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## The landscape of European science communication

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### Abstract

European science communication project QUEST surveyed and reviewed different aspects of European science communication, including science journalism, teaching and training in science communication, social media activity, and science in museums. This article draws together themes that collectively emerge from this research to present an overview of key issues in science communication across Europe. We discuss four central dynamics — fragmentation within research and practice; a landscape in transition; the importance of format and context; and the dominance of critical and dialogic approaches as best practice — and illustrate these with empirical material from across our datasets. In closing we reflect upon the implications of this summary of European science communication.

### Keywords

Professionalism, professional development and training in science communication; Science and media; Science centres and museums

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### Introduction

Alan Chalmers' [1999] introduction to the philosophy of science is a classic. Running into four editions, always with an enigmatic picture of a cat on the front cover, the text has been read by generations of students eager to engage with the nature of scientific knowledge production. Perhaps part of the reason for its success is its title, which simply asks: *What is this thing called science?* In the book Chalmers attempts to provide an answer.

There is no book, as of yet, called *What is this thing called science communication?* but perhaps there should or will be.<sup>1</sup> If Chalmers is concerned with the nature of science, much science communication scholarship is concerned with the nature of public communication of and engagement with science and technology. These efforts may be instructional or normative, but they are also descriptive. What does

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<sup>1</sup>At the time of writing the most-read paper in JCOM was Kahan [2015] 'What is the "science of science communication"?' which seems to indicate some appetite for that hypothetical book to exist.

science communication look like? What is its content? Where does it happen? What dynamics shape it, and what are the concerns of its practitioners?

This article seeks to contribute to this tradition of work. Based on research that surveyed different aspects of European science communication, including science journalism, teaching and training in science communication, social media activity, and science in museums, we offer a snapshot of European science communication, and in particular its contemporary concerns, priorities, and struggles. As we describe below, this snapshot is to a large extent based on the views of its practitioners (as well as on large scale quantitative data collection) and should therefore be read as providing insight into the current mood of science communication — its qualities and concerns as much as its structural features. We identify four key themes: fragmentation within research and practice; a landscape in transition; the importance of format and context; and the dominance of critical and dialogic approaches as best practice. In describing these themes we thus provide an overview of the landscape of European science communication as of 2019, when data collection was carried out.

The article proceeds as follows: we first outline existing knowledge concerning the nature and status of (European) science communication; second describe our methods and data; third, in four sections, work through the themes mentioned above, supporting them with empirical material; fourth discuss and reflect on the meaning and implications of our findings; and fifth offer a short conclusion. While the situation for science communication — and indeed life generally — has dramatically shifted since we carried out this research [Massarani, Murphy and Lamberts, 2020], our hope is that the article still provides some insight into the underlying dynamics that animate European science communication research and practice, and offers food for thought for the wider science communication community.

## Research context

In the 2014 edition of the *Handbook of Public Communication of Science and Technology* Trench et al. outline key dynamics structuring the global spread and development of science communication. First, they note, “government programmes to boost science awareness” are becoming ever more prominent around the world; second there is an increase in “training and other supports for scientists in public communication”; third “incentives to support media attention to science”; fourth “university taught programmes in science communication”; and, finally, growth in “university research in science communication” [Trench, Bucchi et al., 2014, pp. 215–220]. These dynamics hold true in Europe as elsewhere. Indeed, since the 1980s there has been a steady development in European science communication as a field of practice [Bultitude, McDonald and Custead, 2011; Claessens, 2012], an educational programme [Mulder, Longnecker and Davis, 2008; Trench and Miller, 2012; Trench, 2012; Trench, 2017], and a multidisciplinary area of scholarship [Anichini and de Cheveigné, 2012; Gascoigne, Cheng et al., 2010; Guenther and Joubert, 2017; Smallman, 2016]. While national contexts remain highly specific, with these developments being articulated in quite different ways, an opening up of practices towards dialogue, engagement, and participation has been generally visible across the continent. Two key projects which sought to map science and society activities across Europe both emphasise public involvement in science as a form of best practice, and one that has largely been on the rise [Conceição et al.,

2020; Mejlgaard et al., 2012]. Though narratives of a move ‘from deficit to dialogue’ were always as much aspirational as descriptive [Gregory and Lock, 2008; Trench, 2008], and though the landscape has been complicated by recent interest in innovation (for instance in the form of responsible research and innovation, or RRI; Broks [2017]), dialogue remains a central feature of European policy on science communication [Conceição et al., 2020].

