



OPEN ACCESS

EDITED BY

Ataharul Chowdhury,
University of Guelph, Canada

REVIEWED BY

Kate Maxwell,
UiT The Arctic University of Norway, Norway
Maggie Boyraz,
California State University, United States

*CORRESPONDENCE

Valentina Grasso
✉ valentina.grasso@cnr.it

RECEIVED 02 May 2024

ACCEPTED 12 August 2024

PUBLISHED 04 September 2024

CITATION

Giuffredi R, Grasso V and L'Astorina A (2024)
Web-based science communication at
Research Institute level: balancing
dissemination, dialogue and promotion in a
major Italian scientific institution.
Front. Commun. 9:1427033.
doi: 10.3389/fcomm.2024.1427033

COPYRIGHT

© 2024 Giuffredi, Grasso and L'Astorina. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](https://creativecommons.org/licenses/by/4.0/). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Web-based science communication at Research Institute level: balancing dissemination, dialogue and promotion in a major Italian scientific institution

Rita Giuffredi¹, Valentina Grasso^{2*} and Alba L'Astorina¹

¹Italian National Research Council, Institute for Electromagnetic Sensing of the Environment (CNR-IREA), Milan, Italy, ²Italian National Research Council, Institute for the Bioeconomy (CNR-IBE), Florence, Italy

This study examines the online communication practices of research institutes affiliated with the Italian National Research Council. The analysis employs a combination of quantitative and qualitative methods to evaluate whether these institutes leverage digital technologies to transition from a unidirectional, strategic approach to communication towards a more dialogic and engaging approach with the public. Specifically, the study analyses the institutes' websites, assessing their use of communication tools, content, target audience, knowledge flows, and contextualization of communication activities, while also highlighting disciplinary-based differences. Although recent research identified Research Institutes' level as a promising ground for research communication to flourish, our study suggests that, on average, they still employ digital technologies in the same way as traditional media, disseminating information about institutional advancements rather than fostering interactive dialogue. Communication styles remain grounded in Dissemination and Strategic models, which restricts the ability of research institutes to develop a dynamic and transformative relationship with society.

KEYWORDS

public communication of science and technology, public engagement with science and technology, strategic communication, digital science communication, institutional communication of science

1 Introduction

While science communication is a well-established field of study, research analysing the communication of scientific organizations beyond universities is lacking. In such cases, science communication often merges with strategic communication, which aims to compete for public attention and to legitimize science and research institutions (Nisbet and Markowitz, 2016; Besley, 2020; Schäfer and Fähnrich, 2020). In science communication studies about research institutions, organizational aspects are often overlooked, in contrast to other science communication contexts, such as media or publishing houses, which are more frequently studied from this perspective (Schäfer and Fähnrich, 2020, Zimmerman et al., 2024).

Communication has assumed a crucial role within major research institutions, where dedicated offices are responsible for institutional communication, promotion, and media relations. Research organizations now consider the dissemination of science and active engagement with society as a duty rather than a virtue (Entradas et al., 2020). This duty is further emphasized by EU research funding programs, which require science communication as a prerequisite for funding scientific projects. In parallel, calls for democratising science (e.g., EU programmes, Responsible Research and Innovation) have emerged, alongside pressures pushing research institutions toward marketization in the context of “academic capitalism” (Davies and Horst, 2016). Research institutions’ “Third Mission” include communication and engagement activities, along with strategic plans for technology transfer to local enterprises. On the researchers’ side, over the past decades, scientists of all domains have also become increasingly engaged in communication, motivated by personal enthusiasm or a sense of social responsibility, and helped by the disintermediation leveraged by digital technologies and social media (Davies, 2021; Davies et al., 2021; Mannino et al., 2021). Scientists have been even encouraged to move beyond the traditional linear model of knowledge transfer and engage in complex interactions with diverse audiences, with the goal of conducting ‘science with and for society’ (L’Astorina and Di Fiore, 2017; Owen et al., 2012), blurring the borders between knowledge producers and users, questioning traditional power hierarchies, and leading to a rethinking of research work and the knowledge production process. Examples of such approaches include Citizen Science, Do-It-Yourself and the Makers’ movement, open data initiatives, and co-construction of knowledge (Jasanoff, 2004), as well as action-research and participatory research involving ‘extended peer communities’ (Funtowicz and Ravetz, 1993).

The emergence of digital technologies, such as interactive websites and social media platforms, has in fact hastened this transformation, offering individual researchers and scientific institutions the chance to directly engage with society, enabling researchers to play a prominent role in science communication, moving beyond the agendas set by traditional media and bypassing intermediaries (López-Pérez et al., 2016). These digital platforms facilitate the sharing of knowledge, and enable bi- and multi-direction exchanges, supporting more deliberative and democratic forms of science communication (Fontaine et al., 2018; Huber et al., 2019); they also serve as platforms for enhancing visibility and reputation. According to Brossard and Scheufele (2022), social media could become the primary gatekeeper for information and communication about science.

The communication practices of both institutions and individual researchers have been significantly shaped by the evolving landscape of reflections on the interplay between science/society, as well as the role of research within society. As an academic domain, science communication has extensively focused on the interactions between science and society, analytically describing different models for the communication exchange. These models can be broadly categorized into three main groups: the Dissemination model, also known as the Deficit model or Public Understanding of Science (PUS); the Dialogue model, referred to as Public Engagement with Science and Technology (PEST), which subsequently blurs into the Participation or Science in Society model (Trench, 2008). Although further scholarly reflections have recognized the coexistence of these communication models within the actual practices of science-society exchanges (Metcalf, 2019; Bucchi and Trench, 2021; Metcalf, 2022),

the three approaches show discontinuities in the direction of the flow of knowledge and in the hierarchical power relations based on knowledge.

According to the synthetic overview by Trench (2008, pp. 119–135), within the Deficit model “science is transmitted by experts to audiences perceived to be deficient in awareness and understanding,” while in the Dialogue model “science is communicated between scientists and their representatives and other groups, sometimes to find out how science could be more effectively disseminated, sometimes for consultation on specific applications.” Finally, in the frame of the Participation model, “communication about science takes place between diverse groups on the basis that all can contribute, and that all have a stake in the outcome of the deliberations and discussions.”

In terms of the dissemination of knowledge, the aforementioned models demonstrate a clear progression from a predominantly one-way flow of information from experts to the general public (model one), to a bi-directional exchange of knowledge (model two), and finally to a multi-directional conversation that is characterized by a complex and dynamic exchange of ideas (model three). With regard to power relations centred on the possession of knowledge, the first model demonstrates a clear hierarchy, with experts and scientists occupying the most significant roles, while the public is positioned as ignorant and passive. In contrast, the second and third models illustrate a shift toward a more egalitarian dynamic, with non-experts and stakeholders assuming greater prominence in the conversation.

Dissemination, Dialogue and Participation models have faced criticism for not adequately considering the goals of legitimising and promoting science, scientists, and scientific institutions (Kessler et al., 2022; Nisbet and Markowitz, 2016; Davies and Horst, 2016). In response, Strategic models of science communication have been proposed, where objectives such as building reputation and increasing visibility gain prominence alongside the goals of knowledge dissemination and public engagement. As a result, strategic communication frequently depends on one-way flows of knowledge to achieve its desired outcomes, in a manner analogous to that observed in the Deficit model.

The communication activities of research institutions are frequently situated at the nexus of dissemination, engagement, and strategic communication. Participative science communication, on the other hand, is more often associated with deliberative contexts within the public sphere. Additionally, the institutional constraints imposed by central communication offices exert considerable pressure on research institutions. In fact, communication from central offices is primarily strategic science communication and often follows an institutionalized ‘push’ style, with press releases and social media posts being the dominant forms of public science communication (Marcinkowski and Kohring, 2014). Recent research has already highlighted how the aspirations of science communication models are frequently overlooked in practice, which tends to prioritize the dissemination of scientific information to the public over genuine engagement with them (Metcalf, 2019; Bucchi and Trench, 2021; Zimmerman et al., 2024). In this context, a promising direction of research is the one that takes into consideration scientific institutions like Research Institutes as a potential environment where science communication can thrive (Entradas, 2021).

The present study, against this backdrop, examined the web-based communication activities of the Research Institutes (RIs) of the

National Research Council (CNR), Italy's principal multidisciplinary research organization, in the context of the evolving understanding of the environment, nature, goals, and content of science communication. The investigation sought to determine whether and how the network of Italian National Research Council Institutes effectively leverages the opportunities for interaction and engagement presented by the evolving dynamics of the science-society interplay, particularly those driven by digital transformations. The objective was to explore whether their approach prioritises public understanding (dissemination), strategic communication, or public engagement (dialogue), in order to assess the potential of the Institutes as a promising environment for science communication to thrive.

