



## OPEN ACCESS

## EDITED BY

Tarla Rai Peterson,  
The University of Texas at El Paso, United States

## REVIEWED BY

Bruno Takahashi,  
Michigan State University, United States  
Julian Matthews,  
University of Leicester, United Kingdom

## \*CORRESPONDENCE

Liliana Oliveira  
✉ lilianaoliveira@ua.pt

## SPECIALTY SECTION

This article was submitted to  
Science and Environmental Communication,  
a section of the journal  
Frontiers in Communication

RECEIVED 16 September 2022

ACCEPTED 12 January 2023

PUBLISHED 02 February 2023

## CITATION

Oliveira L and Carvalho A (2023) How climate  
scientists and communication professionals  
view public engagement with science:  
Perspectives, practices and constraints.  
*Front. Commun.* 8:1046501.  
doi: 10.3389/fcomm.2023.1046501

## COPYRIGHT

© 2023 Oliveira and Carvalho. This is an  
open-access article distributed under the terms  
of the [Creative Commons Attribution License  
\(CC BY\)](#). 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.

# How climate scientists and communication professionals view public engagement with science: Perspectives, practices and constraints

Liliana Oliveira<sup>1\*</sup> and Anabela Carvalho<sup>2</sup>

<sup>1</sup>Communication and Society Research Centre, University of Minho, Braga, Portugal, <sup>2</sup>Department of Communication Sciences, University of Minho, Braga, Portugal

**Introduction:** This article examines understandings of public engagement in science by scientists and communicators in four universities in Portugal and Spain.

**Methods:** Based on mixed-methods research, we present an integrative analysis of practices and perceptions of climate change scientists and communication professionals, and identify critical barriers for them to further public engagement.

**Results:** More similarities than differences are found between the four universities and the two countries but there are important differences between the two professional groups. Universities and the scientific community at large tend to privilege forms of science communication that are focused on dissemination of information and on self-promotion. Over the last decade there are signs of positive developments, even though some aspects of science communication practice appear to have worsened.

**Discussion:** Despite the advancements presented this article Portuguese and Spanish universities are not yet making the most of the potential inherent to public engagement. This raises important questions for research and practice. Although several interviewees acknowledge a normative requirement of having citizens participate more deeply in science, they stay short of fulfilling such commitment. This may be partly due to implementation barriers but also because scientists and especially communication professionals make a relatively narrow reading of the potential benefits of engaging the public in science.

## KEYWORDS

public engagement, climate change, universities, scientists, communication professionals, Portugal, Spain

## 1. Introduction

The relation between science and (the rest of) society has been conceptualized differently in a variety of science communication models, which may be classified into two general groups with distinct orientations. Models in the first group were hegemonic in the 1960–1980s and are based on the premise that citizens lack knowledge (hence the common designation of “deficit model”). Based on one-way communication processes, from scientists to society, those models focus on the dissemination of scientific information. Models in the second, and more recent, group are underpinned by the dual propositions of dialogue and participation. Their proponents advocate dialogic processes of communication centered on public participation in science and technology (S&T) issues (Bucchi, 2008). With this “dialogic turn” (Phillips, 2011) the public has been idealized as an active agent in the discussion and analysis of science-related matters with opportunities to get involved, ask questions, and exchange perspectives, knowledge and experiences with the scientific community. Anchored in this dialogic model, the concept of

Public Engagement with Science and Technology (PEST) came to the fore in the mid-1990s. It assumes that science is inseparable from social and institutional contexts that shape its production and uses, and calls for a “conversation” on multiple levels, with multiple publics, and in multiple settings (cf. [Bucchi and Trench, 2021](#)). Science agendas—many argue—should take into account the interests, needs and priorities of both the scientific community and citizens.

Multiple scholars have maintained that public involvement and participation in S&T play an important role in fomenting two-way learning between citizens and the scientific community by sharing knowledge and cultural, social and ethical values ([Lewenstein and Brossard, 2006](#)). It has also been argued that such engagement may help restore science’s public legitimacy and trust ([Wynne, 2006](#)). Moreover, it can lead to better outcomes by injecting various types of (scientific and non-scientific) expertise into knowledge production and decision-making processes ([Stirling, 2008](#); [Wesselink et al., 2011](#)). A recognition of the diverse characteristics, preferences and views of individual citizens and social groups has led to increasing calls for inclusivity considerations in science communication ([Canfield et al., 2020](#)).

Achieving effective public engagement with S&T in Spain and Portugal has proved to be a complex task ([Felt, 2003](#); [Hagendijk and Irwin, 2006](#)). Incentives for public engagement in these countries have been few and far between and the public has generally been kept away from most S&T-related decision-making processes. Surveys from a decade or so ago showed that most respondents did not spontaneously seek information on S&T, and that Portugal and Spain were among the European countries where people had the lowest levels of scientific culture, were least informed and expressed least interest in S&T ([European Commission, 2010, 2013](#); [FECYT, 2011, 2015](#); [Fundación BBVA, 2011](#)). As detailed below, there has been a notable improvement in recent years, especially in Portugal ([European Commission, 2021](#)).

Although research has expanded in the last few years, scholarship is still sparse on how different members of academia are involved in science communication and in PEST, on the roles of various social agents in PEST, and on related institutional dynamics and organizational contexts ([Schäfer and Fähnrich, 2020](#)). Available data on the perceptions of some of these social actors regarding public engagement ([Entradas, 2016](#)) is limited and this is certainly the case of communication professionals working at universities. Above all, as highlighted in a recent review, there is a clear need for research that brings together various facets of science communication and public engagement, and for comparative studies ([Gerber et al., 2020](#)).

This article draws on a wider project aimed at understanding how Portuguese and Spanish universities that are leaders in climate change research (might) intervene in public engagement and focuses on scientists’ and communication professionals’ conceptions. Although these are rather different professional communities, we argue that there is value in comparing their views given their shared responsibilities in public engagement, and ask: How do the principal agents involved in communicating with and engaging the public in climate change at key Iberian universities, namely scientists and communication professionals, view those processes? What are their aims and the anticipated benefits of public engagement?

The article is structured as follows: we begin with a review of research on public engagement with science and the roles of various agents therein and follow with a short overview of science

communication in Portugal and Spain; we then present the methods employed in this research and analyze the perceptions of public engagement with science (with a focus on climate change) held by scientists and communication professionals in Iberian universities.

## 2. Engaging the public with science: Agents and roles

Current societies face several societal challenges involving S&T-related issues, which have to be addressed democratically and inclusively. Climate change is the most critical of such challenges and science, alone, cannot produce a “solution” for it. For a number of years, scholars, activists and politicians have called for the enhancement of public engagement with climate change ([Wibeck, 2014](#); [Hügel and Davies, 2020](#)) and some studies suggest that “scientific citizenship” and (strong) participatory processes (e.g., [Horsbøl and Lassen, 2012](#)) are key to climate change research and politics.

Although it is valuable, there is a degree of ambiguity in the concept of Public Engagement with Science ([Davies, 2013a](#); [Bensaude Vincent, 2014](#)), and so is the case concerning climate change ([Höppner, 2009](#); [Murunga, 2022](#)); hence, some conceptual discussion and clarification is in order. A rhetorical dimension is often involved in references to PEST ([Delgado et al., 2011](#)) and there is frequently a disparity between definitions of public engagement and the objectives of the activities that are labeled as such. Thus, the concept’s breadth of meanings ranges from simple presence of the public in science communication activities to a deeper involvement with S&T, through active citizen participation in defining problems, producing knowledge, debating implications and having a say in decisions. We acknowledge that there are different degrees in which the public can be invited to engage in—and actually engages with—science and will employ the term in a broad sense although putting the emphasis on deeper forms of citizen participation in S&T. PEST happens in and *via* communication so it comes under the term of “science communication”. The latter concept, however, is clearly distinct when used to refer, for instance, to mere dissemination of scientific findings *via* the media or other means.

Although the scope for participatory engagement with decision-making in research and development is somewhat narrower than in other fields, such as urban planning, public involvement with S&T and the nurturing of scientific citizenship has significant potential ([Mejlgaard, 2009](#)). Arguments supporting it can be substantive (e.g., improve decision-making) and normative (e.g., the public’s right to participate), besides instrumental ones (e.g., promote a university’s public image) ([Fiorino, 1990](#)). Citizens can play a key role in the production of knowledge itself, which in some cases results from an interaction between experts and laypeople in the context of “hybrid forums” ([Callon et al., 2001](#)). Thus, contributing to engage the public with (climate) science can be viewed as a social imperative and an obligation of universities, who are key agents in the field of S&T.<sup>1</sup>

The reformulation of participatory processes does not seem to be enough to fulfill a “civic model” of science communication. The

1 Monitoring reports of the [European Commission \(2012\)](#) show that European higher education institutions, along with governments, have led the definition of science communication agendas and the organization of most actions in the field.

social and cultural meanings that guide perceptions and actions are mediated by a set of social and discursive practices in which institutional conditions and communicative processes interact. It is, therefore, relevant to better understand these factors and the influence of different agents in maintaining and/or changing them.

