerging from the target stakeholders, based on the principle of utopian thinking, as a hopeful and imaginative approach that supports that the future may emerge from any unexpected direction, enabling to deal with uncertainty, disappointment and surprise [Brown, 2015; Fernando et al., 2018]

Participants were, then, asked to approach these dimensions from different perspectives, following the six thinking hats methodology that includes six hats – or similar elements that can be related – of different colors, each representing a different way of thinking and focused on specific aspects [de Bono, 2016]. Any given participant could choose to use any perspective and change to a different perspective with every thought or idea. We placed sticky notes with each of the six colors on one side of the map, so that participants could pick a desired color whenever needed. In order to promote different views and keep the conversation going, each participant was encouraged to add at least one thought from a different perspective in each area, as long as coherency was maintained – for instance, there won’t probably be any “black” thoughts under the strengths area. The suggested duration to complete this dynamic was 120 minutes. Participants were asked to follow the map’s order, from (i) strengths to (v) wishes, with 20 minutes per dimension, except for “opportunities”, with an extra 10 minutes and a wider area in the map to fill in (Figure 2). Finally, in the last 10 minutes, participants reviewed their information, grouped similar ideas, connected concepts between areas, added other ideas that might not have been present previously and reflected about the overall map.

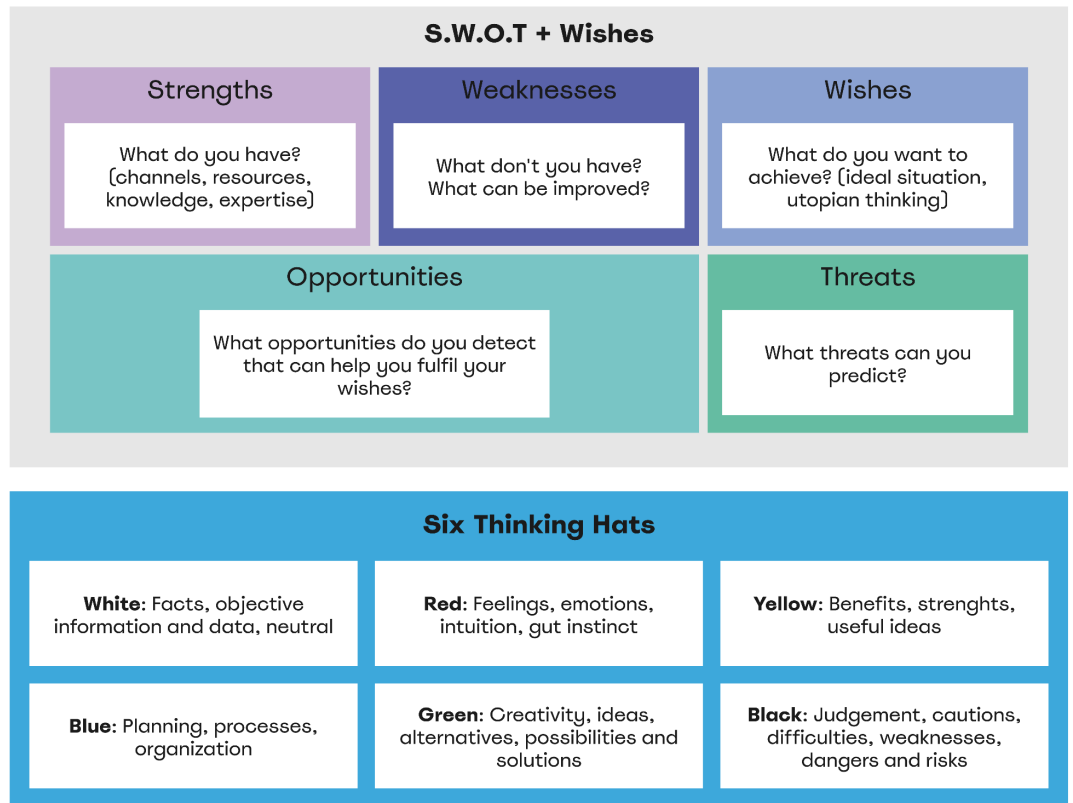


Figure 2. Template used for the “Diagnosis” dynamic, consisting of an adapted S.W.O.T. analysis (Strengths, Weaknesses, Opportunity and Threats) that included a utopian thinking perspective (Wishes) and the six thinking hats approach. The upper area defines the order in which the dynamic was carried out, whilst the lower one defines the roles of the six perspectives adopted.