2 Context and background

For public science organizations, such as research councils, a significant proportion of science communication takes place at Institute level, where ample are the opportunities for closer interaction and engagement with local stakeholders (Entradas and Bauer, 2017; Entradas et al., 2020; L'Astorina, 2011). Multidisciplinary research institutions are better positioned to foster meaningful dialogue with society compared to those specialized in a single field. They benefit from a diverse range of topics, enabling more specific connections with various stakeholders. Furthermore, a multidisciplinary organization has the potential to present science in all its dimensions to the public and foster transdisciplinary synergies at the research level, best suited to address complex socio-ecological issues. Given its multidisciplinary focus and public-facing mission, the Italian National Research Council (CNR) may be well-situated to transition its science communication approach from a dissemination model to one emphasising greater dialogue, engagement, and public participation.

While national or disciplinary community segments have been analyzed (Entradas and Bauer, 2017, 2018), multidisciplinary institutions have not been widely studied. Furthermore, there is a paucity of literature on the communication strategies employed by Research Institutes, despite the fact that RIs represent the most territorially based level of scientific organization, situated closest to the laboratories where research is conducted. Consequently, they play a pivotal role in the construction of relations between science and society, as well as in the creation of shared public narratives about science. As Research Institutes are more closely connected to local stakeholders and communities, and are less constrained by the rigid communication practices of central structures, they may represent an environment where public science communication can shift from a one-way dissemination model to a more interactive and engaging approach. In fact, the CNR RIs exemplify a well-defined meso-level of research (Entradas et al., 2020), positioned midway between the central level of institutional communication offices and the level of the individual researcher. This intermediate position avoids the pitfalls of both over-reliance on individual goodwill and overly centralized, professionally driven communication often dominated by public relations and promotional goals (Marcinkowski and Kohring, 2014). Moreover, compared to universities, CNR institutes exhibit greater autonomy from central structures. Universities tend to be more organizationally and geographically cohesive, often influenced by marketing-oriented strategies. As Italy's leading multidisciplinary

research institution, the CNR employs over eight thousand staff and organizes its institutes into seven disciplinary departments¹.

CNR communication practices at the institutes' level were already examined in 2009 in a series of surveys, returning the portrait of a scientific community increasingly aware of the importance of communication, but investing scarce budget, human resources and training in these activities (Agnella et al., 2012; L'Astorina, 2011; L'Astorina et al., 2013; L'Astorina and Rubbia, 2009; Valente, 2011). The studies showed a very rich, albeit still poorly structured landscape of public communication, with various initiatives involving different audiences, contexts, and motivations. Outcomes were in line with results from similar studies conducted in the same years at the international level (Besley and Nisbet, 2013; Nielsen et al., 2007; Petersen et al., 2009). This new study aims to investigate whether CNR, a multidisciplinary research institution, has effectively harnessed the opportunities for interaction and engagement offered by the emergence of digital communication, to understand whether the Research Institute level is indeed a promising environment for science communication to flourish (Entradas et al., 2020), successfully shifting from a dissemination approach toward a more engaging and dialogical exchange with citizens on science-based issues.

This study examines digital communication within Research Institutes, specifically through institutional websites. The institutional website is widely acknowledged as a dominant communication tool, both internationally (Entradas et al., 2020; Entradas and Bauer, 2017; Massoli, 2007) and specifically for CNR (L'Astorina, 2011), accessible also to institutions without dedicated communication staff thanks to the current proliferation of online content management tools. Websites are the first public showcase through which institutes communicate, offering an intentional public representation of their work and their role in the local, national, and international socio-economic context. In doing so, they often rely on models and master narratives about science, society, and research, shared and validated by the institutes' group of researchers.

In this study we opt for a web-based quantitative/qualitative content analysis of Research Institutes' communication, an approach not very much explored in literature. Existing studies tend to focus on the analysis of technology transfer activities, mainly with an economic perspective (Darnell et al., 2017; Volpe and Esposito, 2018); online communication has been so far analyzed in Italy mainly for Universities, and only marginally for Research Institutes (Cerroni and Giuffredi, 2021; Lovari and Giglietto, 2012; Massoli, 2007; Volpe and Esposito, 2018).

3 Objective and methods

Our research question – whether CNR Research Institutes capitalize on digital communication opportunities to foster a more dialogic relationship with society, thereby demonstrating

¹ In some cases, an Institute can belong to more than one Department. All the Departments are listed here: <https://www.cnr.it/en/departments>. We need to mention also that in the years (2017–2019) this organization in Institutes/Departments underwent a deep reshaping, with the merging or renaming of some Institutes.

their role as a meso-level where science communication and public engagement flourish – is broad and multifaceted. We address this question through a combination of quantitative and qualitative methods. Close references to our study are constituted by the research previously conducted at CNR (L'Astorina, 2011) and by the comparative analysis by Entradas et al. (2020, 2021) on the landscape of international communication by Research Institutes.

Our analysis articulates as follows:

- **Quantitative information-based assessment:** we collect information on communication efforts from the RIs' websites, as listed in Table 1. In order to specify what "thriving science communication" means in our case, we have organized the information retrieved from the institutional websites into three levels corresponding to different sectors of communication effort: "public-oriented," i.e., the effort to establish a basic communication channel with a non-scientific public; "Institute visibility," i.e., the effort to collect and present on websites the research and dissemination/communication activities of the institute; "engagement," i.e., the effort to achieve public engagement through interactive events and digital tools.
- **Qualitative exploration of the discourses published on websites** in the sections devoted to communication, where available, to investigate the recurring themes regarding the legitimisation of science communication, the role ascribed to research in the socio-economic context and the social actors and sectors deemed relevant for research.

For the quantitative part, we treated RIs' online communication data mainly as aggregated by Departments/Scientific areas, to expose any differences on a disciplinary basis. The areas were appointed as follows: Engineering and ICT; Agricultural sciences; Biomedical sciences; Chemistry; Physics; Social sciences and Humanities; Earth System sciences.

The combination of quantitative and qualitative analysis of the websites enabled the quantitative assessment of the amount and types of communication activities documented by the RIs on their webpages, providing a comparable overarching landscape of communication from all the Institutes at CNR. Alongside, qualitative analysis of texts allowed us to explore the frames, meanings and

features of communication activities, as described by the RIs themselves on their primary communication channel.

Quantitative assessment categories (Table 1) were based on previous studies on the communication and public engagement efforts of research institutions (Massoli, 2007; Neresini and Bucchi, 2011; L'Astorina et al., 2013; Feldy, 2015; Entradas et al., 2020; Entradas, 2021). The qualitative content analysis (de Lillo, 2010; Zhang and Wildemuth, 2009) was conducted on a subset of sites that featured a link to a section devoted to communication on their homepages (level 2c): devoting a website section to the RIs' communication activities was interpreted as a proxy indicator of relevance ascribed to them. Consequently, the texts of these websites were analyzed to gain a deeper understanding of the features of the activities, the contexts and frames in which the activities were placed and the underlying visions of the science-society interplay and of the societal role of research. Qualitative content analysis is the most appropriate methodology for the purpose of extracting the meanings underlying discourses, and it is more suited to inductive analysis, which involves the identification of the relevant categories and meanings within the text, thus illuminating the intentions of the drafters (de Lillo, 2010; Zhang and Wildemuth, 2009). Texts were collected anywhere, on the subset of sites, appeared a reference to research-society exchanges (prevalingly under the labels of communication, outreach, dissemination, third mission, education, knowledge transfer). The texts were coded, by a single coder, through repeated close-reading, choosing the themes as units of analyses, regardless of their being expressed by words, sentences or paragraphs (de Lillo, 2010; Zhang and Wildemuth, 2009). The coding categories were derived inductively from the texts. In particular, the content categorisations made by the websites' drafters themselves, as reflected in the titles and menu articulations of the webpages, were given particular weight. Specific focus was placed on elements that pertain to science communication models relevant for RIs – Dissemination, Dialogue and Strategic (Trench, 2008; Nisbet and Markowitz, 2016): the flow of knowledge (mono-directional in the Dissemination and Strategic models, bi- or multi-directional in Dialogue model), the degree of knowledgeability assigned to actors of the communication exchange (scientists as experts and public as deficitarian in awareness and understanding for the Dissemination model; a distribution of different types of knowledge among all relevant actors for the Dialogue model), values assigned to communication (cultural and pedagogic for the Dissemination model;

TABLE 1 A synoptic view of the information used to assess CNR RIs' websites and the results of the analysis.

Information/data per level	% of total n° of institutes analyzed
Level 1: Public-oriented effort	
(1a) Language of the welcome page: Italian or English	73% Italian
(1b) Presence of welcome text in homepage presenting the institute	59%
Level 2: Institute visibility effort	
(2a) A news/events feed or section in home page	94%
(2b) News published on CNR web portal	98%
(2c) A menu or section of the website related to communication/dissemination activities	35%
Level 3: Engagement effort	
(3a) Section/menu of the website related to activities with schools	37%
(3b) Information about visits to laboratories, open days or similar	12%
(3c) Any mention of the Institute participation in the European researchers' night	27%
(3d) A reference in the homepage to institutional social media profile	40%

societal and democratic for the Dialogue model; promotional and application-oriented for the Strategic model).