The scientific community is a key social group with regard to the public communication of science, since they are the main producers of scientific knowledge and the organizers of most scientific dissemination activities (Pearson, 2001; Rothwell, 2002; Nielsen et al., 2007; Davies, 2008). Various studies show that scientists are generally motivated to communicate science, including in Portugal and Spain (Pinto and Carvalho, 2011; Casini and Neresini, 2012; Escutia, 2012; Davies, 2013b). Horst (2013) found that they see themselves as “representing science as both “speaking on behalf of” science and symbolically “standing for” science and its organizations” (p. 758). Along the same lines, Dudo and Besley’s (2016) found that scientists “most prioritize communication designed to defend science from misinformation and educate the public about science, and least prioritize communication that seeks to build trust and establish resonance with the public” (p. 1).

Whereas there is a significant body of survey-based research on scientists’ communication practices, as Davies pointed out in 2008 and is still accurate in the present, far less frequent are in-depth qualitative studies about “scientists” ideas and assumptions about communication and public engagement, despite the fact that these will certainly affect the way how they engage in such activities” (p. 415). Davies (2013a) herself later conducted research on how scientists in the UK understand PEST and found that it had multiple meanings to them: “many different understandings and meanings of PEST co-existing simultaneously” which could “be accounted for through multiple narratives, genealogies, and personal histories” (p. 702).

Studies focused on scientists’ practices to involve citizens in science and dialogue with them show that the dialogic component is rarely present (Royal Society, 2006; Escutia, 2012; Davies, 2013b). Moreover, although scientists recognize the moral virtues of public participation, they may not promote it in part because of unfavorable social and professional contexts (Bergeron, 2000) but also because of barriers of socio-epistemological and ideological nature (Dudo, 2012). Therefore, it becomes necessary to thoroughly understand their beliefs and opinions in relation to public engagement with science, how they think about interactions with the public and the factors that condition deeper or farther engagement (Besley et al., 2015).

Research that concentrates on scientists working on climate change, for which public engagement is most important (even vital, arguably), is especially critical. Extant related research focuses on the attitudes of climate scientists in Germany toward the media (Post, 2016), on diverse science communication practices by US climate scientists (Entradas et al., 2019), and on the views of climate scientists in both countries on political engagement (Cologna et al., 2021). All studies are based on surveys and are about “central” Western countries. Although this research is valuable, in-depth qualitative work in different countries is called for as social, cultural and political contexts and histories are likely to impact conceptions and practices of public engagement.

There is no doubt that communication activities have increasingly become professionalized in universities and other science-related institutions over the last few decades and that communication professionals have become critical agents in their

overall communicative performance. An extensive cross-national comparison has shown that “variation in communication is associated with institutional commitment to public communication such as having a policy in place, professional communications staff and available funding” (Entradas et al., 2020a, p. 13). Staff availability was also found to be an important factor for public engagement activities in a comprehensive study of Portuguese research institutions (Entradas and Bauer, 2017).

Communication professionals have become the main agents responsible for media dissemination of research results at universities. They act as gatekeepers of the information that comes out (Ankney and Curtin, 2002), have a considerable influence on the way in which science communication is promoted in their institutions, how the media cover it (Peters et al., 2008), and in the management of the institution’s “trust portfolio” (Borchelt and Nielsen, 2014) in terms of its social responsibility, competence, credibility, integrity, legitimacy and productivity. The importance of communication units (and their personnel) is also enhanced by the fact that they often “work closely with university leadership in strategic processes” (Elken et al., 2018, p. 1119) within universities. This involves a degree of (informal) power at the internal level that may have important potential implications for policies and practices concerning external publics. However, studies of communication professionals’ understandings of public engagement are extremely sparse.

As both scientists and communication professionals play important roles in universities’ science communication and relations with the public, this article jointly analyses the practices and perceptions of public engagement of both professional groups in a set of Iberian universities. Both groups are influenced in their actions by the organizational culture of their institutions, the resources available and the relationships they establish with other professionals (e.g., Casini and Neresini, 2012; Escutia, 2012). Hence, it is critical to examine their views in the context of universities as organizations. In addition, wider national contexts (and their differences) concerning culture, politics and other factors relevant for S&T matter to meanings of PEST (Davies, 2013a).

### 3. Contextualization: Science communication and public understanding of science in Portugal and Spain

With some of Europe’s lowest rates of citizen participation in public life (Cabral, 2000; Montero Gibert and Loriente, 2006), in the beginning of the century, Portugal and Spain were still taking initial steps toward public engagement as far as S&T issues are concerned. This was partly due to the late arrival of democracy in these countries and the consequent conditions for exercising such forms of citizenship, as well as to low levels of schooling (which have been rapidly improving in the last few decades). Although there have been mechanisms and legal provisions designed to safeguard citizen engagement and the right to information, they have often played no more than a symbolic function (Estévez Cedeño and Escobar Rodríguez, 2009).

If we look back a decade, roughly, citizens in both countries appeared to be generally unaware of the importance of their involvement in S&T and S&T-related issues (Delicado and Gonçalves,

2007; Alves, 2011; FECYT, 2015). Still, citizens seemed to be increasingly interested in being consulted and in taking an active role in decision-making (European Commission, 2010, 2013). Although science culture, levels of information and interest in science matters were still some of the lowest in Europe, the situation was improving somewhat (Miller et al., 2002; Delicado and Gonçalves, 2007; European Commission, 2010, 2013; Fundación BBVA, 2011; Bauer and Howard, 2013; FECYT, 2015). According to the latest Eurobarometer (European Commission, 2021), the scientific literacy of the Portuguese respondents has increased sharply and surpassed the European average. Portugal now leads the group of countries with the greatest interest in S&T. Portugal also leads interest on “environmental problems including climate change” with 70% of respondents saying they are “very interested” (Spain comes next with 52%; EU average is 38%). It is important to underline, however, that this survey also showed that 50% of Portuguese respondents believe that scientists still do not spend enough time explaining their work to the public (44% in Spain). Albeit to a lesser extent than in Portugal, in Spain, citizens’ interest and trust in science to find solutions to society’s problems also increased during the pandemic and scientists continue to be highly respected by citizens. Like the Portuguese, Spaniards recognize the importance of “involving non-scientists in research and technological developments” to ensure that society’s values and expectations are duly considered (both countries standing close to the top of the EU ranking). However, there are contradictory results as Portugal and Spain are well below the EU average for the percentage of people that consider that the public should be involved in decisions about S&T.

Iberian universities only started considering science communication as a priority at the beginning of this century. This was largely driven by policymakers, with the implementation of (European Union) operational programmes, the formulation of a legal framework and the creation of structures and programmes for this area that included universities as partners (Miller et al., 2002; Alves, 2011; Revuelta, 2011). Focusing mainly on the dissemination of knowledge and the promotion of a positive perception of science, universities have public engagement with the knowledge production process and decisions on S&T (Alves, 2011; Torres-Albero et al., 2011).

For a long time, the scientific community showed little interest in organizing initiatives to involve citizens in S&T or in dialogic approaches, and goals typical of the deficit model persisted. In the case of Portugal, however, it is interesting to note that already a decade ago there had been “growing calls for wider public discussion on procedures for engaging citizens and civic movements in a higher level of democratization” (Alves, 2011, p. 25). Despite a significant expansion of infrastructure for science communication (with an increase in means allocated to public communication and professional staff in research institutions and universities) resulting in a growing number of public initiatives being organized by universities and research centers, and in a greater openness and accessibility of Portuguese science to society in recent years, scholars maintain that “lack of resources and professionalization” persist and “public participation in research and policy is marginal” (Entradas et al., 2020b, p. 707).

Specific programmes for science communication have also been established in Spain, such as the 2007 *Plan Integral de Comunicación y Divulgación de la Ciencia y la Tecnología en España*. Structures that involve universities as partners have been set up. These

include the SINC science news service, the network of local agents for the organization of Science Week and the UCC-i—science and innovation communication units within scientific research institutions. These steps have been crucial to expansion and Revuelta et al. (2020, p. 842) argue that such growth of communication in universities and research centers “together with the experimentation around new more participative formats (such as citizen science initiatives, hackathons, social labs, etc.) have been one of the main transformations of communication of science in Spain in the last decade”.

We will now turn to our empirical study aimed at exploring the views of the main agents of science communication in Portuguese and Spanish universities: scientists and communication professionals.

## 4. Methods and data

In face of a scarcity of in-depth research on understandings of public engagement by the most relevant social actors—scientists, communicators and citizens—the first project that led to this article (initiated in 2011) involved a multi-method research design including document collection; interviews with scientists and communicators; and questionnaires and focus groups with citizens in Portugal and Spain. The research was carried out as part of the first author’s PhD (Oliveira, 2015) with methodological triangulation allowing for a rich compilation and analysis of data.

Given the continuing lack of comparative analyses of perceptions of public engagement and of studies of science communication in specific organizational contexts (cf. Elken et al., 2018; Schwetje et al., 2020) in the present, as well as recent calls for integrative approaches to science communication research (Gerber et al., 2020), we revisited the original project and offer a summary of findings<sup>2</sup> from in-depth interviews with scientists and communication professionals. With the purpose of assessing the relevance of those findings in the present we also conducted an online survey in 2021 directed at the same individuals.

The research questions underpinning the interviews were as follows: What practices of science communication and public engagement with S&T do climate scientists and communication professionals carry out? How do they conceive the potential benefits and gains of public engagement? What constraints and limitations do they perceive regarding public engagement? The interview scripts for the two professional groups are available as [Supplementary material](#) to this article.