At the end of the session, all participant groups were invited back to the plenary group and each group had 5 minutes to present their results, plus additional 5 minutes for questions and answers. Finally, participants shared their impressions from the session and the process, as well as the most interesting opportunities that emerged from their “Diagnosis” map.

**Session 2a:
co-design of
communication
strategies**

Session 2 started with a brief summary of the main results obtained at the previous session. Participants were then divided into breakout groups to work on each CS project, with the main goal of defining a “Communication Strategy” from scratch, based on the opportunities identified previously. To do so, we built a conversion funnel [Martin, 2010], also known as the knowledge funnel, which includes different stages, being each one more specific or detailed than the previous one, from a starting point with many inputs, which are usually disorganized and mixed, to an end point with specific, detailed and structured outcomes. This was divided into five areas: (i) Opportunities; (ii) Feasible opportunities; (iii) Communication actions and prioritization; (iv) Benefits; and (v) Plan for the first actions (Figure 3). This dynamic also used the six thinking hats approach to distinguish different perspectives. The opportunities for each CS project – placed under the fourth area of the “Diagnosis” map – were transferred to the conversion funnel map, filling the first of the working areas. Participants were asked to analyze and select the most

feasible opportunities to then work with them in the second area. This part took 20 minutes. During this process, opportunities could be redefined, for example by grouping different ideas in one or extracting more than one idea from one specific opportunity.

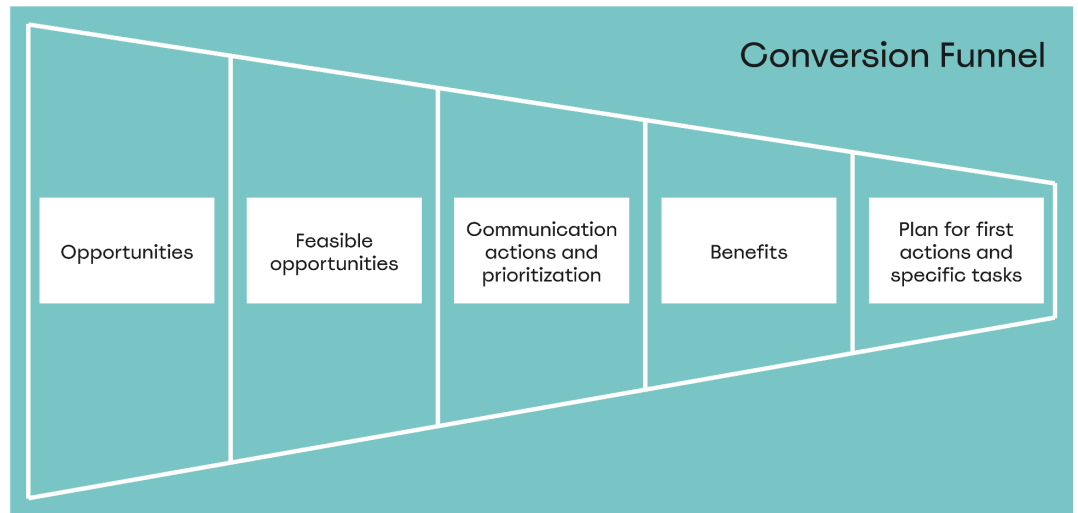


Figure 3. “Communication strategy” template used in session 2. A conversion or knowledge funnel was divided into five areas: Opportunities, Feasible opportunities, Communication actions and prioritization, Benefits and Plan for the first actions and specific tasks.

The next step was transforming the selected feasible opportunities into concrete communication actions (third area), for which participants had another 20 minutes. Then we asked participants to write on one hand, the actions, and on another, a brief description of the processes needed to implement them, placed side by side. Then, 10 minutes were given to prioritize actions, ordering them from top to bottom.

The fourth working area was dedicated to the benefits in order to strengthen the importance of designing a communication strategy aligned with the wishes of both the CS projects and their target stakeholder group. In this part, for each communication action, benefits for the CS project were placed on the upper part of the designated area, and, for the target group, on the lower part. Participants could choose to address benefits of all the actions together, or address individual benefits of each action separately. They were given 20 minutes to address this task.

Finally, the last area of the funnel was used to start planning the first actions that had been prioritized in the third working area. Participants had 20 minutes for placing the first actions on the left-hand side of this working area, and defining the specific steps to follow, on the right-hand side.

Session 2b: defining impact indicators

After co-designing each CS project “communication strategy”, participants were presented with the “Defining indicators” map (Figure 4). Hereby, they were asked to propose concrete and measurable indicators, to be used for the impact assessment of their communication actions defined and prioritized in the previous map and to be implemented during NEWSERA.

