2 What do citizens want?

Science communication in the eyes of the public

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Introduction

Over the past 20 years, science and innovation have been democratised to promote the involvement of the general public. This interest in public engagement has also led to a shift in science communication, from the deficit model, based on the understanding that the citizenry's distrust of science is mostly due to ignorance, to more dialogic and participatory models.

Traditionally, science was communicated through dissemination and popularisation in a linear, closed fashion – from experts to laypersons, who were seen as lacking in awareness and understanding – with science usually being 'translated' for society by journalists and communicators. Today, science communication is looking for ways to make it easier for citizens to express their opinions and views and for scientists to listen to them, so that a common understanding can be developed (Gascoigne et al., 2020). So, in recent years, there has been a tendency towards two-way or multi-channel communication, via dialogue, active participation and the involvement of different audiences who, in some cases, can make a contribution and have a stake in the outcome of deliberations and discussions (Bucchi & Trench, 2016).

Despite the theoretical distinction between models, in practice, they all form part of a continuum characterised by two dimensions: (1) the intensity of collaboration between the different actors in the knowledge production process and (2) the extent to which the public is engaged by the promoters of initiatives (Bucchi, 2009). Therefore, different kinds of science communication coexist, which will continue to be put to use in certain circumstances and may contribute to enhance the science-society relationship.

The effectiveness of the public communication of science has long been the subject of empirical reflection and study, and one of the main drivers behind the search for innovative science communication strategies (Newman, 2020; Kupper, Moreno-Castro, & Fornetti, 2021). Most studies aimed at improving the effectiveness of science communication have focused on the opinions, ideas and experiences of scientists and science communication practitioners (e.g. Llorente et al., 2019; Rafter, 2019; Anjos, Russo, & Carvalho, 2021), while fewer have considered the contribution of citizens.

DOI: 10.4324/9781003400943-3

In the CONCISE project, a different approach, consisting in the analysis of citizens' views on science communication, was taken. To this end, five consultations with 100 participants each were held, in which they were asked to discuss different issues relating to science information. The choice of the public consultation format as the data collection method was justified by the intention to (1) run multiple group discussions simultaneously; (2) to create a participatory experience for the attendees and to empower them by offering them the opportunity to contribute to scientific development; and (3) to foster among them the feeling of forming part of a national and international community. Such a qualitative, multilayer data collection approach can, among other things, help to gather citizen feedback that could be overlooked when employing other survey techniques and to attune science communication more to citizens' needs and concerns (Delicado et al., 2021).

This chapter focuses on the third part of the group discussions in which the citizens taking part were directly engaged in the research process by asking them how science communication on the four topics discussed – climate change, vaccines, CAM and GMOs – could be improved. The aim was not only to discover their views on different aspects of science communication but also to understand, from their perspective, what the main priorities were in terms of improving this and the presentation of scientific knowledge.

The suggestions made by the citizens from the five countries focused on different types of initiatives, audiences, producers of communication and topics (for an analysis of the suggestions made on the topic of climate change, see Dzimińska et al., 2021). Sometimes, the suggestions were very specific, including examples of types of initiatives or measures that could be adopted. While at other times, they were broader and focused on general concerns about science communication. The citizens made many suggestions relating to the need for science content not only in traditional (e.g. TV, radio and the press) but also digital media (e.g. social media like YouTube and Instagram), as well as in other specific formats (e.g. flyers and billboards). They also expressed their views on the education system (e.g. school initiatives and science in the syllabus), while highlighting the importance of specific communication styles and advocating for the dissemination of science information in a clearer, more engaging way, in addition to the need for the institutional recognition of the social relevance of science.

To make sense of all this material, a grounded theory qualitative analysis was performed on the citizens' statements so as to gain further insights into the array of ideas put forward and to understand their interrelationships. This analysis was based on a common codebook that allowed for identifying all the suggestions made by the citizens during the discussion sessions in all five countries. An inductive analysis was then performed on their suggestions, with the aim of determining (1) their priorities for improving science communication, (2) whether or not there were differences between countries and topics, and (3) how their suggestions reflected specific ways of understanding public engagement with science (hereinafter PES).

As a result of these analyses, it was initially possible to identify 14 science communication themes, which were not mutually exclusive. They included aspects such as the availability, curation and relatability of science information. These

dimensions were then grouped and recoded into broader categories, allowing for classifying them in four main science communication dimensions that the citizens appreciated and in which they believed that there was room for improvement: accessibility, validation, understanding and engagement. Table 2.1 presents an overview of the results and proposes a multidimensional/multilayer framework that includes the main dimensions, sub-dimensions and examples of the types of suggestions made by the citizens.

In the following sections, the project results are presented in further detail, taking into consideration the main dimensions and sub-dimensions. The citizens' quotes provided below for illustrative purposes are identified by country, topic (climate change – CC, alternative medicines – CAM, vaccines – VAX, and genetically modified organisms – GMOs), gender (male, female, non-binary and others), age group and level of education (primary ed., secondary ed. and university ed.).

Accessibility

The accessibility of science information was the main issue highlighted by the citizens in the five countries involved. Many were concerned about the need to disseminate science to the public at large and to make it available in the mass media, while also contending that it should be better targeted so as to engage hard-to-reach and/or disengaged audiences. They also stressed how important it was to make science more easily available to both the general public and to specific groups, more visible in the public sphere and more accessible in terms of language and content.

One of their concerns was that science information should be readily *available* to everyone, suggesting different ways of achieving this, like, for example, by creating content and programmes in the mass media to ensure that it reached even those who had no interest in such topics. Television, in particular, was considered as an essential medium for communicating with larger audiences.

> In all those [media channels] that have a greater impact on the general public. And above all television, without a doubt. Because we all realise there isn't much information on the subject [on TV]. There is, but in a very limited way. I think it should be mainly on television. And why? So that it's disseminated as widely as possible.
>
> (Portugal, CAM, female, 55–64, university ed.)

> I think there should be special TV programmes because TV's the quickest way of reaching the largest number of citizens possible. And it should be immediately clear that this is a scientific programme and that by watching it, we'll find answers to the most relevant and most interesting questions.
>
> (Poland, CC, male, 65+, university ed.)