Interviewed scientists and communicators were affiliated with four universities that host sizeable climate change research groups in the Iberian peninsula: University of Aveiro and University of Lisbon, in Portugal, and University of Barcelona and University of Castilla-La Mancha University, in Spain. A total of 44 interviews were conducted between October 2011 and May 2013, of which 28 were with (junior and senior) scientists studying climate change in the fields of environmental engineering, physics, chemistry, biology, geosciences and social sciences (the latter having smaller research groups than the natural and physical sciences working on climate change in all four

<sup>2</sup> The PhD thesis (which was supervised by the second author) was published in a book in Portuguese (Oliveira, 2021) but interview findings have not been previously published in English nor summarized into article form in any language.

universities); 16 interviews were with communication professionals working in the communication offices of the selected universities. The interviewees were drawn from a range of career levels and ages, and from both genders, as we aimed for diversity in profiles (see Table 1) and recruited by e-mail. Almost all the interviews were face-to-face (except for three that were online), audio recorded and transcribed. They included 12 open-ended questions addressed to communication professionals and 13 to scientists, several of which were common to the two groups. Semi-structured interviews allowed us to obtain a description of the subjects' concrete practices and to understand personal interpretations of the meanings of public engagement.

The analysis of interviews was inspired in the constant comparative approach of grounded theory (Strauss and Corbin, 1994) and supported by the QSR's qualitative analysis programme NVivo. A constant comparison between what was said by the different respondents led to the inductive construction of theme categories at different levels of abstraction.

The data collected through the interviews was complemented with information gathered between 2011 and 2015 from about 40 documents published by the four selected universities (e.g., action plans, institutional webpages, activity reports), government documents concerning science communication in both countries, and relevant legislation in order to understand the organizational environments in which scientists and communication professionals operate. The list of analyzed documents is available as Supplementary material. The documents were analyzed through the same method of qualitative analysis applied in the interviews, using the QSR's qualitative analysis programme NVivo. The qualitative analysis of those documents focused, among other themes, on the means and tools used by communication offices and university research units in communicating S&T in general and climate change in particular; on teaching and research activities, with special attention given to the science communication component; and on government support and attribution of responsibilities to HEIs on science communication promotion. In order to probe continuities and/or changes in views and practices, we conducted an exploratory online survey in July 2021<sup>3</sup>, which was addressed to the same scientists and communication professionals interviewed about a decade earlier in Portugal and Spain. The survey's main aim was to assess whether the conclusions of the earlier research remained valid. Participants were asked whether the purposes of science communication activities that they identified a decade ago, as well as the potential benefits of public engagement that they had mentioned then, had become more, equally or less important; whether different constraints faced in science communication activities had improved, remained the same or worsened; and whether the characteristics that they associated with different actors involved in science communication had changed and in which direction. Those open ended questions/responses built directly on the synthesis of findings presented below in order to facilitate comparison. In each set of closed ended questions we also included the option of adding a textual (open ended) response indicating other types of changes or additional observations. The questionnaire can be found as Supplementary material. A total of 16 individuals answered the questionnaire: 6 communication professionals working in the communication offices of the selected universities and 10 climate scientists. We acknowledge that the rate of responses to the

online survey is suboptimal and that this limits the strength of the findings. The fact that such a rate was not significantly improved in spite of our multiple e-mail requests may itself be indicative of professional circumstances and conditions in universities as well as of COVID-19-related burdens. We conducted an analysis of response frequency but will refrain from reading distributions in terms of percentages or more elaborate statistical analyses given the size of the sample.

Bringing together different studies carried out within the same project is critical to our goal of gaining a comprehensive understanding of perceptions of scientists and communication professionals about public engagement and of how they may have changed during the last decade. However, doing so in the context of a journal article, necessarily raises challenges in terms of space, especially for presenting and analyzing qualitative data from interviews, which are at the core of this research; for those reasons, we will only be able to offer a few illustrative excerpts from documents and interviews.

## 5. Science communication activities at four Iberian universities

The data drawn from documentation and interviews conducted in 2011–13 revealed that the four selected universities took similar approaches to science communication and made use of the same types of resources and initiatives; they also shared broadly the same objectives. Moreover, the study showed that there were no specific institutional strategies or policies for science communication except for the University of Barcelona.

In universities' websites and activity reports, science communication was associated to initiatives of "scientific dissemination"<sup>4</sup>, "outreach"<sup>5</sup> and "cultural extension and dissemination"<sup>6</sup>. Stated objectives included: "Stimulating curiosity and interest in scientific activity, attracting young people and less young people to study and research in all areas of knowledge"<sup>7</sup>; promoting the "development and understanding of ways of creating and using knowledge"<sup>8</sup>; contributing to "transfer of knowledge"<sup>9</sup>, "dissemination of achievements"<sup>10</sup>, "public understanding of science"<sup>11</sup>; respecting the commitment to "provide a quality service to both the academic community and the society that supports it"<sup>12</sup>;

4 In <http://www.ua.pt/PageText.aspx?id=459>; <http://www.uclm.es/comunicacion>; <http://www.ub.edu/laubdivulga/> (accessed on 20 January, 2015).

5 In <http://www.fc.ul.pt/pt/pagina/622/gabinete-de-comunica%C3%A7%C3%A3oimagem-e-cultura>; <http://www.ics.ulisboa.pt/instituto/?ln=p&mm=2&ctmid=1> (accessed on 20 January, 2015).

6 In [http://idl.ul.pt/sites/idl.ul.pt/files/docs/Est\\_IDL.pdf](http://idl.ul.pt/sites/idl.ul.pt/files/docs/Est_IDL.pdf) (accessed on 20 January, 2015).

7 In <http://www.ua.pt> (accessed on 20 January, 2015).

8 In <http://www.ciceco.ua.pt> (accessed on 20 January, 2015).

9 In <http://www.ics.ulisboa.pt/instituto/?ln=p&mm=2&ctmid=1> (accessed on 20 January, 2015).

10 In [http://idl.ul.pt/sites/idl.ul.pt/files/docs/Est\\_IDL.pdf](http://idl.ul.pt/sites/idl.ul.pt/files/docs/Est_IDL.pdf) (accessed on 20 January, 2015).

11 In <http://www.ua.pt/PageText.aspx?id=459> (accessed on 20 January, 2015).

12 In <http://www.uclm.es/comunicacion> (accessed on 20 January, 2015).

3 Just before summer holidays in Iberian universities.

TABLE 1 Characterization of the interviewed scientists and communication professionals (2011–2013).

Interviewed scientists and communication professionals							
	University		Position	Area	Gender	N	
Portugal	Aveiro	Scientists	Senior	Environmental Engineering (2) Biology (1) Marine Geology (1) Physical Engineering (1)	M	5	
			Junior	Environmental Engineering	F	1	
		Communication professionals	Office director		F	1	
			Press and communication officer Public relations and marketing		M F	2 1	
	Lisbon	Scientists	Senior	Coastal Geology (1) Geophysical Sciences (1) Physics (2) Sociology of Communication and Environment (1)	M (4) F (1)	5	
			Junior	Social Science studies	F	1	
		Communication professionals	Office director		M	1	
			Press officer Press officer and Public relations		M F/M	1 2	
	Spain	Barcelona	Scientists	Senior	Atmospheric Physics (1) Climatic Physics (1) Earth Physics (1) Forest Ecology (1) Biology (1) Marine Geology (1) Marine Biology (2)	F (2) M (6)	8
				Junior	Environmental Sociology	F	1
Communication professionals			Press and communication officer		F	3	
Castilla La Mancha			Scientists	Senior	Physics (2) Environmental Engineering (1) Physical Engineering (1) Chemistry (1)	M	5
		Junior		Physical Engineering (1) Environmental Engineering (1)	M	2	
		Communication professionals	Office director		F	1	
			Press and communication officer		F (3) M (1)	4	

and fostering “social interest in science and knowledge, (...) scientific culture and (...) scientific vocations”.<sup>13</sup> As other researchers have found elsewhere (e.g., [Bauer and Gregory, 2007](#); [Ashwell, 2012](#)), deeper forms of citizen involvement and participation were given only secondary importance with a few references to “models, processes and contexts of management, governance and evaluation of science and teaching institutions”<sup>14</sup> and a “more effective public participation in decision-making processes (...) while being scientific and (by implication) democratic”<sup>15</sup> (for a detailed analysis of discourses on public engagement in Portuguese universities and research institutions, see [Oliveira and Carvalho, 2015](#)).

The first issue explored in interviews with scientists and communication professionals concerned the nature or type of science communication carried out in their institutions (and in which they may have been personally involved). Push communication, that is, communication fronted by communication professionals and often taking the form of press releases sent to traditional news media was one of the most common ways of communicating with society in all universities, as [Entradas et al. \(2020a\)](#) also showed in their more recent study about public communication in research institutes in Portugal and elsewhere. Some of the scientists in our study believed that this was the only form of communication that should take place. Other face-to-face initiatives (public conferences, seminars, lectures, exhibitions, scientific internships for young people, science weeks, open/theme days) were largely led and delivered by scientists (cf. [Entradas et al., 2020a](#)), who would turn to communication professionals when they needed logistical support for organization of activities and media dissemination. There was little involvement

13 In <http://www.ub.edu/laubdivulga/> (accessed on 20 January, 2015).

In <http://www.ciceco.ua.pt> (accessed on 20 January, 2015).

In <http://www.ics.ul.pt/instituto/> (accessed on 20 January, 2015).