For this, we worked on a brainstorm graphic organizer [Hanington and Martin, 2012; Hyerle, 1996], to organize concepts more visually, with three columns for three types of indicators, those related to (i) digital communication channels or scope, (ii) communication effectiveness and (iii) social perception, and with as many rows as the communication actions defined by each project. Specifically for each type of indicator we intended to define (i) quantitative indicators for social media to be measured through a novel multiple variable analysis and visualization tool (KAMPAL Social Tool) to be explored under NEWSERA that considers the evolution and complexity of networks [Pelacho et al., 2020]. Icons of different social media platforms or other digital presence were included, so that participants could propose indicators based on what they are using or plan to use; (ii) quantitative and qualitative indicators to measure the effectiveness of both digital and non-digital communication actions; and (iii) qualitative indicators to measure the impact of the CS project on the social perception of science (ie. users and/or participants) based on their communication actions. Moreover, participants were asked to use sticky notes to tag each indicator (as shown in Figure 4) using a specific impact dimension such as, Scientific / Social / Economic / Political / Environmental / Other, following the model proposed by the ACTION Project [Kieslinger et al., 2017] to allow assessment of each of the actions. We suggested defining at least one indicator for each type, unless it was not relevant within the scope of a particular project. There were in total 90 minutes to complete this task, whereas time allocated to each communication action defined varied for each project depending on their specific actions (from this experience, 10 to 30 minutes each).

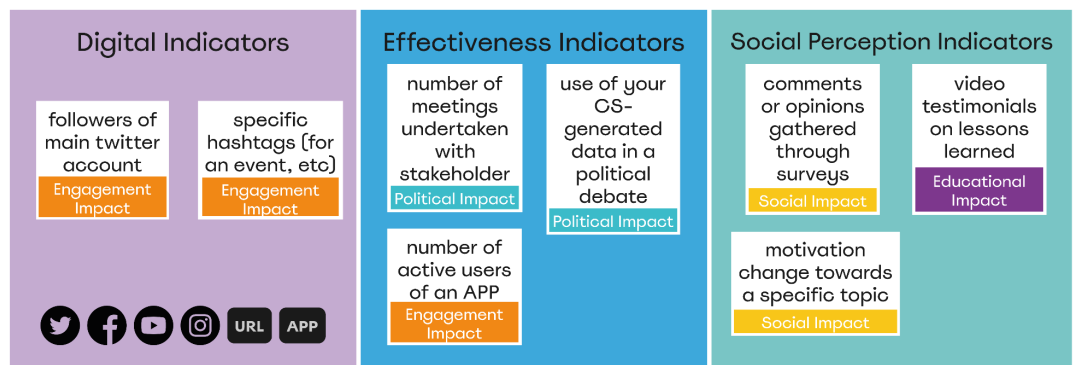


Figure 4. “Defining indicators” dynamic template for Digital, Effectiveness and Social Perception Indicators to be filled for each of the communication actions defined, with some examples.

However, defining indicators was not a simple task. Even though there was a collective effort by each CoP, and the dynamics was organized considering different indicators and communication actions, participants found it difficult to implement and too demanding. It has to be taken into account that a considerable amount of work had already been undertaken in the conversion funnel. As a consequence, for most of the projects only a small number of indicators were reached, and/or incomplete maps were produced by others. Running the activity on a separate day and with a fresh mind would probably have worked better and result in more complete maps. Nonetheless, this exercise set the basis for later defining the NEWSERA multilevel impact framework [Giardullo, Citarella, Neresini et al., 2021]. Moreover, and taking into consideration the complexity of different factors inherent to each of the NEWSERA Pilots (such as time, human

resources, experience, phase of project, etc), the definition of indicators has been considered an ongoing process under continuous refining, to be further completed during Round 2 of the Labs.

After this map was completed, the breakout groups were redirected to the plenary room, and each had 5 minutes to present their results, explain their communication actions, how and why these were prioritized, and which were the most relevant indicators defined. Each project had 5 minutes extra for Q&A (Table 1).

Session 3: presentation of results — the NEWSERA Fridays

The third and final session was oriented to define common grounds and share the lessons learnt by all NEWSERA pilots, promoting mutual learning about key communication actions, opportunities to engage with target stakeholders and the main challenges faced for effective communication.

To achieve this, session 3 followed a different structure. Whilst sessions 1 and 2 were performed in each country, using local languages, session 3 gathered all CS projects from each country working in the same Lab (citizens, scientists, policymakers and industry) and was carried out in English. As such, this session constituted an opportunity for networking and sharing experiences amongst similar projects.