The analysis was conducted in 2019, allowing for the documentation of a snapshot of the situation just prior to two significant changes: the advent of the global pandemic, and the restructuring of the institution on an internal level (including the suppression and merging of Institutes). The aforementioned conditions resulted in significant alterations that had ramifications for the public communication of the Institutes. Consequently, an analysis conducted subsequent to 2019 would have revealed that the ambiguity surrounding communication practices (or the absence thereof) was a direct consequence of these changes or influenced by the ongoing transition. Conversely, the analysis conducted in the pre-pandemic era illuminates how digital platforms were leveraged by RIs to disseminate scientific knowledge, enhance their visibility, and engage with citizens at a time when digital tools were widely adopted by the public, researchers, and institutions.

4 Results and discussion

Table 1 displays the synoptic view and the results of the information retrieved on CNR RIs' websites analysis of online information. Graphic representations are available in Figures 1, 2.

As may be reasonably anticipated, all of the Institutes have established their own websites, thereby demonstrating the continued significance of web-based communication as a fundamental channel for communication (Entradas et al., 2020; L'Astorina, 2011).

4.1 Communicating to peers, enhancing the RIs' visibility

In Figure 1 the asymmetry of the radar graph to the right, with peaks in news and events published on the Institute's home page (94%

of the websites studied) and on the CNR portal (98%), show that communication is primarily expressed through efforts to enhance the Institute's visibility, accomplishing both the missions of disseminating science to the public and of promoting the Institute. Publishing news is the easiest way for researchers to address a variety of audiences; it is also a straightforward channel to fulfil the duty of accountability in the socio-economic sphere perceived and reported by scientists (Davies, 2021).

Considering that the CNR web portal reaches a larger audience than the RIs' websites, the possibility to publish on the central website (after approval by the deputed staff) represents a real opportunity for researchers to increase the visibility of their work, bypassing the selection of journalists and directly reaching a wide audience. Between 2016 and 2019, researchers from the 81 RIs published 569 news items and 1,065 events on the CNR portal (for comparison, the central structures published 534 news items and 620 events in the same period). Events, mainly related to workshops and conferences, count twice as much as news, likely because the objective of researchers in disseminating information about events is primarily to keep colleagues apprised in order to boost attendance.

If a website is an open window on the activities of the Research Institutes, we would expect all websites to have welcome elements on their home pages, providing basic information about the RIs, as a minimum indicator of the willingness to communicate with the public, as expressed by the effort of creating a website; on the contrary, 41% of the RIs do not provide any welcome text. Furthermore, about one third of the Institutes chose English as the default language (with some notable disciplinary differences, e.g., Physics – nearly total English – and Social Sciences – nearly total Italian –, see Figure 2), thus showing more interest in an international community, probably the community of peer scientists, than in the national, Italian-speaking public. Moreover, the communication activities that are more clearly aimed at the public (3a, 3b, 3c and partly 3d in our analysis) are mentioned by less than half of the Institutes and just one-third of websites have a specific section devoted to the communication activities of the Research Institute (2c).

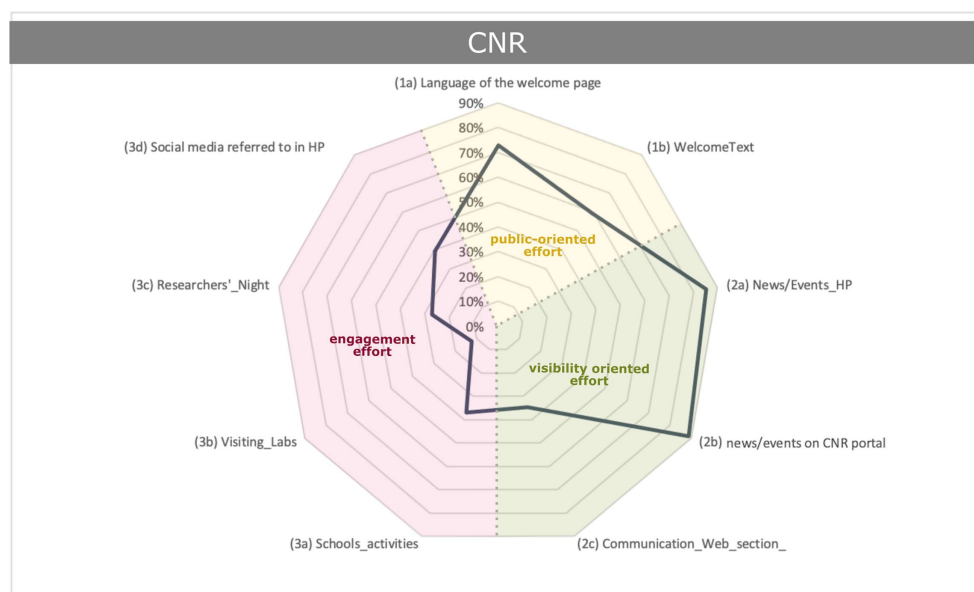


FIGURE 1

A radar chart illustrating the identified levels of web-based communication at the CNR.

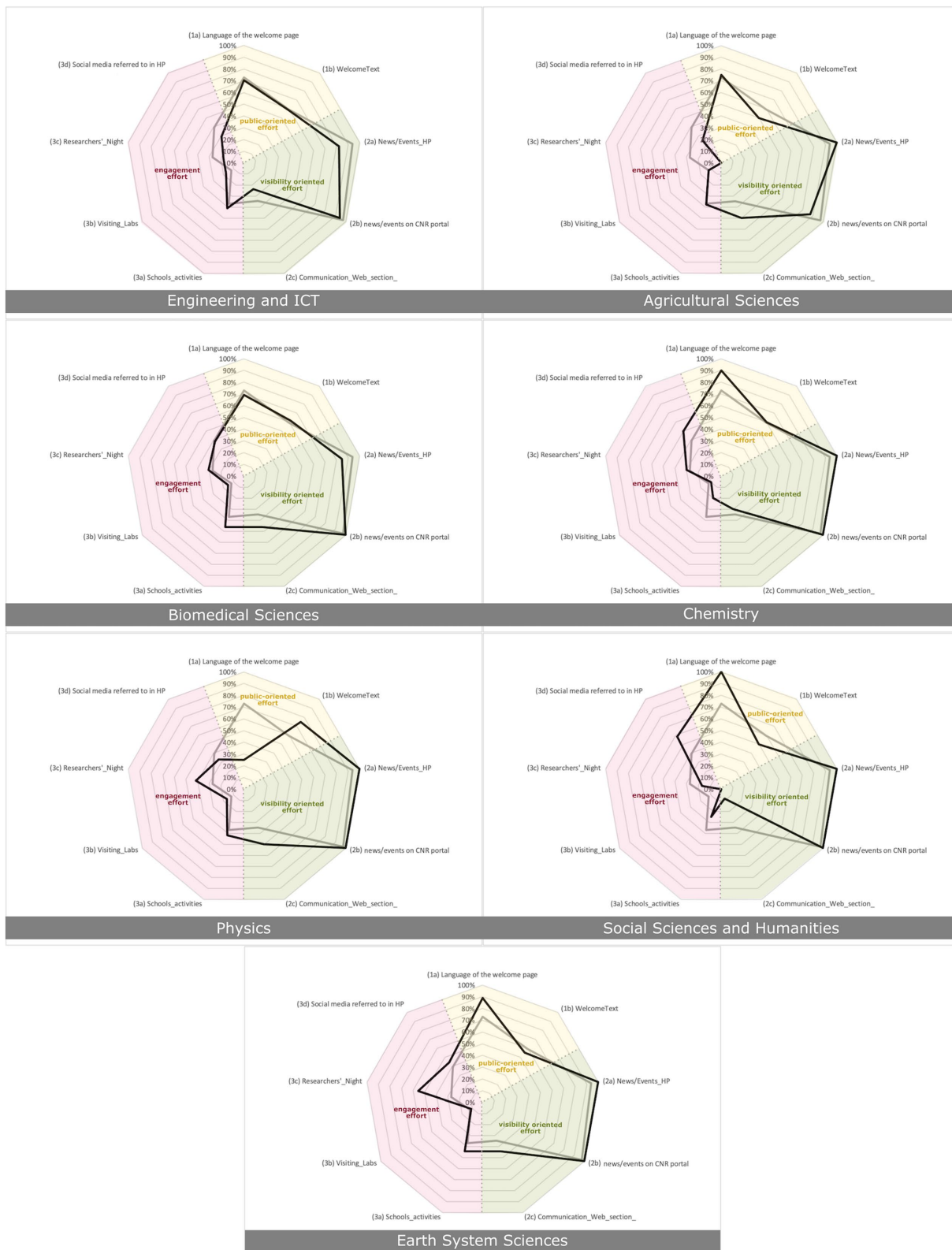


FIGURE 2
The radar charts illustrate the three-level assessment of online communication among CNR Research Institutes across different scientific areas.