This concern about the dissemination of science content in the mass media was also reflected in their suggestions for making more room for it, like, for example, through specific TV formats like documentaries, debates and dedicated channels.

Table 2.1 Citizens' science communication improvement framework

Main dimensions	*Definition*	*Sub-dimension*	*Definition*	*Types of suggestions (examples)*
Accessibility	Improving public access to science information	Availability	Making science information readily available to the general public and hard-to-reach audiences	Science content in large-audience programmes, debates, monographic programmes and specialist TV channels, fiction programmes, podcasts, flyers, posters, specific outlets like social media, schools, local newspapers and health centres
		Visibility	Attracting attention to science and making it more visible in the public sphere	Primetime TV science programmes; increasing the number of science programmes; more scientific coverage in newspapers; social campaigns; open days; celebrity endorsements/ involvement
		Intelligibility	Simplifying/adapting the message	Good communicators, comprehensible messages and an appropriate language for the public; the use of concrete data and visual images
Validation	Making it easier for the public to assess information quality	Curation	Selecting relevant and credible information for the public	Institutional websites linking to relevant, credible information, repositories and databases; social media content curation; promoting credible research and the official communication channels of research institutes
		Certification	Having relevant information verified and certified by credible institutions	Environmental and health certificates, green labels, fact-checking services, accurate labelling

		Recognition	Enhancing the social relevance and/or importance of scientific knowledge	Initiatives that promote political recognition of the value and authority of science; the promotion of expertise through public campaigns; the visibility of scientists/experts
Understanding	Taking into account the way in which the public understands and relates to science information	Literacy	Promoting the public's knowledge of science	Science educational initiatives; promoting science content in educational programmes; literacy skills initiatives; lifelong educational initiatives
		Critical thinking	Fostering the citizenry's ability to evaluate science information	Initiatives that promote information analysis, scientific methods, digital literacy and on- and offline evaluation skills
		Appropriation	Sharing information to which citizens can relate because of similarities to themselves or their own experience	Information that includes recommendations on what people can do or how they are impacted by a specific issue; engaging formats that take into account peoples' interests
Engagement	Involving the public in science communication	Direct contact	Promoting direct contact between scientists/ science communicators and citizens	Scientists visiting schools; science students making presentations in bars/ unconventional venues; face-to-face presentations; science fairs; seminars; lectures
		Dialogue	Offering citizens the opportunity to pose questions	Digital platforms on which citizens can pose questions, talk with experts or take part in workshops; specialist phone lines; debates with the public
		Participation	Promoting initiatives/ projects that take into account the citizenry's knowledge and perceptions	Consultations, local initiatives, citizen councils, participatory projects

Source: Own elaboration.

> There're a lack of TV programmes that explain science; there're a lack of documentaries, debates […] there should be less sensationalist news and more programmes devoted to educating the public.
>
> (Spain, CAM, male, 25–34, university ed.)

> We've … I don't know how many sports channels … . With 20 or 30 universities, we could have a science channel … […] The state would have to make an effort and it could even include different institutions. […] There's a serious problem in our country. We have a string of rubbish TV programmes that reach us every day […] there's no alternative for those who want to keep themselves informed about anything. And nowadays, it's very easy with television, with a remote control for flicking back and forth, to have a programme, or two or three or four, on certain scientific topics, which we can easily access.
>
> (Portugal, VAX, male, 45–54, university ed.)

The citizens also advocated for adopting different formats that engaged people through a variety of channels, such as social media, billboards, leaflets and new digital outlets, among others, as well as specific initiatives and formats in schools and universities.

> I think theatre's fantastic. For example, organising shows on the use of separate waste collection […], undoubtedly theatre has a very strong impact. Of course, it should be public theatre and not along the lines of people being shut up inside a hall, but on the street, where instead of juggling an actor tells me the story of the Earth […]. In my opinion, theatre can play this role.
>
> (Italy, CC, female, 45–54, secondary ed.)

> I think different types of large festivals, like, for example, the Pol'and'Rock Festival [Polish 'Woodstock Stop' Festival held yearly from 1995–2017], are good for spreading information. Greenpeace, look, they were really active at [the Polish] Woodstock; yes, I learned about the problems with the Baltic Sea just at Woodstock. There were half a million people there and everyone was hooked somewhere; they were given leaflets, invitations to meetings with specialists in the fields of biology, meteorology, chemistry and so on.
>
> (Poland, CC, female, 25–34, university ed.)

> I think a format like the Political Tribune could also be useful. […] For political information, there used to be the Political Tribune, which in 15–20 minutes proposed a small roundtable, very quick, on a topic. It was stimulating … then someone says, 'Hell, I've never thought about that!' This topic has many aspects. It's a format that doesn't only provide information, but can also stimulate curiosity …
>
> (Italy, GMOs, male, 65+, university ed.)

This interest in specific dissemination formats also emerged when the citizens highlighted the importance of making science content available to hard-to-reach

audiences. They were often aware that they themselves were privileged, in terms of access to information and knowledge, while referring to the need to design communication strategies for reaching less engaged audiences. They also stressed the importance of local print media or tabloid newspapers for reaching older audiences, in addition to creative strategies tailored to the daily lives of these specific groups.

> Somewhere in the media, the traditional print media that everyone reads, more should be written about it with substantiated arguments. For example, the print version of the [mainstream] newspaper *SME*'s also read by older people in different regions. They should offer more coverage of this topic, because some of my older neighbours don't even know what GMOs are.
>
> (Slovakia, GMOs, female, 45–54, university ed.)

> In villages, because people there don't go looking on the Internet or turn on a computer … . There should be information in parish councils. There should be clarification sessions. There should be door-to-door leaflets like with Lidl. Or make agreements with Lidl to inform the nation in its leaflets. […] Or in the *Correio da Manhã*. Those newspapers distributed in all the coffee shops and village associations, a page of the *Correio da Manhã* on which the state informs the citizenry about vaccines.
>
> (Portugal, VAX, female, 45–54, university ed.)

Similarly, the citizens also considered that, in order to appeal to younger people, it was necessary to devise alternative strategies, such as creating engaging campaigns in their preferred channels, namely social media platforms, like YouTube and Instagram:

> Maybe the format of the press that we read's boring for the younger generations, because of social networks, because they're digital natives. Current press formats should be adapted so as to make them more appealing to these types of people, in order to arouse their interest in the topic. But, instead, the press has adopted a format identical to that of social networks, and that isn't how it should be.
>
> (Spain, GMOs, female, 25–34, university ed.)