The methodology used for the Citizens Lab was slightly different than for the other stakeholders, which was modified to account for the lessons learnt. In the first case, the session consisted of a brief introduction to the NEWSERA Round 1 process, a presentation of the communication actions conceptualized by each CS project, and a final discussion with Q&A.

For the presentation of the communication actions conceptualized for each CS project, a graphic illustrated recording was performed (Figure 5). The graphic recording consists of a visualization process that captures the main themes and ideas emerging from group discussions, where all concepts and ideas are introduced in a general concept map, interconnected with arrows or other graphic elements, creating an attractive and structured visual piece at the end of a process [Dean-Coffey, 2013]. So, in the first area, dedicated to the CS project presentation, an invited artist drew in real time their main characteristics. For the other areas, we placed explanatory icons that contained the main information presented by each CS project. Moreover, a graphic recording of the final discussion was also kept. However, we found that the time allocated for the graphic recording (90 minutes for the description of up to 4 projects) was insufficient, resulting in cumulative delays and incomplete boards. This also reduced the allocated time for discussion, which was expressed by the participants, as the most interesting part of the mutual learning exercise. As a result, we decided to change the NEWSERA Fridays dynamics to have more time for interaction and discussion.

So, for the remaining Labs, the first 20 minutes were dedicated to welcoming participants using icebreakers and sharing catchy and funny questions, using the audience interactive tool SLIDO (<https://www.sli.do/>), to bring participants to focus on the topic of the day and to start collecting their feedback.

Thereafter, during 30 minutes, we used virtual fishbowls, a common strategy for organizing structured medium- to large-group discussions, in order to involve all

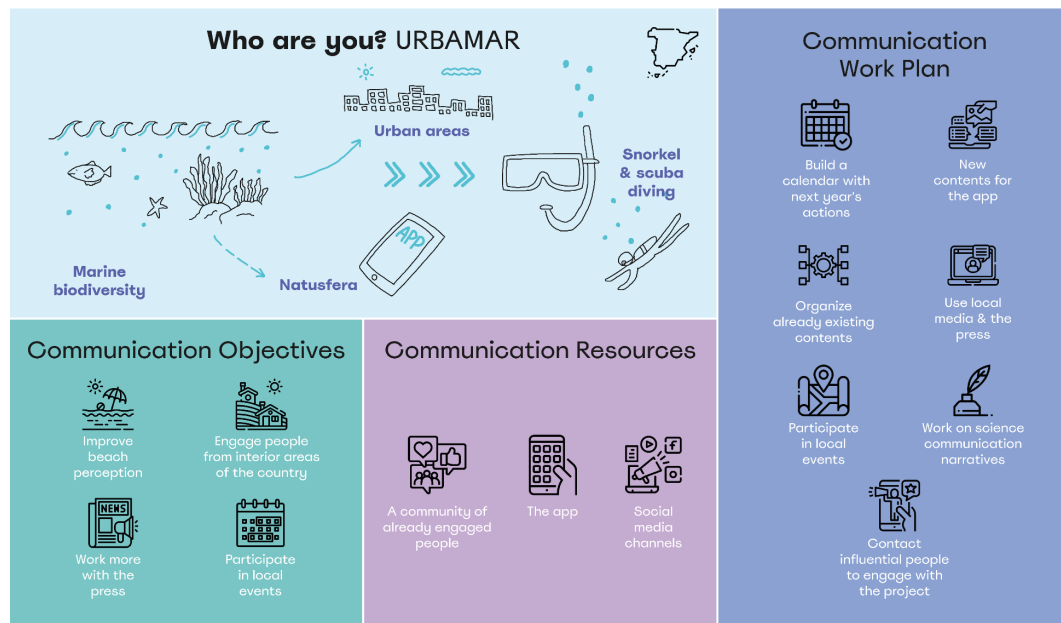


Figure 5. Example of one of the NEWSERA pilots graphic recording, including: CS project description, communication objectives, resources and work plan.

participants around 2 key questions: the obstacles and challenges encountered, and sharing feedback/suggestions on what could be improved in the future organization of the Labs. A short summary of the aims and methodological approach of the first round of Labs, as well as similarities and differences among the three countries was provided during the following 10 minutes.