Therefore, from the analysis of the elements that RIs choose to present on their websites, it seems that for disciplines like Physics and Biomedical sciences the main effort is focused on sharing research

lines and results with other scientific institutions. This aligns with [Neresini and Bucchi's \(2011\)](#) findings on a European sample. Such efforts primarily support the strategic goals of enhancing institutional

visibility and public reputation (Marcinkowski and Kohring, 2014). Conversely, establishing dialogic communication channels and engaging with the lay public appears to be a secondary objective of these websites, on average.

4.2 Communicating to and engaging with the public

While all Institutes communicate via the web, and many promote the Institute's activities by providing information on research topics and seminars via the website, only a minority of Institutes describe engagement or participatory communication activities as a way to connect with the public. Most activities aimed at the non-scientific public take place in schools and at local events.

Students are the most favored group of participants, as documented on at least half of the websites. In Italy, the relationship between RIs and the education sector was strengthened by the inclusion of work-related learning experiences in high school curricula, known as 'Alternanza scuola-lavoro', in 2015, and many Institutes describe the participation of their staff in such activities. However, it is worth noting that activities with schools had been ongoing for several years prior, as evidenced by the previous survey on the Italian landscape and at CNR (L'Astorina, 2011; Grasso et al., 2012, 2017). This result is consistent with findings from other European research institutions (Neresini and Bucchi, 2011). In fact, the boundaries between science communication and science education are often blurred, and the interpretation of school education as science communication is still disputed (Davies and Horst, 2016).

Local events involving researchers, such as European Researchers' Nights, territorial science exhibitions or environmental festivals, are a second important category of activities presented on websites, as reported in Table 1, points (3a), (3b), (3c). Already identified in 2009 as the most important communication channel for the CNR's Institutes, engagement with local communities represents a valuable and easy opportunity for researchers to reach the public at first hand, to highlight their relevance to stakeholders, territorial associations, NGOs and specific communities, and to become a trusted point of reference on their scientific topics. Engaging with communities is an opportunity that is naturally more available at Institute level than at central communication offices and while the presence of these events on institutional websites reflects the value researchers and Institutes place on them, it does not provide a reliable measure of the actual impact these events had on the local community or target audience. On the other hand, communities play a central role in the exchange between science and society (Orthia et al., 2021) and represent a favorable setting in which participatory, critical and dialogical science-society interactions can flourish. The copious documentation of local events on websites may thus serve as an indicator of public engagement efforts by the RIs.

Nonetheless, most events reported on websites, even when they are labeled as 'public engagement', are presented as seminars or lectures, i.e., their format relies on a mono-directional transfer of knowledge, shaped on education models, assigning the public a passive, receiver, role. This tendency may be driven by several factors, including researchers' own comfort zones and prior training in the traditional Dissemination model of science communication, as well as institutional pressures to demonstrate "public engagement" without

necessarily fostering genuine dialogue (Entradas et al., 2020; Riedlinger and Joubert, 2022; Metcalfe, 2022). Without a deeper commitment to more participatory approaches, such as the Dialogue or the Participative models (Zimmerman et al., 2024; Trench, 2008), such occurrences have the potential to reinforce the Deficit model where the public is seen as an audience to be educated rather than as active partners in the research process. The lack of genuine dialogue in many of the public engagement activities described on the RIs' websites is consistent with the observation from the literature that, despite the rhetoric around a "Dialogue" model, the Deficit model continues to be the dominant paradigm in science communication in practice (Davies et al., 2021, Cortassa, 2016; Simis et al., 2016). In fact, emerging research has acknowledged that, in practice, the different models of science communication often coexist, and where research institutions have established trusted relationships with local communities, dissemination-focused approaches play a relevant role in effectively facilitating genuine changes in public attitudes or behaviors (Metcalfe, 2022).

4.3 Communicating science with digital instruments and on social media

Social media are among the factors that have contributed most to reshaping the communication ecosystem and have also become a primary source of scientific information (Davies and Horst, 2016). They have become widely used in the field of scientific research, encouraging direct and rapid exchanges between colleagues, but also allowing to reach a wider community of researchers (Collins et al., 2016; Côté and Darling, 2018). Platforms such as Twitter, Facebook or academic social networks such as ResearchGate and Academia.edu are recognized as fruitful ways to promote research (Duffy and Pooley, 2017) and increase citations (Eysenbach, 2011).

However, RIs seem reluctant to fully exploit the potential of digital communication technologies and social media (Entradas et al., 2020). Despite the opportunities offered by new technologies, RIs do not seem to have fully embraced them as a means of engaging the public, establishing multi-directional communication. Few websites engage visitors through blogs, forums or RSS channels (Feldy, 2015); and even fewer embed social media feeds, reinforcing the predominance of a unidirectional communication model.

On the homepages surveyed, Facebook profiles are the most frequently linked (27% of Institutes), followed by Twitter accounts (20%) and YouTube channels (16%); LinkedIn, Instagram, ResearchGate and SlideShare are far behind, with very few examples. Thus, at the time of our survey, more than 70% of the Institutes did not use Facebook and 80% did not use Twitter, indicating that the communication of research via social media still plays a marginal role for many scientific institutions.

The disintermediation enabled by new technologies is struggling to gain traction, particularly at the level of CNR RIs. Even when social media are employed, the communication of the RIs seems to be at an early stage, mainly conceived with the characteristics of traditional media, as a way to inform the public and increase visibility (Feldy, 2015). The communication through digital technologies, and especially social media, seems to be squeezed between the communication of institutional channels, managed by professional staff and mainly

dedicated to promoting the visibility and reputation of the Institutes, and the personal profiles of individual researchers, who share scientific information and engage in discussions on scientific topics, but only on a personal level. Reaching out to the general public through institutional communication appears to be a very challenging task for CNR Research Institutes. There are exceptions in certain domains like in Social Sciences and Humanities, as well as in Information and Communication Technologies, where Research Institutes have been more successful in leveraging digital communication and social media to engage with the broader public, as discussed in the next section.

4.4 Differences among disciplines

Disciplinary fields differ in their attitudes and practices when communicating science (Figure 2). The Earth System Sciences, Physics, and Biomedical sciences are the most active scientific areas, communicating more and on a wider range of channels than other areas.

Significant differences emerge among scientific areas in terms of the main language used on the analyzed websites (Figure 2). In Social Sciences and Humanities, no Institute has a homepage in English. Conversely, in Physics, 9 out of 12 (75%) are in English, indicating that the international research community is their primary target audience to be reached via the website. English is the default language for one-third of Biomedical Sciences websites (31%) and Engineering and ICT (29%).

According to the websites, the Earth System Science area has the highest number of active Institutes in engagement events at the local level, followed by Physics, Biomedical Sciences, and Chemistry. On the other hand, Social Sciences and Humanities, as well as Agricultural Sciences, appear to be the least engaged, as shown on the left side of the radar graph. Possible reasons for the relevance of some fields to public debate include their timeliness, such as environmental or health-related topics, and the greater availability of laboratories for live events compared to other fields. Previous research has identified

environmentalists as the most involved in public engagement, both at international and CNR levels (Entradas and Bauer, 2017; L'Astorina, 2011). However, the Social Sciences Institutes' website has poor documentation on activities with the public, indicating a trend in the opposite direction (Figure 3).

Out of the websites displaying a communication section, only 1 out of 11 in Social Sciences and Humanities and 4 out of 13 in Engineering and ICT include it. In contrast, approximately half of the Institutes in Physics, Earth System Sciences, Agricultural and Biomedical Sciences have such a section (see Figure 4). This suggests that hard sciences are more likely to dedicate a section to non-scientific activities on their websites, while Institutes in Social Sciences, Humanities, Engineering, and ICT document these initiatives less frequently.

Finally, our inquiry has identified disciplinary-based variations in the existence and use of social networks (Table 2). Specifically, in the fields of Social Sciences and Humanities and Engineering and ICT, more Institutes have social profiles.

4.5 Understandings of research/society exchanges in websites' communication discourses

To investigate the deeper levels of meaning in the Institutes' web communication, we closely examined the website sections dedicated to exchanges with society. Figure 4 presents a breakdown of disciplinary affiliations according to the presence or absence of a communication section within the Institute.