> State science institutes should find a more appealing way of communicating. They should be active on social media and do something like popularisers do, some kind of popularisation of their science.
>
> (Slovakia, GMOs, female, 45–54, university ed.)

To improve accessibility, availability must be considered together with *visibility*. This means that to improve science communication it has to be made more visible in the public sphere, stressing its significance and value for society. This concern was apparent in the suggestion that more room should be made for science communication on primetime TV. The citizens often said that they were aware of some programmes on science-related topics, but that they were often relegated to cable

networks, secondary channels and off-peak hours. Many suggested broadcasting science programmes in primetime, inviting scientists to large-audience news programmes or even including science content in general TV programmes.

> In terms of science, visual images have a big impact. I wouldn't just have a debate; I'd have a programme designed for the whole family and present it, just like the open days at a research institute, so that it could be shown on television in order to engage people of all ages with science. Maybe make some kind of quiz show for children, bring science back to the whole family, present it in a quiz format, so that people can see the applications of science.
>
> (Spain, GMOs, female, 35–44, university ed.)

> But you have to know how to show it. You have to know how to engage press journalists with interesting information. You have to know how to sell it. Science information's a kind of commodity. You can't limit yourself only to periodicals. Because if you want to reach society, you have to use technological developments.
>
> (Poland, VAX, male, 45–54, university ed.)

The citizens also believed that the visibility of science could be enhanced by creating campaigns that reached large audiences more systematically. This was particularly relevant, for example, in those statements in which they suggested that the state had a duty, or mission, to act and to keep the general public informed about specific topics. In this case, they advocated for campaigns based on relevant information that had the ability to reach the public at large and to highlight the social relevance of the topic in question.

> Social campaigns. Not advertising, but social campaigns. Well, they have them about road safety which are often quite poignant … . I think those about road accidents reach at least some people. Perhaps this type of campaign on vaccines would also be a good idea; it'd counteract the anti-vaccine campaigners in some way.
>
> (Poland, VAX, female, 55–64, university ed.)

> You see different billboards and banners that are placed so purposefully that you don't even notice it. This should also be done with vaccination because sometimes, when you hear about the topic, you can recall one of those banners. If there were such banners or billboards with information on how important vaccination is, it'd influence your decision-making. It comes from the depths of the mind, it's essential and I want it.
>
> (Slovakia, VAX, male, 45–54, university ed.)

Another suggestion for improving the visibility of science was to recruit famous people, celebrities and even prominent scientists to disseminate scientific

knowledge. Their participation was seen as a relevant way of engaging the population, reaching larger audiences and making the message more appealing.

> It's also good to use authoritative figures or people who are even very well known; I don't know – actors, sports stars and so on. They could endorse solid science information.
>
> (Poland, CAM, male, 45–54, university ed.)

> There's television, the medium to which Italians resort most. Maybe … an authoritative figure, like Piero Angela, is necessary. Maybe it isn't necessary to be a figure like Professor Roberto Burioni. He's too divisive. We could invite a vaccine expert and let them also do a televised comparison with another expert. We need to make it interesting!
>
> (Italy, VAX, male, 35–44, university ed.)

The citizens also criticised the accessibility of science information when it was communicated in a complex manner, using technical jargon, in a way that did not engage people. To deal with this problem, they also pointed to *intelligibility* issues, in terms of content that could be read and understood by the public. This concern was expressed mostly for those sections of society with lower levels of literacy (e.g. 'my grandparents') but also:

> If there was someone who could simplify the messages that are conveyed, it'd be much easier for my grandparents to understand them and maybe become aware of what's important. […] I think that's where the problem lies: the message and the way it's transmitted. Because if they simplified it, I think more people would become interested in the subject, in that topic. And maybe they'd start researching on it, and maybe if they said that those sites were good places to search, maybe people would visit them, and maybe they would read a little bit every day, or a news item or two, and start to be more aware of that subject.
>
> (Portugal, CC, female, 18–24, secondary ed.)

> I think scientific articles are very often heavy going and have a lot of vocabulary that's difficult to understand and perhaps not accessible to the general public. What I want to say is, although it's true that anyone can read it, a potentially interested 12-year-old might not understand it, nor an older person either. So, what's needed is a language that's more accessible and easier to read and that's much more entertaining so that it motivates you to continue reading.
>
> (Spain, CC, female, 18–24, secondary ed.)

The citizens also highlighted the importance of having 'good communicators' sharing information on science-related topics to improve their intelligibility. These communicators were seen to play an essential role in translating relevant

information for the general public, not only making it more engaging but also easier to understand.

> I think the mainstream media lack good communicators … . If we had good communicators … I see a clear example; I think it's Pedro Azevedo, if I'm not mistaken. He's an astronomer at RTP [national television channel] whose a great communicator. I wasn't interested in anything, but he communicates so well that I get hooked watching him and learn about astronomy. Something that didn't interest me directly. I think we lack that kind of good communicator to talk about climate change and sustainability in the media, especially in the mainstream media.
>
> (Portugal, CC, male, 25–34, university ed.)

> La gata de Schrödinger and Quantum fracture [well-known Spanish science communicators on YouTube]: I think the dynamics or the language or the strategies they're using are very interesting, because they're getting young people involved in scientific issues and in keeping themselves informed. I think the media or information on climate change could copy or consider this way of communicating. Because now we've a lot of tools, videos, social networks, text, photos, 360º videos and infographics; we've a lot of tools that could be used to attract people with an appealing language and to keep them informed in a rigorous way without resorting to sensationalism.
>
> (Spain, CC, female, 18–24, university ed.)

Finally, the citizens also referred to the importance of using visual images and including concrete data in science communication to make it more understandable and relatable. For they were of the mind that this type of information allowed for a better visualisation of the issues under discussion and for understanding their implications in a very concrete manner.

> I reiterate what I was saying and what S. also said, which is to use images, use information … something that's easy. We usually say a picture is worth a 1,000 words, right?
>
> (Portugal, CC, male, 35–44, university ed.)