The second part of the session, focused on the concrete results that emerged from the Labs, using the collaborative mural virtual tool PADLET (<https://es.padlet.com/>), where participants were divided in two groups for 30 minutes: group one focused on the barriers to communication actions addressed the target stakeholder (i.e. channels, aims and challenges) from the CS projects point of view; whilst group two focused on societal needs and expectations towards science communication performed in CS projects (i.e. needs and suggestions) that have emerged from the participating stakeholders. Finally, the groups were brought together, to share and discuss the main outcomes reached, for 15 minutes. The session was closed with the main conclusions.

Lessons learned

When addressing CS projects and their communication strategies towards 4H stakeholders, there is no one-solution-fits-all approach. The main challenge of the #CitSciComm Labs was to find a common methodology to apply to each pilot, which could be useful to co-design communication actions and how to measure their impact, whilst ensuring that the specific characteristics and diversities for each stakeholder group and each CS project's objectives were taken into account.

To do so, the first round of workshops for each of the NEWSERA Labs followed the methodology hereby described, to run a shared journey that brought participants from merely sharing their experiences to co-designing *ad hoc* communication strategies with relevant stakeholders and communication professionals. In

addition, the Labs created connections amongst CS projects aiming at identifying differences and commonalities, goals, challenges, and barriers, linking across different ongoing experiences, promoting networking and mutual learning.

Understanding specific contexts in which CS projects operate was a key point to identify general barriers and opportunities for CS communication: the sharing of different experiences and backgrounds is basic to define a focused communication strategy. Building on this, it is possible to go through a more general conception of certain issues about strengthening communication strategies and designing joint practical actions for 4H stakeholders engagement in CS, and how to overcome common challenges.

We have also shown that the co-design methodology is flexible and adaptable to different environments (face to face vs virtual, different languages and cultures) which can be very valuable for further replication, even during pandemic and physical lockdowns [Roche, Arias et al., 2021].

Moreover, participating CS projects expressed the need for closer support in order to implement their communication strategies over the course of NEWSERA. As such, NEWSERA partners have been periodically meeting the projects in individual or group meetings, providing mentorship and also establishing connections of CS projects that have complementary approaches with the potential to address cross-border challenges (related to biodiversity, health or other topics) that can leverage each other's objectives and increase their impact (from their communication actions but also from the projects). One successful example was the constitution of the "Iberian Interest Group on Citizen Science of Freshwater Ecosystems" [Violatto, 2022], spurred between one pilot from Spain (RiuNET) and another from Portugal (Rios Potáveis) and that already has the participation of 17 projects beyond NEWSERA pilots.

Also, we detected the need to tackle other cross-cutting issues such as ethics, misinformation, impact or evidence-informed policies, among others, which are being progressively introduced in parallel project activities and following rounds of Labs.

Finally, a cross-cutting Lab, addressed to data journalists, is planned to advance in parallel, while keeping the momentum and the engagement of the CS projects in NEWSERA and promoting the use of citizen generated data to build up newsable stories of interest to society and other stakeholders.

Recommendations

During the first round of co-design workshops of the NEWSERA #CitSciComm Labs, it was possible to unveil the main barriers in reaching each of the 4H target stakeholders, for example, understanding the most effective channels to be used for promoting citizen engagement, not only as volunteers employed in the phases of the scientific process, but as actors who produce knowledge and change. Thus the role that each stakeholder can play in CS projects was identified. For example, citizens can play an important role as ambassadors of CS projects or even act as science communicators themselves, shaping a more personal dimension that citizen science can bring to science communication [Jensen, 2022].

The opportunities to tackle the different barriers towards each of the 4H stakeholders constitutes the basis for the first NEWSERA policy brief [Elorza et al., 2021], available in the NEWSERA Zenodo community, in four languages, to be used by the wider science communication and/or citizen science communities, willing to improve their communication strategies, for which we provide a brief summary (Figure 6).



Figure 6. Recommendations on how to improve your CS communication strategies towards quadruple helix stakeholders [Adapted from Elorza et al., 2021].

Conclusions

This work shows the potential of the NEWSERA #CitSciComm Labs, run through its 38 pilots, and its co-design methodological approach to improve CS project's communication strategies towards 4H-stakeholders. This was achieved by equipping them with skills and tools, and how to partner with their target stakeholders, science communication and journalism professionals, to maximize the impact of their research outputs and their communication efforts. In the long term, this will benefit the overall impact of the CS project, unveiling the power of CS as a science communication tool.

Specifically, we have shown the flexibility of the co-design methodology both as replicable and adaptable, and how the results reached can serve as guidelines to be adopted by the wider science communication and/or citizen science communities, contributing to set up communication strategies or rethink current ones, by finding innovative routes to meet their goals.

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