Upon repeated close readings of the text, we identified recurring themes used to describe research/society exchanges, with reference to context, audience, style, and purpose of the interactions:

- Research Institutes interact with society by teaching scientific contents to the public, to spread scientific culture and promote new scientific careers;

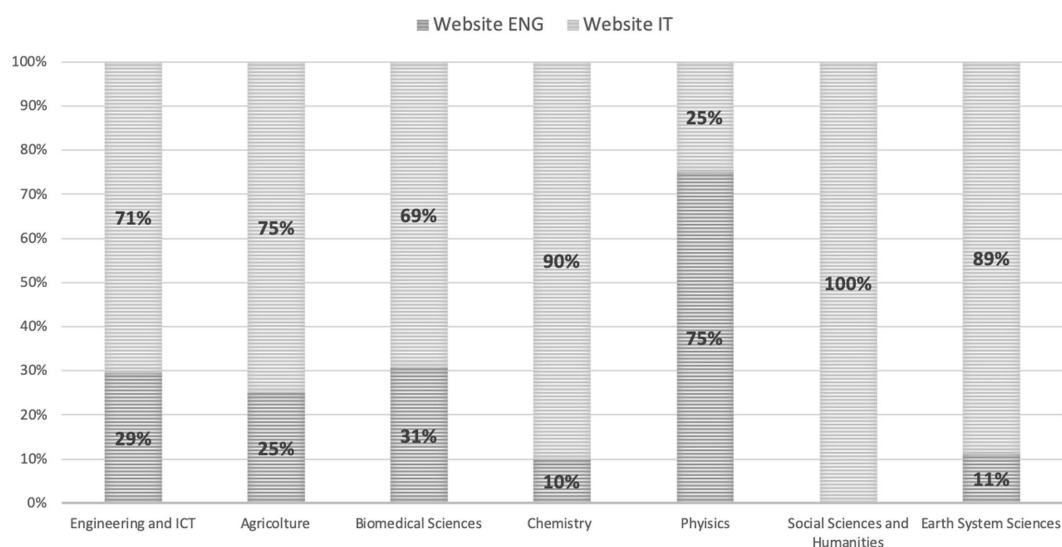


FIGURE 3
Default language of the explored Research Institutes' websites (percentage). Data categorized by scientific areas.

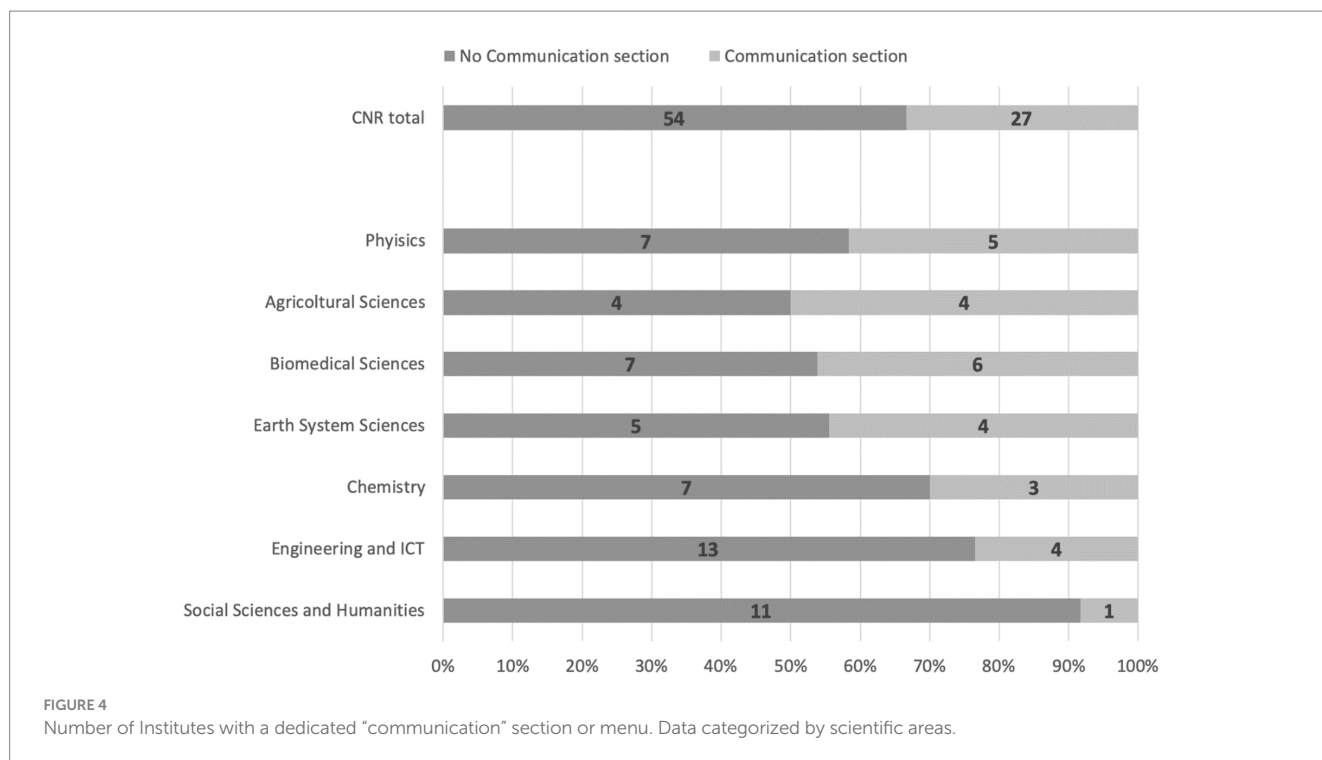


TABLE 2 Number of institutes having a referral in the homepage to social media platforms.

Areas	Facebook	YouTube	Twitter	Total accounts/discipline
Engineering and ICT	3	3	4	10
Agricultural Sciences	2	1	1	4
Biomedical Sciences	3	3	1	7
Chemistry	4	1	2	7
Physics	3	1	1	5
Social Sciences and Humanities	6	2	5	13
Earth System Sciences	1	2	2	5
Total CNR	22	13	16	51

Data are grouped for scientific areas (corresponding to departments).

- Research Institutes interact with society through knowledge transfer, particularly with the goal of contributing to economic development or supporting public administrations;
- Research Institutes interact with society by sharing information on the Institute’s scientific focus and activities with a “general public,” to enhance their scientific knowledge and gain support for science.

The categories resound with previous studies on communication and research policy (e.g., Cerroni and Giuffredi, 2021; Giuffredi, 2018; Molas-Gallart and Castro-Martínez, 2007; Volpe and Esposito, 2018) and with the labels defined by the Italian National Agency for the Evaluation of Universities and Research Institutes (ANVUR, cf. ANVUR, 2018).

In terms of communicative models, all the themes are susceptible to realization within a Dissemination model of science communication, assuming the audience as a deficit learner. However,

while the first two (education and knowledge transfer) are predominantly conceptualized as a unidirectional transfer of information, the third (public communication) may be interpreted through multi-directional or participatory methods.

The primary focus of educational activities is on high school and university/postgraduate students. This is achieved through a variety of methods, including lessons in high schools of the territory on the scientific topic covered by the Institute, welcoming students in the RI’s laboratories, and collaborating with local universities to enrich the students’ curricular offer. Vocational training is less common, with examples including refresher courses for adults in the field of information and communication technology.

Educational discourses revolve around recurring themes that are shared with the PUS model of science communication. One of these themes is the need to simplify scientific concepts for the uninformed public and to raise awareness of the relevance of

research to society. The content is often described along a simple-difficult axis and is presented in a progressive and didactically incremental manner. Secondly, educational engagement is presented as fulfilling the ethical duty of researchers to spread scientific culture and promote new scientific careers, in line with the belief that spreading scientific literacy will naturally increase support and shared consensus for science and scientific research. In the following example, one of the RIs motivates the commitment to training from the acknowledgement of an insufficient awareness of the importance of scientific culture, research and technological development in the audience. Furthermore, the RI's contribution to teaching activities in schools is identified as a decisive booster of students' motivation to study, which eventually promotes the choice of a scientific career:

Disseminating scientific culture and research – and the technological development that accompanies it – is intended to raise awareness of their importance for human activities and to strengthen their rooting in society. These are initiatives that certainly help and contribute to making teaching activities in schools more effective as well, since they have a decisive impact on each individual's motivation to study and act as a school pre-orientation.