14 In <http://www.ciceco.ua.pt> (accessed on 20 January, 2015).

15 In <http://www.ics.ul.pt/instituto/> (accessed on 20 January, 2015).

of communication professionals in the design of the structural framework for those initiatives.

A public visibility-aiming orientation was quite clear in the *modus operandi* of communication professionals, who were (seen as) largely responsible for passing research results on to the media. As put by a Spanish professional: “We add all facets of communication to make the message more intelligible and we recommend, we suggest (...) This counseling is fundamentally in terms of contact with the media” (COM10ES).<sup>16</sup> Most of the initiatives involved a top-down one-way dissemination of results, which is in line with previous studies in both countries (e.g., Alves, 2011; Revuelta, 2011; Torres-Albero et al., 2011; European Commission, 2012). Dialogue was occasionally facilitated by an exchange of views between the citizens and the scientific community on how to apply some research results. However, this type of initiative was not yet common practice in most research units/universities analyzed here and we found no evidence of debates on research priorities or on controversial science issues involving the citizens. Downstream engagement was the most frequent type/phase of contact with the general public.

The practices and discourses of scientists were (still) very much anchored in the premises of the “deficit model”. In both countries, some scientists were, however, undertaking efforts toward developing practices that contain elements of dialogue, albeit only very near the end stage of the knowledge production process. There were hence signs of some flexibility and willingness to engage in this type of communication with the public.

## 6. Perspectives of scientists and communication professionals

In the analysis of interview data various structuring themes emerged, of which we will focus here on a subset, namely: rationales of science communication and public engagement; constraints on implementation; and stances on citizens, policymakers and the media.

The interviews revealed that there were no formal monitoring or assessment processes for science communication activities (in their various guises), mainly due to the lack of human resources, which was aggravated by the economic crisis that started around 2008 and hit Portugal and Spain badly. Arguably, individual experiences and perceptions would thus have been critical to the prosecution of any new activities, especially in an institutional framework where they are voluntary and often not formally rewarded for scientists, and where there are no organizational strategies neither for science communication in general nor specifically for climate change.

### 6.1. Rationales of science communication and public engagement

During the interviews, scientists and communication professionals were asked about the purposes of the science

<sup>16</sup> Initials used in Sections Methods and data, Science communication activities at four Iberian universities and Perspectives of scientists and communication professionals: SCI, scientist; COM, Communication professional; PT, Portugal; SP, Spain.

communication activities organized by their universities and research units. This was, unsurprisingly, an important theme in the responses, and is explored below. Other questions addressed their personal views on what the objectives of science communication activities should be and on citizen participation in science and in decision-making on S&T-related issues. The common theme here is the potential benefits of public engagement. Within both themes (purposes and potential benefits), a finer analysis led to the construction of multiple subordinate categories corresponding to *specific* purposes and potential benefits mentioned (listed in Table 2). Further to this type of analysis, we organized those subordinate categories under three broader rationales—instrumental, substantive and normative—that drew on Fiorino (1990), as well as on more recent scholarship along the same lines.

Under an instrumental rationale “engagement is a means to endorse favored decisions and favored outcomes such as citizens’ trust, consent and behavior change” (Höppner, 2009, p. 3), including strengthening or restoring the social legitimacy of science. Substantive rationales are connected to the improvement of agendas and decisions with the inclusion of citizens’ knowledge and perspectives: it is assumed that citizens’ judgments, values and experience matter in debating and finding solutions to multiple issues, and that their contributions can be as valid as scientists’ knowledge. Normative rationales are linked to the realization of values such as openness, transparency, plurality/inclusiveness and equality, allowing all those affected by an issue to influence the decisions taken, and thus challenging established interests (Fiorino, 1990).

Interviewees in this study mainly saw science communication and public engagement instrumentally. Scientists considered that they “had” to use communication initiatives to publicize their work, obtain funds, and attract new students, a view shared by communication professionals—“There is a clear perception that science communication is essential to attract audiences to all areas of knowledge, funding, partnerships” (COM12PT).<sup>17</sup> As expressed by a Portuguese scientist—“We have to have good “products” to sell” (SCI5PT). In interviewees’ discourses, this “mercantilist” concern was often justified with reference to funding cuts due to the economic crisis. Distinctly from the scientists, in the discourse of the communication professionals, there was a clear emphasis on political-institutional interests, in promoting a positive image of the universities and the work done by their scientists as a whole, as this would display their benefits for society and socially legitimize them (as well as science itself): “After all we are a public university and we have to be accountable for what we do. Everything will be easier if we have social recognition and endorsement” (COM18ES).

For scientists (three quarters of Portuguese and Spanish interviewees) publicizing scientific results and the dissemination of knowledge to improve citizens’ scientific culture were important priorities: “Our actions have been mainly geared to clarifying that weather and climate are different things and why they are different (...) it is mainly important to show how science is done.” (SCI1PT), an aim that can be viewed as having an instrumental value as well as linked to the production of a substantive effect. Both professional groups mentioned far fewer substantive benefits, such as of how

<sup>17</sup> Abbreviations used to identify interviewees—SCI, scientist; COM, communication professional; PT, Portugal; SP, Spain.

TABLE 2 Purposes of science communication activities (Source: interviews with scientists and communication professionals–2011–13).

Rationales	Purposes of science communication activities	Scientists		Communication professionals	
		Frequent	Rare	Frequent	Rare
Instrumental	Social legitimation of the institution	•		•	
	Attract new students to the institution and to specific scientific areas	•		•	
	Promote service provision (technology transfer)		•	•	
	Obtain new sources of funding		•	•	
Substantive	Raise awareness to the importance of science		•	•	
	Increase scientific literacy	•		•	
	Defend points of view and influence decisions		•		•
	Negotiate strategies for implementing results		•		•
	Collect data for ongoing research		•		•
	Foresee and prevent phenomena with an impact on human life		•		•
	Disseminate results in the service of society	•		•	
Normative	Consult citizens on scientific issues (discuss ethical aspects; understand their arguments)		•		•
	Encourage debate on certain issues, thus contributing to a more reflective society		•		•

“Frequent” refers to mentions by over half the interviewees.

engagement contributes to improving decision-making processes, or normative arguments pertaining, for instance, to the building of a more reflective society: e.g., “Where there is uncertainty regarding an issue, there should be a discussion with society” (SCI8ES). It was interesting to note that some scientists (more Portuguese than Spanish) question the implication of the scientific community in the democratization of S&T. They emphasized that, in many cases, engagement seemed to be a “fad” or a requirement of funding agencies rather than a clear demonstration of the opening up of knowledge-making and decision-making processes: “Public engagement should not occur because it is fashionable or required for project approval (...). These participatory exercises are often just for showing off” (SCI3PT).

Table 2 summarizes the purposes that the two professional groups associated with the initiatives that they (or their universities) have been carrying out, and connects them with the three types of rationales discussed above.<sup>18</sup>

There is a convergence between scientists and communication professionals of both countries with regards to multiple purposes although some differences emerge. Overall, instrumental purposes were more commonly mentioned by Spanish interviewees in the two professional groups, although some were common for the communication professionals of both countries. Portuguese scientists were less likely to reason under an instrumental rationale than their Spanish counterparts.

When asked about what they thought the purposes of science communication activities should be and what their views were on public consultation and participation in science, many interviewees

came back to those listed in Table 2. Importantly, however, scientists (and, to a much lesser extent, communication professionals) mentioned several other potential benefits from public engagement (see Table 3). Although an instrumental rationale was sometimes expressed, most of those potential benefits include both substantive and normative aspects. Still, important substantive values, such as two-way learning between the scientific community and the public or the development of practices of co-production of knowledge were not notably present in the discourses of most scientists. The following statement comes close:

“We do studies using computer models and we remain a little detached from reality (...) These people who are in real life and in direct contact with the climate give details that only those who are working directly in the field can give us, not only from a meteorological data point of view but also about what interests them.”(SCI 11 ES).

Tables 2, 3 also offer a comparison of the perspectives of scientists and communication professionals. Our findings suggest that scientists have a more comprehensive understanding of the functions of science communication and especially of potential extra benefits of engaging the public in science than communication professionals. The latter’s relatively narrow view of public engagement may deter the exploration of deeper forms of public participation and more innovative and ambitious engagement activities.

The questionnaire applied in 2021 showed that obtaining new sources of funding, disseminating results in the service of society, increasing scientific literacy, raising awareness of the importance of science and encouraging debate on certain issues (thus contributing to a more reflective society) had grown in perceived importance over the last decade for both the communication professionals

<sup>18</sup> Frontiers between the three types of rationales are not always sharp, and some purposes mentioned by participants in the study overlap two types.



**TABLE 3** Additional perceived potential benefits of public engagement, not associated to the initiatives carried out (Source: interviews with scientists and communication professionals—2011–13).