> Statistical data, I think. Reliable statistics. How many cases of the disease are there in the vaccinated group, how many in the group that didn't get vaccinated?
>
> (Poland, VAX, male, 65+, secondary ed.)

> Specify it in more detail and in the context of universal history, that is to say, contrast more data, but not just say that the situation's very bad, that we're going to die, which is terrifying for the public. I don't want 15 minutes of being reminded about this; I want 15 minutes of them explaining to me what's going on. Maybe it's because I'm studying physics and like to see data, but I want to see figures, I want to see what the situation's like now and how it was 50 years

> ago, in order to be able to contrast it with a little more empirical rigour, instead of really subjective opinions; at least that's how they seem to me in the way things are being explained to us right now.
>
> (Spain, CC, male, 25–34, university ed.)

Validation

Although the accessibility of science information was undoubtedly the main issue raised by the citizens, many of their suggestions related to another dimension of science communication: information validation. This is particularly relevant because they often felt overwhelmed by the quantity of information that they received on certain 'hot' topics (like climate change) and by the spread of disinformation and misinformation, both on traditional and digital media. The citizens felt that it was difficult for the public to assess the quality and credibility of the science information that they came across and called for different mechanisms for validating it, namely, initiatives relating to content curation, certification and recognition.

The citizens talked about the difficulty that they had in choosing and being able to identify relevant information when there was so much available through so many channels and sources. In this case, they often suggested the need to have access to *curated* information, to wit, information selected by reliable sources and made available to the public. For example, they requested repositories that guaranteed access and information quality, websites that summarised credible information on a specific topic and official communication channels providing the citizenry with such information:

> But at a European level, it'd be possible, for example, to make an effort and gather all the credible information on the same page, on the same website, tailored to different population groups. From the most detailed information, very scientific, to the more general kind. That would be possible. […] At a European level, it'd be possible to build a space where information was filtered and served as a support for schools, families, whoever wants to access that specific information.
>
> (Portugal, CC, male, 55–64, university ed.)

> So, on the Internet, there's all this pseudoscience that actually generates more fear than true information. The problem is that academies and research centres would need official channels for communicating with citizens. In other words, open science: so, if I've doubts about the greenhouse effect and want to look for information on it and there's a group of scholars at the Polytechnic of Milan who're really studying it and […] they should make popular science, because […] chemical-physical parameters, which no one really understands, are useless to us.
>
> (Italy, CC, female, 55–64, university ed.)

This concern applied especially to the information that the citizens accessed on the Internet and social media. They often criticised the criteria used by platforms to promote content and how information circulated on them. In this respect, they claimed that science information disseminated online was often dubious and that it should be selected according to expert criteria and checked before being shared online. In some countries, the citizens expressed how important it was to have official bodies that fact-checked the information posted online, so as to guarantee its quality for the average citizen.

> Excuse me, but I must insist: the Internet isn't the ideal place for looking for information because who controls the Internet? As anyone can post what they want, it's the Ministry of Health that should have its experts and studies, and clarify what's good, what isn't, and what's good for us and what isn't good for us.
>
> (Spain, CAM, male, 65+, university ed.)

> It'd be an uphill struggle to verify that the information's correct and not distorted. People are being bombarded with a lot of bullshit.
>
> (Italy, GMOs, Male, 45–54, secondary ed.)

Many of the citizens also suggested that *certificates*, issued by reputable institutions, would be a good way of providing the general public with guidance and helping them to assess information or product quality. This was suggested in relation not only to the explicit labelling of GM products, for example, but also to the development of environmental certificates for different types of products (in the context of the climate change discussions).

> Definitely state institutions, the Ministry of Health, the Ministry of Agriculture or other state institutions should take responsibility. There should be a catalogue, register or database available with official information on food certificates.
>
> (Slovakia, GMOs, female, 25–34, secondary ed.)

> There should be a seal of quality, a stamp that's on these products but certified and legalised, so that the seal isn't given to those who don't meet the requirements. Just as there is for other products and services, such as designations of origin [a type of geographical indication aimed at preserving the designations of origin of food-related products] and everything else.
>
> (Spain, CAM, male, 45–64, primary ed.)

> Now, whenever we buy a product, we should be able to know its environmental impact […] this mug was on sale in the supermarket; on the label of the mug it said, 'For this mug, so many litres of water were used, so many litres of oil, so many this, so many that, and it emitted I don't know how much CO_2.' If this – let's call it a green label – was provided, I could decide between buying this mug

> or buying a glass mug, imagine, and make the decision taking into account that green label.
>
> (Portugal, CC, male, 45–54, university ed.)

To improve the public's assessment of science information, the citizens also referred to the importance of enhancing the social *recognition* of science by promoting the authority of scientific expertise. For example, they emphasised the role of the state in the communication of science topics like vaccines and climate change, stating that this would prevent radical differences of opinion on these subjects, thus making the message clearer for the general public.

> Here, the state, or the Ministry of Health, plays an important role in popularisation. Well, because how else can we fight? Going by experience, you don't discuss things with stupid people because they'll bring you down and defeat you. So, if the state took over, a RESPONSIBLE STATE, such reliable information – why are we doing this, why is this important? What does epidemiology involve, what's the increase in a disease, how could it end, what are the symptoms of polio? For example, to show, to make people aware of, to visualise what this disease looks like.
>
> (Poland, VAX, male, 45–54, university ed.)

> I think there should be some state scientific organisations. The Slovak Academy of Sciences has a department that deals with this topic and, if there's an interest, they should provide the public with more information about it. They should work on some informative materials, like the posters announcing EU funding. They should cooperate in creating informative materials about GMOs to disseminate such information.
>
> (Slovakia, GMOs, female, 35–44, university ed.)

But they also advocated for science communication initiatives that gave scientists visibility and promoted them as experts, while also stressing the importance and value of scientific knowledge for society.

> I do think the meaning of the word 'expert' should be highly valued, and the opinion of experts must always be taken into account in their area of expertise, instead of believing what anybody says about that issue. So, it does seem to me that the media and politicians, the European Union, etc., should shoulder some of responsibility for facilitating access to expert information, but in an informative way so that the public can understand it. You shouldn't address them using technical jargon.
>
> (Spain, VAX, female, 18–24, secondary ed.)