Most of the analyzed websites have a section dedicated to the “Third Mission.” These activities are usually related to transferring knowledge and technology to the productive sector, as well as supporting public administrations, such as in the fields of health or cultural heritage conservation. Although research institutions' Third Mission includes, in principle, cultural and educational initiatives like public debates, festivals, and activities for schools or professional training, economic valorization of knowledge and commercialization of technology play a central role. This is reflected by the majority of the Institutes' websites, which predominantly list collaborations with the business system, patents, R&D contracts with companies, spin-offs, and start-ups (Molas-Gallart and Castro-Martínez, 2007; Volpe and Esposito, 2018). The language used for Third Mission activities is detailed and focused, reflecting the categories defined by the Italian National Agency for the Evaluation of Universities and Research Institutes (ANVUR). The actors of the knowledge transfer process and their interactions are clearly referenced: the discourses mention in the first place the actors of the triple helix – policy makers, researchers, industry – but also “research centres,” “public institutions,” “industrial system,” “leading companies,” “national system,” “individuals and communities.” Some websites make reference to the triple helix or innovation models, which suggests an awareness of the theoretical research background on systems of innovation developed within the context of science, technology and innovation (STI) research. Generally, Third Mission discourses refer to the pragmatic narrative that innovation is the only key to ensuring the survival and development of enterprises in the competitive global market, with research as the basis for the process (Chakraborty and Giuffredi, 2019; Giuffredi, 2018). However, upon close examination of the discourses, a nuanced differentiation emerges in how the Institutes describe their role within society. They frequently view themselves as “interfaces,” providing support for “research,” “businesses,” or “public administrations”:

For the indicated subject lines, [RI name], in its role as an interface with industry, provides companies with technical-scientific capacity and appropriate solutions for research projects and consultancy activities on product development, process development and optimisation and new technologies.

Depending on the situation, they may align more closely with one or the other role: for instance, they may emphasize their work on “public utility” applications of knowledge or their contribution to the definition of public policies, highlighting their value in supporting communities and building the public good. Alternatively, they may choose to highlight their interaction with local industries. Finally, they may see their mission as “research market exploration,” emphasising their pragmatic or marketing contribution to society.

Finally, the discourses describing the communication activities of the Institutes for the “general public” present, under the labels “popularization,” “outreach” and “dissemination,” public events, exhibitions, museums, scientific cafés, the Researchers' Night, as well as media products such as videos, books and materials from the press and social channels. In general, education and communication are presented as a pair, both aimed at proposing simplified scientific content or cultural activities to introduce non-experts to the disciplinary orientation and research results of the Institutes, mostly grounding on the value of advancing knowledge and spreading scientific culture in society. Similarly, education and communication activities often share the objectives of consensus building and talent recruitment. The target actors and partners involved are mostly mentioned in general terms (“the general public,” “the wider public,” “society,” “people”), without identifying specific groups.

Despite some indications of an awareness of the value of an interactive approach, the texts in question continue to rely on the use of mono-directional metaphors such as “translations” or “transfers” of research results to society. Furthermore, the term “dialogue” is seldom employed. As anticipated, most of the websites' discourses report mono-directional styles of communication rather than a bi- or multi-directional exchange, thus positioning within the PUS model. In fact, most of the descriptions of communication activities imply acts of “teaching” or “transferring”/“disseminating” knowledge, which are inherently activities based on a one-way act of communication from a knowledgeable actor to an audience which does not possess relevant knowledge and has a passive attitude. On the other side, “sharing” knowledge could in principle include multi-directional exchanges, thus opening to proper engagement of the public in an active position.

A minority of Institutes employ the terms “public engagement” and “science and society” and provide comprehensive descriptions of initiatives designed to advance democratic processes, including citizen science, RRI, and participatory research. These descriptions elucidate the theoretical underpinnings of these initiatives and refer to citizens as the primary beneficiaries of these activities. In select instances, the core values of democracy, participation, and ethics are explicitly mentioned. In addition, a small number of websites list communication products dealing with topics “of interest to citizens” or describe initiatives aimed at informing people about the correct behavior in case of crises, e.g., hydrogeological risks, thus testifying to the existence of RIs where a reflection is underway on shifting from the public understanding frame to the promotion of active citizenship.

In particular, [RI name] aims to investigate the role played – in the complex relationship between science and society – by the scientific community operating in research facilities. The topic is emphasised both as a field of study and as an institutional activity – carried out within the framework of national and international projects – in which new communication practices and science-society interaction are experimented.

With regard to the choice of language and the conceptual references employed, the descriptions of educational or knowledge transfer activities are characterized by clarity and detail. In contrast, on average the documentation of references pertaining to more complex and interactive communication activities on the websites in question appears to be less comprehensive. One of the most discernible outcomes of the analysis is the pervasive overlap in the conceptualization of the role of research in society, coupled with the multifaceted nuances in the interpretation of pivotal concepts across the websites. Institutes often use different communication- and education-related terms as synonyms: for example, a menu section on “popularization” may open a page entitled “teaching” with sub-headings on “education,” “events” and “meetings.” Although the Third Mission sections show a certain precision in the naming of initiatives, the concept is sometimes understood strictly as a contribution to the economic valorisation of knowledge, sometimes loosely as an exchange with society. In addition, the diffuse use of lingos derived from European funding programmes (“outreach” and “dissemination”) or from the ANVUR classification (patents, intellectual property, spin-offs, start-ups, support to public administrations, etc.) suggests external references to the choice and organization of content to be presented on the Institutes’ websites, rather than a reflection on communication with society developing within the research community, whether in the direction of mono-directional or dialogical science communication, or of strategic communication.

In conclusion, the analyzed websites share a general understanding of communication on websites as a channel for presenting and valorising the activities of the Research Institutes, as in the Strategic communication model, and report communication activities that, with some notable but sparse exceptions, can be mostly understood within the Public Understanding of Science model.

5 Discussion and conclusion

This study aligns with recent scholarly calls for research that acknowledges the interconnectedness of science communication and organizational communication within scientific institutions (e.g., Casini and Neresini, 2012; Entradas and Bauer, 2018). Focusing on the digital communication strategies of Italian National Research Council (CNR) Research Institutes, we examine how these meso-level organizations (Entradas et al., 2020) can foster science communication. By analyzing institute websites for elements reflecting societal engagement and digital interaction, we sought to understand how science communication is embedded within these organizational contexts (Trench and Bucchi, 2010).

In accordance with the growing interest of international scientific institutions in public communication activities (Davies, 2021; Horst, 2021), CNR Research Institutes are increasingly demonstrating their

commitment to science communication on their websites and social media platforms. However, the landscape is highly fragmented in terms of effort and conceptual scope (as in previous studies at the EU level, see Davies et al., 2021; Neresini and Bucchi, 2011). The analysis conducted on Research Institutes’ websites (Table 1), paired with the content analysis on the texts documenting exchanges of RIs with society, shows that the prevailing orientation of the RIs’ documentation of communication activities on their websites is to support their institutional visibility and reputation, as in the strategic communication approach, with a diffused concern about showing an adherence to the Third Mission indicators, evaluated by central ministerial offices. The communication style is predominantly anchored on the traditional PUS patterns of mono-directional information sharing (via news, possibly on the press), education in schools, and scientists’ conferences.

This approach to communication in Research Institutes is logically tied to the fact that institutional communication is naturally committed to gaining public attention and legitimising scientific institutions and funding for science (Marcinkowski and Kohring, 2014). As noted by Entradas et al. (2020), research institutions tend to align with institutional and public relations communication (Carver, 2014), rather than focusing on the primary objective of public engagement, which was originally to enrich democratic debates on scientific issues.

The digital communication ecosystem transformation has had only a limited impact on the communication of RIs. Rather than being used to promote exchange and participation, digital technologies are used in the same way as traditional media, providing one-way information about the scientific progress of RIs. The introduction of new digital technologies has not automatically reconciled the competing demands of increased public engagement efforts and the pressure for institutional visibility and strategic communication (Bucchi and Trench, 2021). Indeed, the proliferation of communication activities, from events to digital contents, seems to be predominantly guided by the need to ‘appear’ as a modern and proactive institution, rather than by a reflection on the multiple functions of science communication and engagement.

Academic discussions on Science and Society do not seem to be able to impact practices (Salmon et al., 2017; Zimmerman et al., 2024). While academic discussions on the intricate relationship between science and society have advanced, their impact on actual communication practices remains limited (Salmon et al., 2017). Despite the growing body of research underscoring the importance of a more dialogical and participatory approach to science communication (Zimmerman et al., 2024), Research Institutes still tend to prioritize strategic communication and one-way information dissemination over fostering genuine public engagement. Emerging research, such as Metcalfe (2019), Bucchi and Trench (2021), highlight that in practice very often these models coexist, and engagement activities end up improving the efficacy of disseminating science.

The ongoing development of reflections on the interplay between science and society seems to have widened the range of conceptual references in use, as visible in the discourses on the websites, without promoting a real transformative debate within the scientific community, as evidenced by the predominance of traditional one-way communication styles and by the diffuse overlapping of concepts. Conversely, it seems that regulatory pressures, such as the evaluation of RIs by national authorities (ANVUR) or the rules on participation

in European projects, have had a stronger impact, introducing categories of activities worth mentioning on websites.

There are some exceptions: a few RIs report diversified portfolios of activities and articulately understand their role as research institutions within society. However, the fact that these cases are exceptions implies that contextual and specific characteristics may have influenced them. For instance, the presence of researchers or directors with a personal interest in science-society issues or with specific training in the field, or the existence of controversial scientific issues in the local area, which may have stimulated more extensive studies of science communication. The isolation of these cases suggests that a widespread culture has not yet developed and is not equally shared among the different Institutes and researchers.