Rationales	Additional potential benefits of public engagement	Scientists	Communication professionals
Instrumental Substantive Normative	Influence the course of decisions by policy-makers	•	
	Motivate citizens to action (inform to commit)	•	
	Definition of new research problems, understanding what is of public interest, “living in citizens’ shoes”	•	
	Provide equal access to information	•	
	Leverage citizen initiatives	•	•

(5/6) and the scientists (8/10) inquired. For just over half the scientists (6/10), the following were then also more important: social legitimation of their institution, attracting new students to their institution and to scientific areas, and collecting data for ongoing research. There were a few differences between respondents of the two countries. For the Portuguese scientists (7/7), all of the potential benefits of public engagement identified in Table 3 were seen as more important than a decade ago, except for motivating citizens to action (inform to commit), which retained the same level of importance. For Spanish scientists (2/3), most potential benefits of public engagement listed in Table 3 had the same level of importance in 2021, but they (2/3) saw a greater importance in the definition of new problems and understanding what is of public interest. In short, not only instrumental gains were viewed as more critical by both scientists and communication professionals but there were also encouraging improvements in scientists’ appraisals of substantive and normative goals associated with public engagement. As for the communication professionals inquired, the perceived potential of public engagement had been related to leveraging active citizenship (e.g., supporting bottom-up initiatives), which in 2021 had the same perceived importance for the majority as a decade ago.

**TABLE 4** Constraints to implementation of initiatives for deeper public engagement/participation in science (Source: interviews with scientists and communication professionals—2011–13).

Constraints	Scientists	Communication professionals
Lack of communication skills	•	
Lack of time and energy	•	•
Lack of resources (financial, human, logistical)	•	•
Lack of an effective institutional policy for interacting with society	•	
Lack of initiative of communication office	•	
Lack of incentives and professional recognition, and non-obligatory nature of science communication activities	•	
Limited awareness of the importance of citizen engagement	•	
Some scientists offering only limited collaboration	•	•

## 6.2. Constraints to implementation of deeper forms of public engagement

As summarized in Table 3, some scientists and, to a lesser extent, communication professionals conceive of potential further benefits of public engagement. Why, then, are they not implemented? Scientists’ willingness to strengthen public engagement seemed to be affected by various types of constraints, particularly regarding their own communicative competences, lack of resources and institutional support, time and compensatory incentives: “It demands much of us but it goes unrecognized” (SCI10PT); “It is an art and we are not trained to do it. We need support from professionals” (SCI5ES). In multiple cases, scientists alleged that communication offices at their institutions did not take initiative toward developing public engagement activities and often operated as mere interlocutors with the media:

“The main responsibility should not lie with the lecturer or researcher. There should be a centralized body responsible for promoting, searching, suggesting and that basically would take the initiative (...). It should guide us and help us, create

a dynamic and a habit, because basically the most difficult part of the work is done by us [scientists] and with great pleasure.” (SCI1PT).

Table 4 summarizes the most commonly perceived constraints by scientists and communication professionals in the two countries.

There were some differences between the two countries. In general, Spanish scientists attached the same importance to all the constraints they faced whereas Portuguese scientists placed particular emphasis on extrinsic barriers related to resource availability and the (lack of) support of their institutions’ communication structures.

Communication professionals identified a less diverse set of constraints than the scientists. They pointed to lack of resources, lack of conditions to devote themselves exclusively to science communication, and to prejudices held by some scientists regarding public communication as limitations: “We don’t have many people” (COM14PT); “The problem is that there is very little money.” (COM22ES); “Scientists have always been very afraid of vulgarizing their discourses” (COM21ES).

Ten years later, most of the Portuguese scientists (5/7) inquired in the online survey considered that all of the constraints listed in

**TABLE 5** Scientists' and communication professionals' perceptions of citizens (Source: interviews with scientists and communication professionals–2011–13).

	Perceptions of citizens
Scientists	• Lack of engagement
	• Lack of interest in S&T issues (although growing)
	• Scientific illiteracy
	• Social and economic concerns override interest in S&T (socio-economic context)
Communication professionals	• Clients of science institutions
	• Lack of engagement
	• Lack of interest in S&T issues (although growing)
	• Little value given to some scientific results

Table 4<sup>19</sup> had improved, despite the time limitations they continued to feel. For the majority of the Spanish scientists (2/3) barriers were generally similar to the past; yet, (2/3) said that careers were more demanding and competitive. 2/3 felt that communication offices took initiative more often, suggesting an upswing in a critical aspect mentioned above.

For the vast majority of communication professionals in both countries (4/5 in Portugal and 1/1 in Spain), the lack of resources had worsened, a finding that suggests that the investment in science communication offices reported in Section Engaging the public with science: Agents and roles has been far from sufficient in face of the amount of work demands. On the positive side, the same numbers of respondents considered that the availability of scientists for science communication had improved.<sup>20</sup>

### 6.3. Perceptions of citizens

The nature, extent and depth of science communication is dependent on the profiles and conduct of different agents, as well as on how they perceive each other. The statements of interviewed scientists and communication professionals in 2011–13 indicated that they tended to hold relatively similar views on the public. Table 5 summarizes those perceptions, which tend to function as additional constraints to farthing engagement.

Although they acknowledged that levels of public knowledge and interest in S&T and in climate change had been improving, scientists saw the public as not prone to engaging with those domains: “There is a shortage of participation and engagement training is required” (SCI3PT).

Lack of scientific knowledge was viewed as a barrier to participation in science:

<sup>19</sup> With regards to the institutional policy for interacting with society opinions were divided: 3/7 considered that it improved, 3/7 that it did not change and 1/7 that it worsened.

<sup>20</sup> In the only (optional) textual response that we received to the survey, a Spanish respondent referred to the creation of a scientists' association aimed at the promotion of scientific literacy as helpful (Asociación para la divulgación de la ciencia 'Ciencia a la Carta', in Toledo, Spain).

“Discussion with citizens on scientific issues is difficult because it requires a certain level of knowledge and therefore it is not a democratic participation in which everyone who wants to do so can participate; only those who want to participate and who have the knowledge to do so can participate, being restricted to those who know, if we do not want to be demagogic. (...) The panorama of possible recipients is very reduced.” (SCI16ES);

Inclusivity was also seen as challenging in initiatives that should have representation of all citizens affected by a given issue (e.g., not all the citizens who might be affected are interested in getting involved) and difficulties in public access (e.g., due to a low level of knowledge). Many interviewees noted that members of the public need to be interested and informed in order to participate. However, the possibility of knowledge-sharing through mutual scientist-citizen learning was neglected by interviewees. This may be related to the fact that dialogic initiatives were few and far between. Some scientists expressed difficulties in knowing how to open up the process of knowledge production to citizens in certain scientific areas, particularly those working closer to fundamental research. There were also doubts about how to apply the outcomes of public engagement initiatives to the knowledge produced, as well as some concern that the public may censor scientific ambitions. Moreover, there was also difficulty in seeing what the benefits could be and some doubt regarding the public's ability to co-produce knowledge: “Bringing citizens into our projects when they do not have scientific training always poses problems” (SCI7ES). Partners in the business sector and the policymaking area were seen as the most important participants in the discussion of research results.

Portuguese interviewees displayed a more favorable view of the public, particularly with regards to their interest in science dissemination initiatives than the Spanish ones. Nevertheless, even if there was some apparent disposition to do away with the “deficit model”, it was still present in the way most scientists interviewed acted and in the ways they perceived the public.

In the 2011–13 interviews, communication professionals referred to citizens as potential “clients” or “providers” of funding. The objectives of the science communication initiatives that they promoted were hence crafted for the “consumer citizen” (consumer of the knowledge produced and of the services provided). Although most Portuguese communication professionals mentioned a growing interest of young people and their families in those initiatives, some highlighted a lack of public engagement, and a lack of interest in S&T issues. Such lack of interest was also pointed out by most Spanish communication professionals. The following excerpt illustrates the idea that citizens do not appraise all the benefits of research results:

“Citizens” opinion is favorable toward the university and the work of researchers, but it seems there is still some fear - or even a misconception - that the work of researchers does not serve business”. (COM 15 PT)

How did perceptions evolve over a decade? For just over half the scientists (6/10) who responded to the 2021 survey, perceptions of agents involved in public engagement remained largely unchanged. Still, it is worthy pointing out that the majority (2/3) of Spanish scientists considered that some aspects had tended to worsen, such as counter-information campaigns driven by vested economic interests (lobbies), the scientific literacy of decisions makers and

public engagement levels. These are worrisome findings although not surprising in the socio-cultural environment of the last decade (e.g., the growth of disinformation). *Via* the 2021 survey nearly all communication professionals (4/5 in Spain and 1/1 in Portugal) recognized that interest in S&T issues as well as citizen engagement with science had risen, which is in line with the results of recent surveys (FECYT, 2020; European Commission, 2021). However, for most of those professionals (4/5 in Spain and 1/1 in Portugal) citizens continued to undervalue scientific results. All of these conceptions of both scientists and communication professionals shed light on intrinsic barriers to (changes in) science communication and practices of public engagement.

## 7. Discussion and conclusion

Besides contributing to farther existing knowledge on the roles and relations of scientists and communication professionals concerning science communication and public engagement in Portugal and Spain, this article offers a cross-cutting, integrative analysis from the perspective of those two types of agents. Although this can only be done at the cost of detailed data analysis, the summaries that we have offered in the text and tables above allow for a comprehensive outlook into their practices and perspectives, filling in a gap in the literature (Gerber et al., 2020).

In sum, based on a multi-faceted analysis carried out about a decade ago in four Portuguese and Spanish universities, communication practices appeared to be predominantly framed by conventional and somewhat narrow paradigms of science communication, and associated views on scientific literacy and public understanding of science, as previous studies have found elsewhere in these countries (e.g., Conceição et al., 2008; Torres-Albero et al., 2011; Escutia, 2012). A market-oriented logic appeared to underpin a large part of public communication initiatives on knowledge generated in universities. Public relations practices were employed in order to reach out to target publics, seemingly as instruments for achieving personal and political-institutional objectives, promoting scientists' work and, overall, the value of science. More recent literature suggests that these tendencies regarding the strategic value of communication for universities have grown in multiple countries (Wæraas and Sataoën, 2019; Vogler and Schäfer, 2020).