Other recent research has sought to outline and understand science communication scholarship. Such work has argued, for instance, that science communication is becoming increasingly internationalised [Guenther and Joubert, 2017]; that it is composed of at least 11 ‘subcommunities’, from science education to media effects [Rauchfleisch and Schäfer, 2018]; and that its status as an established discipline or field of research is becoming stabilised [Kessler, Fährnrich and Schäfer, 2020]. Such research, which increasingly presents science communication as an area of scholarship that is largely independent of practice, speaks to longstanding concerns about a gap between practitioners and their academic counterparts [Miller, 2008; Priest, 2010]. Indeed, a “[l]ack of transfer between scholarship and practice” was one of the key findings of a major recent review of science communication studies [Gerber et al., 2020, p. 3]. One of the central challenges facing science communication, in Europe or anywhere else, is thus to find ways to approach it as an integrated field, one in which university-based research and diverse forms of practice can be considered as interconnected. This impetus lies behind (largely U.S.-based) efforts to define the ‘science of science communication’ [Hall Jamieson, Kahan and Scheufele, 2017], but it also draws attention to, as Gerber et al. [2020] have argued, the need to go beyond isolated, ‘one-off’ studies and to examine science communication longitudinally or by using different methods and perspectives.

If we are to summarise current knowledge concerning the European science communication landscape, then, we can point to two well described features: a narrative of ‘deficit and dialogue’ and a corresponding emphasis on engagement as best practice, and concerns regarding gaps between scholarship and practice. The research discussed in this article seeks to respond to some of the research needs described above, and to further outline the characteristics of European science communication, by mobilising mixed methods approaches and by examining European science communication as it is articulated in both research and in diverse forms of practice.

## Methodological and analytical approaches

This research was carried out as part of the European project QUEST (‘Quality and Effectiveness in Science and Technology communication’), a collaborative project (with eight partners across six European countries) funded by the European Commission’s ‘Science with and for Society’ (SwafS) programme.<sup>2</sup> The QUEST project offers a still unusual opportunity to carry out large scale research into science communication. In drawing together partners with different forms of expertise — including in data science, journalism studies, museum studies, and STS (Science and Technology Studies) — and in providing a framework for investigating science communication across Europe, the project allowed for diverse forms of data collection in different national sites across different types of science

<sup>2</sup>See the website <https://questproject.eu/> for further details about QUEST.

communication. Specifically, in the work described here QUEST sought to survey current thinking and practices in European science journalism, research and teaching in science communication, social media activity, and science in museums. The empirical material that we draw upon in this article was gathered and analysed in the following ways.

First, large-scale data collection and analysis of science on social media. QUEST researchers collected public data from Facebook, Twitter and YouTube, downloading the content published by a set of accounts of public entities manually selected to be a good representation of science communication in Europe. The list was constructed manually, with the collaboration of QUEST partners, to represent a range of sources of science communication on social media across Europe. The final list includes 737 sources with at least one active account on Twitter, Facebook or YouTube. The dataset contains a total of 498 Facebook pages, 393 YouTube channels and 661 Twitter accounts spread across seven European countries, and includes a set of accounts dedicated to cross-European or international accounts, such as the European Space Agency and Nature. Data analysis involved quantitative analysis of content over time (number of posts, videos or tweets produced), and engagement, concept extraction, and sentiment analysis, done with the Watson Natural Language API (which applies machine learning and natural language processing techniques to analyze text and automatically extract relevant entities and concepts, their semantic relationships, and the emotional sentiments they express). This aspect of the QUEST research therefore offers a snapshot of the content and characteristics of science communication on different social media platforms across Europe.