The CNR case study is noteworthy because, as a large multidisciplinary entity, Science and Society Studies could potentially influence many disciplinary areas to promote a communication that fosters public dialogue and supports public participation. However, our findings counter this expectation. A predominantly unidirectional, performance-oriented communication approach prevails in strategic communication and organizational practices.

A clear differentiation based on disciplinary affiliations of the RIs was observed. Institutes focused on environment and health demonstrated greater success in adopting an engaging communication style, while those in Social Science and Humanities documented fewer communication activities on their websites.

As Science Communication researchers-practitioners within this institution, we are sensitive to the critical gap between scholars and practitioners in the field (Hornig Priest, 2010; Miller, 2008). Further *ad hoc* and updated investigations, also with a qualitative approach, may be useful to enlighten these findings. To strengthen their essential capacities for engaging with society, scientific institutions must undertake new initiatives. This capacity should transcend narrow conceptions of mere 'skills' for effectiveness, encompassing a heightened awareness of the complex and contemporary dynamics of the science-society interface. This leap needs to be supported by debates within scholarly communities. The science communication research community should continue to reconsider how theoretical reflections can enhance mature science communication practices and transform perspectives. Notably, the cultural value of science and its role in contemporary democracies remain underrepresented in public discourse, an area where both scholars and practitioners can contribute to shared cultural transformation. Against the backdrop of evolving cultural perspectives on science, it is clear that science communication is not simply a practice, but rather a transformative process. This process not only influences how research is communicated but also shapes research agendas and methodologies, ultimately defining researchers as scientists intrinsically connected to societal needs and values.

Despite the fragmented and heterogeneous landscape at CNR, the existence of single RIs documenting more articulated science communication visions and practices shows that the context of the Research Institutes offers sufficient institutional freedom to allow researchers to experiment and propose new ways of relating to society. However, without adequate encouragement (communication policies by the central institution, specific training, support in terms of personnel and resources, and in terms of acknowledging the activity for career advancements),

communication styles tend to stick to one-way communication models and to strategic communication (Schäfer and Fähnrich, 2020), losing the opportunity to explore the possibilities to enrich the democratic debate around science as in Public Engagement models. Most significantly, sticking to the model of one-way knowledge transfer to the public means that scientists miss the opportunity to truly engage with the public, to be enriched by this encounter, and to discover a new meaning for the researcher's role within society and the social role of science.

Data availability statement

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

Author contributions

RG: Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. VG: Conceptualization, Data curation, Methodology, Visualization, Writing – review & editing. ALA: Conceptualization, Investigation, Project administration, Resources, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

The authors work at the Italian National Research Council, within different Research Institutes, and are engaged both in researching and practising science communication within their contexts. The authors would like to express their gratitude to Marco Ferrazzoli, Monica Di Fiore, and Andrea Pompili for providing data on the central CNR portal that was used in this research.

Conflict of interest

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

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

- Agnella, S., De Bortoli, A., Scamuzzi, S., L'Astorina, A., Cerbara, L., Valente, A., et al. (2012). "How and why scientists communicate with society: the case of physics in Italy" in PCST book of papers - 12th international public communication of science and technology conference (PCST). eds. M. Bucchi and B. Trench (Vicenza, Italy: Observa Science in Society), 1–8.
- ANVUR. (2018). Linee guida per la compilazione della Scheda Unica Annuale Terza Missione e Impatto Sociale SUA-TM/IS per le Università. Available at: https://www.anvur.it/wp-content/uploads/2018/11/SUA-TM_Lineeguida.pdf (Accessed April 18, 2024).
- Besley, J. C. (2020). Five thoughts about improving science communication as an organizational activity. *J. Commun. Manag.* 24, 155–161. doi: 10.1108/JCOM-03-2020-0022
- Besley, J. C., and Nisbet, M. (2013). How scientists view the public, the media and the political process. *Public Underst. Sci.* 22, 644–659. doi: 10.1177/0963662511418743
- Brossard, D., and Scheufele, D. A. (2022). The chronic growing pains of communicating science online. *Science* 375, 613–614. doi: 10.1126/science.abo0668
- Bucchi, M., and Trench, B. (2021). Rethinking science communication as the social conversation around science. *JCOM* 20:Y01. doi: 10.22323/2.20030401
- Carver, R. B. (2014). Public communication from research institutes: is it science communication or public relations? *J. Sci. Commun.* 13, 1–4. doi: 10.22323/2.13030301
- Casini, S., and Neresini, F. (2012). Behind closed doors. scientists' and science communicators' discourses on science in society. A study across European Research Institutions. *Tecnoscienza - Italian Journal of Science & Technology Studies* 3, 37–62. doi: 10.6092/issn.2038-3460/17055
- Cerroni, A., and Giuffredi, R. (2021). "La Terza Missione dell'Università fra scienza, democrazia ed emancipazione umana - Lavori in corso" in Scienze sociali ed emancipazione - Tra teorie e istituzioni del sapere. eds. V. Pellegrino and M. Massari (Genova, Italy: Genova University Press), 87–92.
- Chakraborty, A., and Giuffredi, R. (2019). Science and technology for the people? On the framing of innovation in policy discourses in India and in EU. *JCOM* 18. doi: 10.22323/2.18030205
- Collins, K., Shiffman, D., and Rock, J. (2016). How are scientists using social media in the workplace? *PLoS One* 11, 1–10. doi: 10.1371/journal.pone.0162680
- Cortassa, C. (2016). In science communication, why does the idea of a public deficit always return? The eternal recurrence of the public deficit. *Public Underst. Sci.* 25, 447–459. doi: 10.1177/0963662516629745
- Côté, I. M., and Darling, E. S. (2018). Scientists on twitter: preaching to the choir or singing from the rooftops? *Facets* 3, 682–694. doi: 10.1139/facets-2018-0002
- Darnell, D., Dorsey, C. N., Melvin, A., Chi, J., Lyon, A. R., and Lewis, C. C. (2017). A content analysis of dissemination and implementation science resource initiatives: what types of resources do they offer to advance the field? *Implement. Sci.* 12:137. doi: 10.1186/s13012-017-0673-x
- Davies, S. R. (2021). An empirical and conceptual note on science communication's role in society. *Sci. Commun.* 43, 116–133. doi: 10.1177/1075547020971642
- Davies, S. R., Franks, S., Roche, J., Schmidt, A. L., Wells, R., and Zollo, F. (2021). The landscape of European science communication. *J. Sci. Commun.* 20:A01. doi: 10.22323/2.20030201
- Davies, S. R., and Horst, M. (2016). Science communication-culture, identity and citizenship. London, UK: Palgrave Macmillan.
- de Lillo, A. (2010). Il mondo della ricerca qualitativa. Torino, Italy: UTET università.
- Duffy, B. E., and Pooley, J. D. (2017). "Facebook for academics": the convergence of self-branding and social media logic on academia. *Edu. Soci. Media Soci.* 3:205630511769652. doi: 10.1177/2056305117696523
- Entradas, M. (2021). Public communication at research universities: moving towards (de)centralised communication of science? *Public Underst. Sci.* 31, 634–647. doi: 10.1177/09636625211058309
- Entradas, M., and Bauer, M. M. (2017). Mobilisation for public engagement: benchmarking the practices of research institutes. *Public Underst. Sci.* 26, 771–788. doi: 10.1177/0963662516633834
- Entradas, M., and Bauer, M. W. (2018). Bustling public communication by astronomers around the world driven by personal and contextual factors. *Nat Astro* 3, 183–187. doi: 10.1038/s41550-018-0633-7
- Entradas, M., Bauer, M. W., O'Muircheartaigh, C., Marcinkowski, F., Okamura, A., Pellegrini, G., et al. (2020). Public communication by research institutes compared across countries and sciences: building capacity for engagement or competing for visibility? *PLoS One* 15:e0235191. doi: 10.1371/journal.pone.0235191
- Eysenbach, G. (2011). Can tweets predict citations? Metrics of social impact based on twitter and correlation with traditional metrics of scientific impact. *J. Med. Internet Res.* 13:e123. doi: 10.2196/jmir.2012
- Feldy, M. (2015). Internet website as a tool of communication in scientific institutions. *Minib - marketing of scientific and research organizations* 18. doi: 10.14611/minib.18.04.2015.09
- Fontaine, G., Lavallée, A., Maheu-Cadotte, M. A., Bouix-Picasso, J., and Bourbonnais, A. (2018). Health science communication strategies used by researchers with the public in the digital and social media ecosystem: a systematic scoping review protocol. *BMJ Open* 8, 1–6. doi: 10.1136/bmjopen-2017-019833
- Funtowicz, S., and Ravetz, J. (1993). Science for the post-normal age. *Futures* 25, 739–755. doi: 10.1016/0016-3287(93)90022-L
- Giuffredi, R. (2018). Which science for which Europe? Between the lines of policy discourses in European science policies [dissertation thesis] [Alma mater Studiorum Università di Bologna. Dottorato di ricerca in science, cognition and technology, 29 Ciclo]. doi: 10.6092/unibo/amsdottorato/8286
- Grasso, V., Bartolini, G., Benedetti, R., Betti, G., Capocchi, V., Gozzini, B., et al. (2017). Engaging students and teachers in meteorology and atmospheric sciences: the LaMMA activities. *Adv. Sci. Res.* 14, 109–114. doi: 10.5194/asr-14-109-2017
- Grasso, V., Manzoli, F., Conti, F., Zabini, F., and Ercoli, T. (2012). "Participating the climate change in school: an Italian case study," in *Proceedings of 19th Symposium on Education, in AMS 90th Annual Meeting*. Atlanta, USA. Available at: <https://hdl.handle.net/2158/921538>.
- Hornig Priest, S. (2010). Coming of age in the academy? The status of our emerging field. *J. Sci. Commun.* 9:C06. doi: 10.22323/2.09030306
- Horst, M. (2021). Science communication as a boundary space: an interactive installation about the social responsibility of science. *Sci. Technol. Human Val.* 47, 459–482. doi: 10.1177/01622439211003662
- Huber, B., Barnidge, M., Zúñiga, H., and Liu, J. (2019). Fostering public trust in science: the role of social media. *Public Underst. Sci.* 28, 759–777. doi: 10.1177/0963662519869097
- Janoff, S. (2004). States of knowledge: The co-production of science and the social order. London, UK: Routledge.
- Kessler, S. H., Schäfer, M. S., Johann, D., and Rauhut, H. (2022). Mapping mental models of science communication: How academics in Germany, Austria and Switzerland understand and practice science communication. *Public Underst. Sci.* 31, 711–731. doi: 10.1177/09636625211065743
- L'Astorina, A. (2011). "Researchers as communicators – a survey on the public engagement of Italian CNR research institutions" in *Sharing science - researchers' ideas and practices of public communication*. ed. A. Valente (Milano, Italy: Scienza Express Edizioni - University Press Series).
- L'Astorina, A., Avveduto, S., Cerbara, L., and Valente, A. (2013). Practices and images of public communication by Italian scientists over the years. Science in public conference 2013, the University of Nottingham, 75–81. Available at: <https://scienceinpublicnetwork.files.wordpress.com/2013/12/sip13-proceedings.pdf> (Accessed April 18, 2024).
- L'Astorina, A., and Di Fiore, M. (2017). A new bet for scientists: implementing the responsible research and innovation (RRI) approach in the research practices. *Rel.* 5:157. doi: 10.7358/rela-2017-002-last
- L'Astorina, A., and Rubbia, G. (2009). *Ricerca e Comunicare-Teorie e buone pratiche negli enti di ricerca, Atti web della giornata di studio del 27 gennaio 2009, Area della Ricerca del CNR di Milano*. Available at: <http://www.mi.cnr.it/static/27-01-09/index.html>
- López-Pérez, L., and Olvera-Lobo, M. (2016). "Chapter 9. Social media as channels for the public communication of science: The case of Spanish research centers and public Universities," in *Facets of Facebook: Use and users*. eds. K. Knautz and K. Baran (Berlin, Boston: De Gruyter Saur), 241–264.
- Lovari, A., and Giglietto, F. (2012). *Social media and Italian universities: An empirical study on the adoption and use of facebook, twitter and youtube (January 2, 2012)*. Available at SSRN: <https://ssrn.com/abstract=1978393> or <https://ssrn.com/abstract=1978393>.
- Mannino, I., Bell, L., Costa, E., Di Rosa, M., Fornetti, A., Franks, S., et al. (2021). Supporting quality in science communication: insights from the QUEST project. *JCOM* 20:A07. doi: 10.22323/2.20030207
- Marcinkowski, F., and Kohring, M. (2014). The changing rationale of science communication: a challenge to scientific autonomy. *J. Sci. Commun.* 13:C04. doi: 10.22323/2.13030304
- Massoli, L. (2007). Science on the net: an analysis of the websites of the European public research institutions. *JCOM* 6:A03. doi: 10.22323/2.06030203
- Metcalfe, J. (2019). Comparing science communication theory with practice: an assessment and critique using Australian data. *Public Underst. Sci.* 28, 382–400. doi: 10.1177/0963662518821022
- Metcalfe, J. (2022). Science communication: a messy conundrum of practice, Research and theory. *JCOM* 21:C07. doi: 10.22323/2.21070307
- Miller, S. (2008). "So where's the theory? on the relationship between science communication practice and research," in *Communicating science in social contexts*. eds. D. Cheng, M. Claessens, T. Gascoigne, J. Metcalfe, B. Schiele, S. Shi (Dordrecht: Springer), 275–287.
- Molas-Gallart, J., and Castro-Martínez, E. (2007). Ambiguity and conflict in the development of "third Mission" indicators. *Res. Eval.* 16, 321–330. doi: 10.3152/095820207X263592