Interviewees mainly saw science communication and public engagement instrumentally. This is in line with what studies on other contexts and on climate change, as well as on other topics, have shown (Royal Society, 2006; Höppner, 2009; Davies, 2013a,b). Nonetheless, we found a noteworthy diversity in the ways in which scientists perceive public engagement and an increased attribution of importance to multiple non-instrumental considerations over the last 10 years. This bodes well for the possibility that they may in the future play a bigger part in defining the objectives of (at least some) initiatives.

Although interviewed scientists and communication professionals appeared to recognize the moral requirement of having citizens participate in science, they stayed short of fulfilling such commitment. This was partly due to given implementation barriers but also largely because, in assessing the cost-benefit ratio, many (especially among communication professionals) took a narrow reading of the potential of such engagement, its meaning and its reach. Although most scientists and communication professionals

feel motivated to contribute to this task, and even more so in 2021 than 10 years earlier, there seemed to be a tension between their perceived moral obligation to interact with the public and a set of constraints—both material and symbolic—that prevent them from fully enacting it. In general, those constraints have decreased in intensity over the last decade for both types of agents in both countries, but the lack of resources (financial, human and logistical) increased for most communication professionals and scientists reported added difficulties with an increasingly demanding and competitive career. Their institutions, in turn, are still in need of more effective policies for interacting with society and for developing S&T *with* and *for* society.

This project showed that climate change scientists and communication professionals in Portuguese and Spanish universities have had a relatively limited view of the potential of citizen engagement with S&T: there is a clear overvaluation of formal scientific knowledge when compared to other forms of knowledge that the public may have, and little or no potential has been seen in terms of added openness, transparency or plurality of processes of public participation. Importantly, recent data from our online survey indicates that this is changing among scientists. The interviews showed that the potential enhancement of policy-related decision-making processes was deemed to be more significant than any accruing benefits for knowledge production, even though scientists are more directly involved in the latter. This may be because scientists and communication professionals did not believe that citizens have a real ability to collaborate in the knowledge production process. With the results of our 2021 survey, it appears that the perceptions that these professional groups have of each other have improved but not of citizens and policymakers. The development of programmes aimed at training scientists and communication professionals in public dialogue and scientific citizenship may go some way to ameliorating this situation.

In climate change-related research, which is involved in this research project, citizens could offer important input as witnesses of climate impacts, as (potential) agents of social and economic change, as stakeholders in needed adaptation plans, among other imaginable contributions.

Our analysis of scientists' and communication professionals' views shows that there is much doubt about citizens' ability to play a part in the democratization of S&T. This perception is common amongst scientists and begs for the question of whether such negative view of the public's abilities might be enough on its own to compromise further opening by Higher Education and Research Institutions (HERIs). Still, it must be highlighted that a clear tendency for improvement was shown among scientists in the online survey that we applied in 2021 compared to the study conducted a decade earlier. This would need to be further investigated given the merely exploratory nature of our survey.

Our 2011–13 interviews showed scientists complaining about obstacles attributable to communication professionals and vice-versa. Although the 2021 survey suggested that mutual perspectives had improved, this study suggests that a good understanding of the "other side" by the main science communication agents at universities would be desirable. Recent research confirms the importance of the perceptions that actors internal to HERIs have of each other for communication (Schwetje et al., 2020) and suggests that there are contradictions (ibid.) or, at least, critical

differences in the conceptions of communication professionals and scientists regarding science communication, which may compromise the development of a “shared sense of purpose” (Koivumäki and Wilkinson, 2020). Learning between the two professional groups could be stimulated *via* joint workshops and similar activities.

At a time when the Portuguese and Spanish publics display great interest in science and technology (and on climate change) (European Commission, 2021), it appears imperative that universities engage fully with the essence of their “third mission” (focused on societal connections). As Davies (2013b) and Devonshire and Hathway (2014) argue, it is likely that, if scientists are to be more committed to citizen involvement in science, academic organizations need to change their structures and policies in such a way as to create the support mechanisms, training practices and incentives that scientists say are lacking. However, the findings of this project indicate that there must also be a shift in the culture, values and attitudes of both scientists and communication professionals, which is obviously a more complex challenge.

Public engagement is critical to take steps toward a democratization of knowledge and in the negotiation of science and technology policies. The work that universities carry out in this regard can have a significant impact on both the design and the operation of “civic” models of S&T, as well on the promotion of a more active scientific citizenship. Notwithstanding the fact that not all members of the public will be equally interested or available to get involved with S&T, and that the most relevant publics for the scientific community to engage with may vary (depending for instance on the S&T issues at stake), citizen engagement remains an important principle for designing and assessing science communication policies and practices. Although different forms of science communication and of interaction with the public will continue to be important, including those aimed at disseminating scientific knowledge, societal developments such as climate change, as well as ethical and value-related considerations discussed in this article, will increasingly require that universities deepen their commitment to more participatory practices of science communication and science-making (cf. Whitmer et al., 2010). Despite the advancements presented above in this article (e.g., Revuelta et al., 2020) Portuguese and Spanish universities are not yet making the most of the potential inherent to public engagement, as recently pointed out by Llorente et al. (2021). This raises important questions for research and practice. For instance, how can science communication scholars encourage universities to broaden and deepen public engagement framed by substantive and normative (i.e. not merely instrumental) arguments? Contributing to reflexive public engagement (Chilvers, 2012) by promoting continuous learning and improvement processes, as well as to broader transformative change (Murunga, 2022), is a critical task for HERIs. There are also important responsibilities on the side of those that teach and research science communication and on social scientists that are enthusiastic about public participation, deliberation and democracy to continuing a qualified conversation toward adding public value to public engagement with S&T (Stilgoe et al., 2014; Davies, 2021).

Although the research presented here produced important insights regarding public engagement with science in Portugal and Spain and the role of universities in this field, limitations must be acknowledged concerning dates, methods and sample size. It is

possible that in the last decade developments in public engagement perspectives have occurred that were not captured by our online survey and our review of recent literature concerning these topics in the two countries. We do not claim to present a full comparison between the two periods especially due to the different methods employed. The initial research project delved into practices and perspectives on public engagement in much greater depth than the 2021 online survey. The number of respondents to that survey was low and hence findings can only be seen as indicative. We recommend that future research deepens the data collected with this instrument through in-depth interviews and other qualitative approaches to thoroughly understand how conceptions and practices may have evolved. Finally, it seems important that studies of this kind are extended to more scientists (in general and especially scientists from humanities and social sciences) and communication professionals, and to other universities, which may even have different dynamics.

## Data availability statement

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

## Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

## Author contributions

LO carried out all the empirical research and wrote most of the article. AC contributed with literature, discussion of the analysis, and part of the writing. All authors contributed to the article and approved the submitted version.

## Funding

Part of the research conducted for this article was co-funded by the Portuguese Foundation for Science and Technology and the European Social Fund (ESF) - Human Potential Operational Program (POPH), under the National Strategic Reference Framework (QREN) Portugal 2007–2013, through a doctoral grant (SFRH/BD/74735/2010) to LO.