> It seems to me that one more thing can be added: maybe know-it-all politicians shouldn't become involved; maybe they should leave it in the hands of competent people. So many interviews are conducted with politicians, but they rarely

include the experts advising them. As a result, this knowledge is only acquired in bits and pieces. […] However, this is too delicate and serious an issue for our health and for future generations, which's why competent people must speak out.

(Poland, GMOs, female, 65+, university ed.)

Understanding

The third aspect of science communication reflected in the suggestions made by the citizens for improving it was the importance of considering how people understood science and the information that they received and how they related to it. This dimension is different from the others because it focuses on the importance of the skills, knowledge and interests of citizens receiving science information.

There were plenty of references to the need to improve people's *scientific literacy*. This was particularly visible in many of the citizens' suggestions, including the importance of investing in science at all levels of the education system, implementing initiatives aimed at different age groups, promoting lifelong learning and setting up a university for seniors.

It'd be nice if there was a subject in primary education for teaching young children to live more ecologically – education in ecology.

(Slovakia, CC, female, 18–24, secondary ed.)

It's important to educate the population, just as we all know that killing's bad, we should also […] educate the population to be critical, to have a science education, to have an education in health, … […] so that when a crackpot comes along and defends something, like a treatment or something else, people are in a position to say, 'I get the message, but …' […] above all, it's … I think it's a question of educating society.

(Spain, VAX, female, 18–24, university ed.)

Lifelong learning, a university for seniors and so on. Education for the older generations should provide them with information on genetically modified organisms, how they're produced, the risks they pose and why.

(Slovakia, GMOs, male, 45–54, university ed.)

The citizens attached particular importance to the need to teach the public *critical thinking* skills. In this connection, more than specific science content, they considered that it was a priority for the public to be able to understand the scientific method and to evaluate science information critically.

It'd be useful if school children were also taught the scientific method, critical thinking. I think it'd also be incredibly important.

(Poland, VAX, male, 25–34, university ed.)

> [It's necessary] to provide the tools for finding one's bearings in the information chaos … . It's useful to recognise information that perhaps isn't black or white. […] In my opinion, perhaps the crux of the problem's forming a scientific mentality for everyone […] otherwise there's a democratic deficit because we don't have the tools to choose, because there's currently a lot of information and we cannot manage or control all of it.
>
> (Italy, VAX, female, 55–64, university ed.)

> I believe that education's fundamental, that this topic must be taught, without being macabre, in schools in a scientific way, explaining the data. […] I also believe that it's necessary to train citizens so that they have criteria and can draw their own conclusions, regardless of media they read.
>
> (Spain, CC, female, 65+, university ed.)

Some citizens also expressed the idea that people felt more engaged with science communication when they could *appropriate* the information being shared, namely, when it ceased to be an abstract, technical issue to become something with which they could identify in their personal lives. According to them, this appropriation of science could be achieved not only by including practical examples, actionable knowledge – things people could do in relation to an issue – but also by exemplifying how people could be impacted by these issues in their daily lives.

> It seems to me that the best option is to present some concrete examples from real life that show how they affect our lives and the actual things they do.
>
> (Poland, GMOs, female, 18–24, secondary ed.)

> I'd also like them to actually provide a solution. Because they give you a 48-page article on the thaw in the Arctic, ok, and I read that article and now what am I supposed to do? So, at least those scientists who performed the study should reach a consensus on guidelines for reversing the situation. […] I think a section of the article should be dedicated to concrete solutions proposed by its authors.
>
> (Spain, CC, male, 25–34, university ed.)

Engagement

The final category reflected in the citizens' suggestions concerns PES. In one-way communication, this dimension was referred to in terms of direct contact between science communicators and scientists and the public. The citizens also stressed the importance of creating opportunities for dialogue between the general public and scientists, as well as the need to promote participatory initiatives that took into account the formers' knowledge and perceptions.

The citizens confirmed their interest in promoting *direct contact* between scientists, practitioners or science communicators and the members of the public and in leveraging direct communication for disseminating scientific knowledge among them.

> Face-to-face communication's very important to us, right? Direct contact with people who tell us things. So, in my opinion, favouring that contact would benefit us all, more or less that we'd believe in it more, we'd be more trusting … so, use the right people … whether they be politicians or not.
>
> (Italy, CC, male, 35–44, university ed.)

> And it wouldn't be a bad idea to organise, for example, once a year, a day in which specialists, doctors, pharmacists, the Ministry […] could get together and reach out to the general public. […] Then we'd be encouraged to regain trust.
>
> (Spain, VAX, male, 25–34, secondary ed.)

In particular, the citizens stressed the importance of educational activities involving science communicators in school initiatives, especially with younger children.

> I'd like the communication style to be enhanced. For me, that's one of the ways in which it engages me. It's through schools. My daughter brings information home. And perhaps some of you – your children, grandchildren, nieces and nephews … I think it's important that those who study this, in academic terms, go and hold mini-conferences at schools!
>
> (Portugal, CC, female, 45–54, university ed.)

> What I was saying is that if, for example, there were talks at school given by professionals to children, that'd engage them much more than the information they receive from their parents or even teachers. After all, children are with their parents and teachers on a daily basis, but in the end they trust more in someone from outside their daily lives who comes to talk to them, because it's exciting for them.
>
> (Spain, CAM, female, 45–54, university ed.)

The citizens appreciated direct communication when scientists were involved. Many of them referred to the importance of having scientists explain their own research to the public, interacting with the population outside academia and devising a proximity strategy to stimulate interest and promote trust in science (see Chapter 4).

> We should be able to encourage scientists to leave their studies, libraries and universities for the streets; that's where the people are … . In my opinion, this is necessary, but doesn't happen … we discover people when they express their opinions, but sometimes it's a bit like crying in the wilderness. Get them out of the academic environment to where the people are.
>
> (Italy, CC, male, 45–54, secondary ed.)

> I think this information on the environment shouldn't be provided by politicians; it has to be provided by scientists, the people who're doing research, in order to engage us, so that meetings are more enjoyable, so that people get involved

> a little more. It's the scientists themselves who're trying to change the world; they're the ones who should give the talks.
>
> (Spain, CC, female, 55–64, primary ed.)