- Neresini, F., and Bucchi, M. (2011). Which indicators for the new public engagement activities? An exploratory study of European research institutions. *Public Underst. Sci.* 20, 64–79. doi: 10.1177/0963662510388363
- Nielsen, K. H., Kjaer, C. R., and Dahlgard, J. (2007). Scientists and science communication: a Danish survey. *J. Sci. Commun.* 6, 1824–2049. doi: 10.22323/2.06010201
- Nisbet, M. C., and Markowitz, E. (2016). “Strategic science communication on environmental issues,” in *Commissioned White Paper in Support of the Alan Leshner Leadership Institute. American Association for the Advancement of Science*. Available online at https://www.aaas.org/sites/default/files/content_files/NisbetMarkowitz_StrategicSciCommOnEnvironmentalIssues_WhitePaper.pdf.
- Orthia, L. A., McKinnon, M., Viana, J. N., and Walker, G. J. (2021). Reorienting science communication towards communities. *J. Sci. Commun.* 20, 1–18. doi: 10.22323/2.20030212
- Owen, R., Macnaghten, P., and Stilgoe, J. (2012). Responsible research and innovation: from science in society to science for society, with society. *Sci. Public Policy* 39, 751–760. doi: 10.1093/scipol/scs093
- Petersen, A., Anderson, A., Allan, S., and Wilkinson, C. (2009). Opening the black box: scientists’ views on the role of the news media in the nanotechnology debate. *Public Underst. Sci.* 18, 512–530. doi: 10.1177/0963662507084202
- Riedlinger, M., and Joubert, M. (2022). Twenty years of science communication: looking back, looking forward. *JCOM* 21:C01. doi: 10.22323/2.21070301
- Salmon, R. A., Priestley, R. K., and Goven, J. (2017). The reflexive scientist: an approach to transforming public engagement. *J. Environ. Stud. Sci.* 7, 53–68. doi: 10.1007/s13412-015-0274-4
- Schäfer, M. S., and Fähnrich, B. (2020). Communicating science in organizational contexts: toward an “organizational turn” in science communication research. *J. Commun. Manag.* 24, 137–154. doi: 10.1108/JCOM-04-2020-0034
- Simis, M. J., Madden, H., Cacciatore, M. A., and Yeo, S. K. (2016). The lure of rationality: why does the deficit model persist in science communication? *Public Underst. Sci.* 25, 400–414. doi: 10.1177/0963662516629749
- Trench, B. (2008). “Towards an analytical framework of science communication models,” in *Communicating science in social contexts*. eds. D. Cheng, M. Claessens, T. Gascoigne, J. Metcalfe, B. Schiele, and S. Shi (Dordrecht: Springer), 119–135.
- Trench, B., and Bucchi, M. (2010). Science communication, an emerging discipline. *JCOM* 9:C03. doi: 10.22323/2.09030303
- Valente, A. (2011). *Sharing science - researchers’ ideas and practices of public communication*. Milano, Italy: Scienza Express Edizioni - University Press Series.
- Volpe, M. della, and Esposito, F. (2018). “Communicating the third mission on Italian universities’ websites. A discourse analysis perspective,” in *Excellence in Services - 21th International Conference Conference Proceedings*. Paris, France: Le Cnam, 261–269.
- Zhang, Y., and Wildemuth, B. M. (2009). “Qualitative analysis of content,” in *Applications of social research methods to questions in information and library science*. ed. B. M. Wildemuth (Santa Barbara, California: Libraries Unlimited), 308–319. Available at: https://www.ischool.utexas.edu/~yanz/Content_analysis.pdf
- Zimmerman, I., Baram-Tsabari, A., and Tal, T. (2024). Science communication objectives and actual practices of science news websites as a showcase for gaps between theory and practice. *JCOM* 23:A05. doi: 10.22323/2.23010205