## 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

- Alves, C. C. (2011). *Monitoring Policy and Research Activities on Science in Society in Europe (MASIS) National report, Portugal*. Retrieved from: [https://www.researchgate.net/publication/333918619\\_Monitoring\\_Policy\\_and\\_Research\\_Activities\\_on\\_Science\\_in\\_Society\\_in\\_Europe\\_MASIS\\_National\\_Report\\_Portugal](https://www.researchgate.net/publication/333918619_Monitoring_Policy_and_Research_Activities_on_Science_in_Society_in_Europe_MASIS_National_Report_Portugal)
- Ankney, R. N., and Curtin, P. A. (2002). Delineating (and delimiting) the boundary spanning role of the medical public information officer. *Public Relat. Rev.* 28, 229–241. doi: 10.1016/S0363-8111(02)00129-7
- Ashwell, D. (2012). Barriers to the public communication of science: Commercial constraints versus public understanding. *PRism* 9, 1–11.
- Bauer, M. W., and Gregory, J. (2007). “From journalism to corporate communication in postwar Britain,” in *Journalism, Science and Society: Sci. Communi. Between News and Public Relations*, eds. M. W. Bauer and M. Bucchi (New York: Routledge), 33–52.
- Bauer, M. W., and Howard, S. (2013). *The culture of Science in Modern Spain: An Analysis of Public Attitudes Across Time, Age Cohorts and Regions*. Bilbao, Spain: Fundacion BBVA.
- Bensaude Vincent, B. (2014). The politics of buzzwords at the interface of technoscience, market and society: The case of ‘public engagement in science’. *Public Understand. Sci.* 23, 238–253. doi: 10.1177/0963662513515371
- Bergeron, A. (2000). “A cultura científica dos cientistas,” in *Cultura científica e participação pública*, ed. M. E. Gonçalves (Oeiras: Celta Editora), 63–80.
- Besley, J. C., Dudo, A., and Storksiedek, M. (2015). Scientists’ views about communication training. *J. Res. Sci. Teach.* 52, 199–220. doi: 10.1002/tea.21186
- Borchelt, R. E., and Nielsen, K. H. (2014). “Public relations in science: Managing the trust portfolio,” in *Handbook of Public Communication and Science and Technology. Second Edition*, eds. M. Bucchi and B. Trench (London: Routledge), 58–69.
- Bucchi, M. (2008). “Of deficits, deviations and dialogues: Theories of public communication of science,” in *Handbook of Public Communication and Science and Technology*, eds. M. Bucchi and B. Trench (London: Routledge), 57–76.
- Bucchi, M., and Trench, B. (2021). Rethinking *Sci. Communi.* as the social conversation around science. *J. Sci. Commun.* 20, Y01. doi: 10.22323/2.20030401
- Cabral, M. V. (2000). “O exercício da cidadania política em Portugal,” in *Atitudes sociais dos portugueses*, eds. M. V. Cabral, J. Vala, and J. Freire (Lisboa: Instituto de Ciências Sociais), 123–162.
- Callon, M., Lascoumes, P., and Barthe, Y. (2001). *Agir dans un monde incertain - Essai sur la démocratie technique*. Paris: Éditions du Seuil.
- Canfield, K. N., Menezes, S., Matsuda, S. B., Moore, A., Mosley Austin, A. N., Dewsbury, B. M., et al. (2020). *Sci. Communi.* demands a critical approach that centers inclusion, equity, and intersectionality. *Front. Commun.* 5, 2. doi: 10.3389/fcomm.2020.00002
- 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 J. Sci. Technol. Stud.* 3, 37–62. Available online at: <http://www.tecnoscienza.net/index.php/tsj/article/view/113> (accessed April 10, 2013).
- Chilvers, J. (2012). Reflexive engagement? Actors, learning, and reflexivity in public dialogue on science and technology. *Sci. Commun.* 35, 283–310. doi: 10.1177/1075547012454598
- Cologna, V., Knutti, R., Oreskes, N., and Siegrist, M. (2021). Majority of German citizens, US citizens and climate scientists support policy advocacy by climate researchers and expect greater political engagement. *Environ. Res. Lett.* 16, 024011. doi: 10.1088/1748-9326/abd4ac
- Conceição, C. P., Gomes, M. C., Pereira, I., Abrantes, P., and Costa, A. F. (2008). Promoção de cultura científica. Experiências da Sociologia. *Sociologia, Problemas e Práticas* 57, 51–81.
- Davies, S. R. (2008). Constructing communication: Talking to scientists about talking to the public. *Sci. Commun.* 29, 413–434. doi: 10.1177/1075547008316222
- Davies, S. R. (2013a). Constituting public engagement: Meanings and genealogies of PEST in two U.K. studies. *Sci. Communi.* 35, 687–707. doi: 10.1177/1075547013478203
- Davies, S. R. (2013b). Research staff and public engagement: a UK Study. *Higher Educ.* 66, 725–739. doi: 10.1007/s10734-013-9631-y
- Davies, S. R. (2021). An empirical and conceptual note on science communication’s role in society. *Sci. Communi.* 43, 116–133. doi: 10.1177/1075547020971642
- Delgado, A., Kjølborg, K. L., and Wickson, F. (2011). Public engagement coming of age: From theory to practice in STS encounters with nanotechnology. *Public Understand. Sci.* 20, 826–845. doi: 10.1177/0963662510363054
- Delicado, A., and Gonçalves, M. E. (2007). Os portugueses e os novos riscos: Resultados de um inquérito. *Análise Soc.* XLII, 687–718.
- Devonshire, I. M., and Hathway, G. J. (2014). Overcoming the barriers to greater public engagement. *PLoS Biol.* 12, e1001761. doi: 10.1371/journal.pbio.1001761
- Dudo, A. (2012). Toward a model of scientists’ public communication activity: The case of biomedical researchers. *Sci. Communi.* 35, 476–501. doi: 10.1177/1075547012460845
- Dudo, A., and Besley, J. C. (2016). Scientists’ prioritization of communication objectives for public engagement. *PLoS ONE* 11, e0148867. doi: 10.1371/journal.pone.0148867
- Elken, M., Stensaker, B., and Dedze, I. (2018). The painters behind the profile: the rise and functioning of communication departments in universities. *High. Educ.* 76, 1109–1122. doi: 10.1007/s10734-018-0258-x
- Entradas, M. (2016). What is the public’s role in ‘space’ policymaking? Images of the public by practitioners of ‘space’ communication in the United Kingdom. *Public Understand. Sci.* 25, 603–611. doi: 10.1177/0963662515579838
- Entradas, M., and Bauer, M. M. (2017). Mobilisation for public engagement: Benchmarking the practices of research institutes. *Public Understand. Sci.* 26, 771–788. doi: 10.1177/0963662516633834
- Entradas, M., Bauer, M. W., O’Muircheartaigh, C., Marcinkowski, F., Okamura, A., et al. (2020a). Public communication by research institutes compared across countries and sciences: Building capacity for engagement or competing for visibility? *PLoS ONE* 15, e0242950. doi: 10.1371/journal.pone.0242950
- Entradas, M., Junqueira, L., and Pinto, B. (2020b). “Portugal. The late bloom of (modern) *Sci. Communi.* in Portugal,” in *Communicating Science. A Global Perspective*, eds. T. Gascoigne, B. Schiele, J. Leach, M. Riedlinger, B. V. Lewenstein, L. Massarani, and P. Broks (Australia: ANU Press), 693–714.
- Entradas, M., Marcelino, J., Bauer, M. W., and Lewenstein, B. (2019). Public communication by climate scientists: what, with whom and why? *Clim. Change* 154, 69–85. doi: 10.1007/s10584-019-02414-9
- Escutia, C. L. (2012). *European scientists’ public communication attitudes: A cross-national quantitative and qualitative empirical study of scientists’ views and experiences and the institutional, local and national influences determining their public engagement activities.* (PhD thesis). University of the Basque Country, Spain.
- Estévez Cedeño, B., and Escobar Rodríguez, A. (2009). Participación ciudadana en el diseño de planes regionales de I+D. Comparativa de dos comunidades españolas (Madrid y Andalucía). *Paper presented at the Foro Ibero-Americano de Comunicação e Divulgação Científica*, Campinas, Brasil.
- European Commission (2010). *Science and Technology: Report. Special Eurobarometer 340/Wave EB 73*, 1. Retrieved from: [https://data.europa.eu/data/datasets/s806\\_73\\_1\\_ebs340?locale=en](https://data.europa.eu/data/datasets/s806_73_1_ebs340?locale=en) (accessed March 15, 2012).
- European Commission (2012). *EUR 25251 — Monitoring policy and research activities on science in society in Europe (MASIS). Final synthesis report.* Retrieved from: [http://ec.europa.eu/research/science-society/document\\_library/pdf\\_06/monitoring-policy-research-activities-on-sis\\_en.pdf](http://ec.europa.eu/research/science-society/document_library/pdf_06/monitoring-policy-research-activities-on-sis_en.pdf) (accessed January 10, 2013).
- European Commission (2013). *Responsible Research and Innovation (RRI), science and technology: Report. Special Eurobarometer 401 / Wave EB79, 2.* Retrieved from: [http://ec.europa.eu/public\\_opinion/archives/ebs/ebs\\_401\\_en.pdf](http://ec.europa.eu/public_opinion/archives/ebs/ebs_401_en.pdf) (accessed April 22, 2014).
- European Commission (2021). *European citizens’ knowledge and attitudes towards science and technology. Special Eurobarometer 516.* Retrieved from: <https://europa.eu/eurobarometer/surveys/detail/2237> (accessed April–May 2021).
- FECYT (2011). *V encuesta de percepción social de la ciencia y la tecnología.* Madrid, Spain: Fundación Española para la Ciencia y la Tecnología (FECYT)
- FECYT (2015). *VII encuesta de percepción social de la ciencia.* Retrieved from: [http://www.idi.mineco.gob.es/stfls/MICINN/Prensa/NOTAS\\_PRENSA/2015/Dossier\\_PSC\\_2015.pdf](http://www.idi.mineco.gob.es/stfls/MICINN/Prensa/NOTAS_PRENSA/2015/Dossier_PSC_2015.pdf) (accessed June 2, 2015).
- FECYT (2020). *X encuesta de percepción social de la ciencia y la tecnología.* Retrieved from: <https://www.fecyt.es/es/noticia/encuestas-de-percepcion-social-de-la-ciencia-y-la-tecnologia-en-espana> (accessed October 5, 2020).

## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fcomm.2023.1046501/full#supplementary-material>

- Felt, U. (2003). *Optimising Public Understanding of Science and Technology (O.P.U.S.): Project report*. Vienna, Austria: Vienna Interdisciplinary Research Unit for the Study of (Techno)science and Society (VIRUSSS), University of Vienna.
- Fiorino, D. J. (1990). Citizen participation and environmental risk: A survey of institutional mechanisms. *Sci. Technol. Human Values* 15, 226–243. doi: 10.1177/016224399001500204
- Fundación BBVA (2011). *Estudio internacional de cultura científica*. Retrieved from: [http://www.madrimasd.org/cienciaysociedad/documentos/doc/Cultura\\_cientifica\\_BBVA\\_08-05-2012.pdf](http://www.madrimasd.org/cienciaysociedad/documentos/doc/Cultura_cientifica_BBVA_08-05-2012.pdf) (accessed March 7, 2012).
- Gerber, A., Broks, P., Gabriel, M., Lorenz, L., Lorke, J., Merten, W., et al. (2020). *Science Communication Research: An Empirical Field Analysis*. *Inst. Sci. Innov. Commun.* 2022-02.
- Hagendijk, R., and Irwin, A. (2006). *Public deliberation and governance: Engaging with science and technology in contemporary Europe*. Minerva, 167–184.
- Höppner, C. (2009). “Public engagement in climate change—Disjunctions and blind spots in the UK,” in *IOP Conference Series: Earth and Environmental Science* (Vol. 8, No. 1, 012010). Bristol, United Kingdom: IOP Publishing.
- Horsbøl, A., and Lassen, I. (2012). “Public engagement as a field of tension between bottom-up and top-down strategies: Critical discourse moments in an “energy town”,” in *Citizen Voices. Performing Public Participation in Science and Environment Communication*, eds. L. Phillips, A. Carvalho, and J. Doyle (Bristol, UK, Chicago, USA: Intellect), 163–186.
- Horst, M. (2013). A field of expertise, the organization, or science itself? Scientists’ perception of representing research in public communication. *Sci. Commun.* 35, 758–779. doi: 10.1177/1075547013487513
- Hügel, S., and Davies, A. R. (2020). Public participation, engagement, and climate change adaptation: A review of the research literature. *Wiley Interdiscip. Rev. Clim. Change* 11, e645. doi: 10.1002/wcc.645
- Koivumäki, K., and Wilkinson, C. (2020). Exploring the intersections: researchers and communication professionals’ perspectives on the organizational role of science communication. *J. Commun. Manage.* 24, 207–226. doi: 10.1108/JCOM-05-2019-0072
- Lewenstein, B. V., and Brossard, D. (2006). *Assessing models of public understanding in ELSI outreach materials*. U.S. Department of Energy Grant DE-FG02-01ER63173. Final report. Ithaca, NY: Cornell University.
- Llorente, C., Revuelta, G., and Carrió, M. (2021). Social participation in science: Perspectives of Spanish civil society organizations. *Public Understand. Sci.* 30, 36–54. doi: 10.1177/0963662520960663
- Mejlgaard, N. (2009). The trajectory of scientific citizenship in Denmark: changing balances between public competence and public participation. *Sci. Public Policy* 36, 483–496. doi: 10.3152/030234209X460962
- Miller, S., Caro, P., Koulaides, V., Semir, V., Staveloz, W., Vargas, R., et al. (2002). *Report from the expert group-benchmarking the promotion of RTD culture and public understanding of science*. Retrieved from Brussels: [ftp://ftp.cordis.europa.eu/pub/era/docs/bench\\_pus\\_0702.pdf](ftp://ftp.cordis.europa.eu/pub/era/docs/bench_pus_0702.pdf) (accessed March 7, 2012).
- Montero Gibert, J. F., and Lorient, M. T. (2006). *Ciudadanos, asociaciones y participación en España*. Madrid: Centro de Investigaciones Sociológicas (CIS).
- Murunga, M. (2022). Public engagement for social transformation: Informing or Empowering? *Environ. Sci. Policy* 132, 237–246. doi: 10.1016/j.envsci.2022.02.031
- Nielsen, K. H., Kjaer, C. R., and Dahlgard, J. (2007). Scientists and science communication: a Danish survey. *JCOM* 06, A01. doi: 10.22323/2.06010201
- Oliveira, L. T. (2015). *As universidades e a participação pública em ciência. Percepções e práticas de cientistas, profissionais de comunicação e cidadãos em Portugal e Espanha*. PhD Thesis. Available online at: <http://hdl.handle.net/1822/40547> (accessed July 21, 2016).
- Oliveira, L. T. (2021). *As universidades e a participação pública em ciência*. Braga: Edições Húmus.
- Oliveira, L. T., and Carvalho, A. (2015). Public engagement with science and technology: contributos para a definição do conceito e a análise da sua aplicação no contexto português. *Observatorio (OBS\*) J.* 9, 155–178. doi: 10.15847/obsOBS932015857
- Pearson, G. (2001). The participation of scientists in public understanding of science activities: The policy and practice of the UK research councils. *Public Understand. Sci.* 10, 121–137. doi: 10.1088/0963-6625/10/1/309
- Peters, H. P., Heinrichs, H., Jung, A., Kalfass, M., and Petersen, I. (2008). “Medialization of science as a prerequisite of its legitimization and political relevance,” in *Communicating Science in Social Contexts. New Models, New Practices*, eds. D. Cheng, M. Claessens, T. Gascoigne, J. Metcalfe, B. Schiele, and S. Shi (Dordrecht, Netherlands: Springer Science + Business Media B.V.), 71–92.
- Phillips, L. (2011). *The Promise of Dialogue: The Dialogic Turn in the Production and Communication of Knowledge*. Amsterdam: John Benjamins Publishing Company. doi: 10.1075/ds.12
- Pinto, S., and Carvalho, A. (2011). Cientistas, jornalistas e profissionais de comunicação: Agentes na comunicação de ciência e tecnologia. *Observatorio (OBS\*) J.* 5, 65–100. doi: 10.1646-5954/ERC123483/2011
- Post, S. (2016). Communicating science in public controversies: Strategic considerations of the German climate scientists. *Public Understand. Sci.* 25, 61–70. doi: 10.1177/0963662514521542
- Revuelta, G. (2011). *Monitoring Policy and Research Activities on Science in Society in Europe (MASIS) National Report, Spain*. Retrieved from: [http://www.masis.eu/files/reports/MASIS\\_SPAIN\\_report.pdf](http://www.masis.eu/files/reports/MASIS_SPAIN_report.pdf) (accessed March 8, 2012).
- Revuelta, G., Semir, V., and Llorente, C. (2020). “Spain. Evolution and professionalisation of science communication,” in T. Gascoigne, B. Schiele, J. Leach, M. Riedlinger, B. V. Lewenstein, L. Massarani, and P. Broks (Eds.), *Communicating science. A global perspective* (Australia: ANU Press), 825–848.
- Rothwell, N. (2002). *Who Wants to Be a Scientist? Choosing Science as a Career*. Cambridge: Cambridge University Press.
- Royal Society (2006). *Science Communication Survey of Factors Affecting Science Communication by Scientists and Engineers*. Retrieved from: [http://royalsociety.org/uploadedFiles/Royal\\_Society\\_Content/policy/publications/2006/111111395.pdf](http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2006/111111395.pdf) (accessed March 10, 2012).
- Schäfer, M. S., and Fähnrich, B. (2020). Communicating science in organizational contexts: Toward an “organizational turn” in science communication research. *J. Commun. Manage.* 24, 137–154. doi: 10.1108/JCOM-04-2020-0034
- Schwetje, T., Hauser, C., Bösch, S., and Leßmöllmann, A. (2020). Communicating science in higher education and research institutions: An organization communication perspective on science communication. *J. Commun. Manage.* 84, 801–825. doi: 10.1108/JCOM-06-2019-0094
- Stilgoe, J., Lock, S. J., and Wilsdon, J. (2014). Why should we promote public engagement with science? *Public Understand. Sci.* 23, 4–15. doi: 10.1177/0963662513518154
- Stirling, A. (2008). “Opening up” and “closing down”: Power, participation, and pluralism in the social appraisal of technology. *Sci. Technol. Human Values* 33, 262–294. doi: 10.1177/0162243907311265
- Strauss, A., and Corbin, J. (1994). “Grounded theory methodology: An overview,” in *Handbook of Qualitative Research*, eds N. K. Denzin and Y. S. Lincoln (Thousand Oaks, CA: Sage), 273–285.
- Torres-Albero, C., Fernández-Esquinas, M., Rey-Rocha, J., and Martín-Sempere, M. J. (2011). Dissemination practices in the Spanish research system: Scientists trapped in a golden cage. *Public Understand. Sci.* 20, 12–25. doi: 10.1177/0963662510382361
- Vogler, D., and Schäfer, M. S. (2020). Growing influence of university PR on science news coverage? A longitudinal automated content analysis of university media releases and newspaper coverage in Switzerland, 2003–2017. *Int. J. Commun.* 14, 3143–3164.
- Wæraas, A., and Satao, H. L. (2019). “What we stand for: Reputation platforms in Scandinavian higher education,” in *Universities as agencies: Public sector organizations*, eds. Christensen, T., Gornitzka, Å., and Ramirez, F. (Springer, Berlin), 155–181.
- Wesselink, A., Paavola, J., Fritsch, O., and Renn, O. (2011). Rationales for public participation in environmental policy and governance: Practitioners’ perspectives. *Environ. Plann. A* 43, 2688–2704. doi: 10.1068/a44161
- Whitmer, A., Ogden, L., Lawton, J., Sturmer, P., Groffman, P. M., Schneider, L., et al. (2010). The engaged university: Providing a platform for research that transforms society. *Front. Ecol. Environ.* 8, 314–321. doi: 10.1890/090241
- Wibeck, V. (2014). Enhancing learning, communication and public engagement about climate change—some lessons from recent literature. *Environ. Educ. Res.* 20, 387–411. doi: 10.1080/13504622.2013.812720
- Wynne, B. (2006). Public engagement as a means of restoring public trust in science: Hitting the notes, but missing the music? *Commun. Genet.* 9, 211–220. doi: 10.1159/000092659