> One thing I experience a lot in the municipality of Braga and in the district of Braga, we have a nanotechnology institute there and, fortunately, we're increasingly connected with science in that context. Why do I think it's the best example of scientists that we have experienced in Braga, fortunately? Proximity. I think proximity's the secret. Proximity to the school community. Proximity to the business community. Proximity to ordinary citizens.
>
> (Portugal, CC, female, 25–34, university ed.)

Some of the citizens also emphasised the importance of *dialogue* between scientists/science communicators and the public, calling for opportunities to interact and spaces for the general public to ask questions. They claimed that the members of the public were willing to participate in direct discussions with experts in those scientific fields in which they had an interest, so as to clear up their doubts or to gain a better understanding of different topics.

> Meeting experts and discussing this subject with them. In my opinion, that's a great way for anyone to approach someone with expertise, to obtain relevant information, to talk directly with an expert.
>
> (Slovakia, CC, female, 45–54, university ed.)

> I'd love to be given the opportunity to have a face-to-face conversation with a specialist, to participate in a consultation. It'd be great for parents of nursery school children to have the opportunity to obtain information at nursery schools at a meeting held on a given day. That's the group that's probably most interested and attendance would be high.
>
> (Poland, VAX, female, 35–44, university ed.)

The suggestions made by the citizens mostly included digital platforms on which they could ask experts questions, maintain a dialogue with them at science workshops or have access to phone lines to discuss issues directly with them.

> But initiatives like GiovedìScienza [science festival] are also really useful, because one of the things that – in my limited experience – work very well is having that kind of relationship with people, giving participants the possibility to ask questions and to receive answers from a person who appreciates their interest.
>
> (Italy, GMOs, female, 25–34, university ed.)

> I think what's needed is an additional space where scientists could make a contribution and talk to citizens in some kind of debate. As we're doing now, but with experts and lay people where we could speak our minds, like we're doing

> now, but in an additional space on social media or other media that could explain to us or bring us closer to the disaster in which we're currently immersed.
>
> (Spain, CC, female, 45–54, secondary ed.)

In addition, the citizens expressed the need to involve different communities and groups in the debate so as to gain further insights into their needs and to engage them with the right kind of science communication.

> Organising debates in local communities involving all generations, convening people with different views to debate in a … first in a dispassionate way, before communicating the results to other communities.
>
> (Portugal, CC, male, 35–44, university ed.)

Finally, the citizens also highlighted the importance of citizen *participation* in science communication, an approach that considers the public's perspectives and creates spaces for their participation in the construction of scientific knowledge. The public consultations carried out in the framework of the CONCISE project offered the citizens participating in them the chance to understand the importance of public engagement. In this respect, emphasis was placed on the need to gather and make use of the public's feedback on acceptable scientific research aims and applications.

> For example, more initiatives like this. In this case, it's a public consultation, but doing this kind of … sometimes there's also the flip side of the coin, which is that people don't participate, but create these … these lectures, these debates. […] having a person there who knows how to deal with the situation, bringing matters into the public eye, so that they can express their opinions on the subject, to see what they know, what they don't know, to interact …
>
> (Portugal, CC, female, 25–34, university ed.)

> I think that, as you were saying, it's also the first time they've asked us for our opinion and the truth is that it'd never have occurred to me that our opinion could count for something. I mean, things like today's event […] we've been told this is being done in five countries now, that there may be many more projects like this. I'd never really considered that I could express my opinion and that it had any importance […] The fact that everyone can hear my opinion's important to me; it can be a good, bad or so-so opinion, but it's mine and it's being heard.
>
> (Spain, CAM, female, 45–54, university ed.)

The citizens also discussed the importance of gathering the public's local knowledge and adapting science communication to different levels. They believed that the venue where this should be done was a crucial factor for science communication, especially in the field of climate change, because they believed that the public's knowledge and experience were essential to mitigate its impact.

> I think there's a need for moments like this, when we have governments, with scientists, with communicators, with locals, with communities … . I think we can have these moments of sharing, but active sharing, because it isn't a forum on climate change, it's listening to scientists talking about their studies. No … it's real sharing […]. Let's design a strategy that makes sense in Loulé, but that isn't the same that makes sense in S. João da Madeira.
>
> (Portugal, CC, female, 18–24, university ed.)

> Because people in the community are also [knowledgeable] … maybe if there was an effort on the part of municipalities and councils … . For example, in rural areas people are used to the idea of saving and reusing water. Until 2005, there were areas in the borough of Loulé that didn't have mains water. People had to have their own cisterns, their own wells, and they had to manage that water. So, the knowledge of these people can help us – those who're far removed from these experiences …
>
> (Portugal, CC, male, 35–44, university ed.)

The citizens' suggestions about PES showed that they had had direct experiences with these kinds of science initiatives, which demonstrates the effectiveness as well as the interest in the public's involvement in creating science knowledge and actively improving their beliefs about science.

> I don't know if you've noticed it's happening more and more often. Even today, we're taking part in projects. These projects are being carried out and the scientific side's making an effort to communicate with society. There're various polls … not polls, actions, and that instead of a plastic bag, it's a linen bag, right?
>
> (Poland, CC, female, 35–44, university ed.)

> I like the kind of participatory events they have in Trnava – ekotopfilm, children see a film, also in the afternoon for adults … about food wastage. This should be more frequent. At this event, there're also conferences and workshops with ecologists; there're discussions in which anyone can participate … about how to resolve all these issues, how to persuade people to take action. There's a lot in the newspapers about climate change, but such events are lacking. I formed part of an open debate with an expert from the Institute of Circular Economics, and we discussed how the circular economy could be achieved in everyday life. People need to be involved in discussions, they need someone to explain to them why things should be done sustainably.
>
> (Slovakia, CC, female, 25–34, university ed.)

Discussion

Studies in the field of science communication often focus on specific aspects either associated with one or a few key characteristics, such as accessibility, validity, understanding and engagement. Few studies have offered a framework that

describes in detail the characteristics of effective, high-quality science communication. Seethaler et al. (2019), for example, identified a series of ethical elements and values that promoted effective science communication, while Mercer-Mapstone and Kuchel (2017) distinguished 12 fundamental skills for achieving this. The analysis of the suggestions made by the citizens during the consultations points to an understanding of science communication in which the identified dimensions and sub-dimensions complement each other, as well as suggesting that their joint application may promote science communication outreach. The key dimensions of the citizens' science communication improvement framework that were identified by analysing their suggestions support the findings presented in the literature. However, the framework offers a novel synthesis and contextualisation of recommendations for improvements.

Accessibility tends to be a major issue when discussing science communication. On the one hand, it is about ensuring that the greatest number of people not only have access to information, but that it is also understandable to them. On the other, it is a way of improving social inclusion (Matias et al., 2021). In recent decades, the media have allowed scientific knowledge to be shared at unprecedented rates, enabling widespread access to science information and bolstering public engagement and transparency. Many studies have focused on the coverage of science and technology issues in the media, showing that the overall coverage of science in newspapers and on television has slowly but surely increased over the past few decades (Bauer et al., 1995; Pellechia, 1997; Bucchi & Mazzolini, 2003).

However, the citizens taking part in the public consultations advocated for increasing the accessibility of science information to the public in general, making information easier to obtain for all those actively searching for it. For those less engaged with or less interested in science, the citizens suggested solutions aimed at passive receivers, for example, on primetime TV. They also proposed enhancing the visibility of science and its role in society. Finally, they pointed to the need to communicate science using an understandable language tailored to different audiences. In other words, communicators need to ensure that their messages are understandable, with the final public in mind, implementing different strategies, such as more adept use of visuals or data (Bucchi & Saracino, 2017; Rigutto, 2017; Delicado & Rowland, 2021).

The idea of the *validity* of science information is directly connected with a specific assumption about the public communication of science: the more science information there is, the more accurate it will be and the greater the social acceptance of science and technological innovation will be. This conception has long been the dominant view on the role of science communication (Hilgartner, 1990). Many of the citizens' suggestions reflected a growing concern about how to ensure the validity of available information. As Weingart and Guenther (2016) noted, science communication depends on trust, both in the source and in the communication channel. In recent years, there has been an apparent increase in 'anti-scientific' positions. According to some authors (Vernon, 2017; Crease, 2019), authoritative observers, anti-vaccination propaganda, climate change deniers, promoters of medicines not based on scientific evidence and many more have been waging a real

'war on science'. They also pose a real threat to the health of millions of people and to the protection of the environment (Douglas & Sutton, 2015). This mistrust of science has often been traced to specific information sources and channels, particularly to the increasingly more important role played by social media.

According to the dominant narrative circulating in the media in recent times, we have witnessed an uncontrolled spread of 'fake news', with repercussions for the political, economic and social spheres, marking the beginning of an era that some call 'post-truth'. As Scheufele and Krause (2019) observed, being misinformed depends not only on the citizenry's ability and motivation to spot falsehoods but also on their chances of being exposed to (mis)information. For this reason, fact-checking sites and other initiatives aimed at countering science misinformation have proliferated. In this context of growing misinformation (Schiele, 2020; Allcott & Gentzkow, 2017), the citizens put forward ideas on how to make content curation more targeted and how to support its verification so as to ensure that the public had access to credible information (ALLEA, 2021). These included introducing certification schemes and campaigns aimed at highlighting the importance of science, with the public authorities being signalled out as those that should shoulder this responsibility (EC, 2020).

Traditionally, the deficit model of the public communication of science has been based on the assumption that *understanding* science is related, by and large, to scientific literacy (Miller, 1983), and that achieving this guarantees favourable attitudes towards scientific and technological innovations. This model has also emphasised the public's inability to understand or appreciate scientific achievements. In order to resolve this deficit, public and private bodies – especially since the mid-1980s – have launched schemes to promote public interest in and awareness of science. Since the early 1990s, these assumptions have been strongly criticised on several grounds (Evans & Durant, 1995; Wynne, 1991), although many studies have shown that scientific literacy is associated with positive attitudes towards science (Sturgis & Allum, 2004; Rutjens et al., 2018). In this study, the citizens' views revealed that they endorsed this line of research, for they believed that they needed to have the necessary skills to understand science information, to verify its validity and to identify its relevance for their lives. They advocated for developing science literacy and critical thinking skills more intensively in the education system in order that society should be better prepared to evaluate and differentiate true information from the false kind (ACARA, 2015). With increased knowledge and skills, they would also be able to put the information gained from their own experiences to better use and to see how it could be applied in their daily lives (Cook et al., 2011).

In recent years, citizens have also increasingly called for the involvement of lay-people in science, allowing them to help to shape the research agenda. This has led to reconsidering the role of the public communication of science and technology. In the year 2000, the UK House of Lords identified a 'new model for dialogue'. Subsequently, other institutions supported the need to review existing strategies, in light of the broader agenda that science communication was addressing (Bucchi, 2008). New models of science communication, namely, those involving dialogue and participation, started to appear during this period. In line with these trends, a

final dimension that emerged from the citizens' suggestions was the *engagement* of society with science. They called for bridging the gap between science and the public at large, while contending that science should not be an intellectual exercise practiced in isolation but should be within the reach of all citizens and more aligned with their needs. Accordingly, they proposed many initiatives that promoted direct contact between scientists and society, organising events that helped ordinary people to enter into dialogue with specialists, experts or scientists in order to obtain explanations or to broaden their knowledge of topics of interest.

The citizens also suggested initiatives that encouraged the public to play an active role in science-related activities. They believed that their *engagement* with science could consolidate their knowledge, generate trust and encourage new attitudes and behaviours. This was especially evident in the discussions on climate change, in which some citizens held that incorporating their concerns and local experience in science communication was not only positive but potentially transformative for science and the state-society relationship.

When analysing the findings, it was revealed that there were striking similarities between the ideas expressed, regardless of nationality. In all five countries, the citizens advocated for the more widespread use of television to reach the general public with a greater impact, the greater involvement of public authorities in verifying and certifying available information and the role of scientists, who should be more active in disseminating scientific findings, cooperating with the media and becoming directly involved in initiatives with the public. In all five countries, it was also suggested that health practitioners should be more involved in communicating medical topics to the public because of their direct contact with patients and presentation of scientific facts, while having the credibility of experts. This communality is significant. Despite the differences existing between the five countries in terms of science communication and public access to science information (see Chapters 3 and 4), when asked about what could be done to improve science communication, the citizens often shared the same priorities.

The differences observed were related to the fact that some dimensions were emphasised more in specific topics. For example, the suggestions for verifying information, certification or recognising science through legislation were widely discussed during the CAM and vaccine sessions, in which the citizens highlighted the health risks posed by the dissemination of false information in these areas. For example, the fact that choosing CAM over conventional medicine might pose a risk to people's health and lives, prompting them to stress the importance of validating available information in this regard. The discussions on CAM revealed that there was still much to be done to improve the effectiveness of communication in this field, especially in light of the fact that the citizens' views on CAM were based mainly on the opinions of family or friends and rarely on scientific evidence. The importance of validation for science communication was also emphasised during the discussions on vaccines, in which the proposals for wider social campaigning and state involvement so as to guarantee information credibility stood out. On the other hand, the topic of climate change elicited the largest number of suggestions of all, especially in relation to direct involvement, being able to enter into a dialogue

with scientists and the introduction of participatory initiatives or events. There were also calls for hands-on initiatives, in which citizens were directly involved, actively participating and acquiring new habits, as well as understanding the consequences of their actions in relation to their own lives or to the town or country in which they lived (Dzimińska et al., 2021).

As will be seen in Chapter 5, traditional (mostly TV) and digital media (i.e. social networking sites) were the main channels for keeping abreast of science news. In all five countries, the older participants preferred the former, while the younger ones opted for the latter. There was also a preference for digital media among the Slovak and Polish citizens, in contrast to their Portuguese, Spanish and Italian counterparts who tended to consume traditional media more. This difference was also reflected in their perception of the quantity/quality of the science information to which they had access. On the one hand, they held that there was a lack of science news in the traditional media. On the other, they considered that there was too much information in digital media. Their suggestions for improving science communication tended to reflect these 'media diets'. Indeed, the citizens put forward suggestions based on how they accessed information on the different topics. Environmental topics (GMOs and climate change) were available through a variety of news channels, with climate change being the most widely discussed and covered topic in both types of media. Health topics (vaccines and CAM), by contrast, were mostly discussed on the Internet and on social media. For example, there were many suggestions for using databases or fact-checking websites for validating information on the topics that were mostly accessed on social media, in particular, and the Internet, in general (climate change but also vaccines and CAM). On the other hand, to improve the quality of science information on the issues most covered in the traditional media, the citizens chiefly suggested promoting programmes aimed at increasing the public's scientific literacy and the greater involvement of experts in science communication aimed at lay audiences.

If the findings are interpreted from the deficit-engagement model perspective (Bucchi & Trench, 2016), it can be observed that most of the citizens' suggestions implied that lay audiences had a knowledge deficit and that there was a need for transmitting science information from experts to the public at large. In other words, they proposed a one-way communication model involving formal education, sharing information through the mass media and organising major social campaigns. They recommended that producers and broadcasters ensure the availability, visibility and intelligibility of the science information that they shared. They also highlighted the importance of programmes for developing the skills of citizens in terms of critical thinking and literacy, alike. Although recommendations of this type might indicate that the deficit model was still deeply rooted in the citizens' perceptions, they also tended to reflect what they knew or were familiar with, that is, the current dominance of one-way models in science communication.

On the other hand, the call for two-way communication models was expressed through references to dialogue and deliberation between the citizenry, scientists, experts and policymakers. This was evidenced, for example, by suggestions relating to the importance of dialogue between practitioners and patients on health-related

issues. As their nature implies individual involvement in one's health, the citizens recommended obtaining information actively and direct interaction with specialists. Additionally, as to the climate change discussions, participatory actions were advocated for because the agency and knowledge of individuals were seen as key to resolving this issue. The fact that the engagement dimension was more present in the suggestions made in the climate change discussions than in those on GMOs and CAM might have something to do with the nature of these topics. In the case of the climate change discussions, for instance, the citizens advocated for various types of actions: social campaigns or events in which climate change impacts were explained and citizen participation was promoted. However, such actions might not be considered as being relevant to GMOs or CAM.

In many cases, the citizens who made these suggestions had previous experience of these kinds of initiatives which they considered to have been positive. Moreover, in view of their suggestions and evaluations (see Chapter 3), it became clear that even those who had never had such a previous experience enjoyed taking part in the consultations, often using them as an example of the kind of initiatives that they would like to be replicated in order to improve science communication. This exemplifies how support for engagement initiatives is often directly related to participation. It is through involvement in participatory projects that the engagement model becomes tangible for citizens and, consequently, something to which to aspire.

Conclusion

All the suggestions made by the citizens taking part in the five public consultations point to a multi-layered understanding of science communication, in which the transversal dimensions of information accessibility and validity and the public's understanding of and engagement with science coexist and are often entwined. This multidimensionality of science communication should come as no surprise. As observed by Trench (2008), several science communication models, including the one-way kind, continue to coexist with two-way models that place varying emphasis on interactivity. This has been confirmed by the findings of our analysis.

The suggestions made by the citizens highlighted the dimensions of science communication that they considered important and in which they saw room for improvement. They stressed the importance of increasing accessibility to science information, especially for the general public and hard-to-reach or less engaged audiences. By their reckoning, there was a need for validation procedures so as to facilitate the assessment of the quality and credibility of science information in a media context in which information and misinformation are increasingly shared. They underscored the importance of taking into account the general public's level of understanding of science for its more effective communication. Lastly, they placed the accent on the importance of citizen participation in science communication not only through dialogue but also, in some cases, through their direct involvement in the construction of scientific knowledge.

Our findings show that the dimensions for improving science communication encompassed the different aspects of the four topics discussed and were relevant in all the countries included in the study. They also show that these dimensions are often seen as complementary. The resulting science communication improvement framework offers an integrated representation of the citizens' suggestions and recommendations that could be used to assess the quality of a specific message or initiative. For example, a message that is accessible (available, visible and understandable) might have a wider outreach than one that meets only the availability criterion. Or when concerns about the accessibility of a message are supplemented by considerations on the direct engagement of the receivers, it might be more likely to appeal to the public. To our mind, the application of this framework has significant advantages since it is based on a methodology that takes into account the richness of perspectives revealed by the citizens in the discussions on four science topics, reflecting not only their major concerns about science communication but also specific ideas on how to improve it to meet their needs and desires.

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