Second, semi-structured qualitative interviews were used to explore the current practices and concerns of practitioners (i.e., professional communicators) within science journalism ( $n = 18$ ), science museums ( $n = 15$ ), and science communication research and teaching ( $n = 16$ ). Interviewees were selected so as to represent practice in these areas across Europe (with interviewees coming from Norway, Sweden, Estonia, the Netherlands, the U.K., France, Germany, Switzerland, Italy, Spain, Greece, Serbia, Bulgaria, and Ireland), and were recruited based on literature reviews, suggestions from QUEST partners, and snowball sampling [Creswell, 2002]. The interviews had the aim of exploring participants' assessments of the current landscape of science communication in their field and region, and therefore included questions about interviewees' views about contemporary science communication and the situation across Europe as well as their own practices, positions, and concerns. All interviews were — with participants' permission — recorded and transcribed. Analysis was carried out through repeated reading and coding of key themes that emerged, both in relation to the aims of the QUEST project and with regard to references or concerns that were repeatedly mentioned by participants [Coffey and Atkinson, 1996]. This aspect of the QUEST research thus provides insight into practitioner views and experiences across Europe.

The result of this work is a number of rich and complex datasets. More detailed analyses of aspects of these (for instance with regard to current concerns within science journalism or detailed comparisons of social media usage across different national contexts) have been published elsewhere or are forthcoming [see Davies et al., 2019; Davies, 2021; Maiden et al., 2020], and we encourage interested readers to engage with these. But, taken together, the material also offers an overview of

current practices and concerns within European science communication. With this in mind, material from all empirical engagements was read and re-read in order to identify any themes, practices, or concepts that repeatedly emerged across the different forms of data. Such themes were then discussed within the researcher team (and wider QUEST consortium) in order to verify their status as robust, cross-cutting dynamics that appear across European science communication. It is these themes that are discussed below, supported by examples from the different datasets we have described.

### 3.1 *A disparate and fragmented field*

We have already touched upon the longstanding concerns that exist in science communication around gaps between theory and practice. It is not surprising, then, that these concerns also emerged within QUEST data (“How is it”, wondered one interviewee succinctly, “that those who are doing science communication aren’t reading the articles, and those who are writing the articles aren’t doing any science communication?”). However, taken as a whole the empirical material suggests a fragmentation that goes beyond the well-established theory-practice divide; instead, what we observe is European science communication as a set of largely independent fields, communities or activities, with little interaction between these. We can illustrate this fragmentation with three aspects of the empirical material.

First, we find linguistic and disciplinary divides within science communication research and teaching. This was clear even as we got a sense of the intellectual universes in which interviewees lived: participants’ accounts of the research landscape, of influential concepts or bodies of scholarship, and of key challenges or research problems were frequently entirely different from each other, and at times diametrically opposed (one person’s best practice is for another something to be avoided). European science communication scholarship thus appears not to be an established discipline working in a widely shared paradigm, but a field that is fragmented according to discipline, national context, or language. Indeed, several interviewees made this explicit. “Each country has its particularity”, said one interviewee. Others discussed or referred to the fact that French, German, English, and Spanish-speaking countries (in particular) all have long histories of carrying out, teaching, and researching science communication, but these histories have been articulated in quite different ways and discussion of them has tended to be done within that language. This means, amongst other things, that the largely Anglophone international academic literature lacks a true sense of the work being done in thinking about science communication. As one interviewee cautioned:

the field is very highly differentiated. [...] It’s taught and researched and thought about in very different ways in the French language zone, in the German language zone, and the English language zone, and so on.<sup>3</sup>

Similarly, disciplinary background was also important. Those we spoke to came from the natural sciences, from science communication practice or journalism, from sociology, or from cultural studies or STS, and they mentioned, when discussing

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<sup>3</sup>Given that the European science communication research community is relatively small, we do not identify interviewees by national context or gender in order to help preserve their anonymity.

concepts they used or traditions they worked in, fields from psychology to history to communication studies to anthropology. In other words, there was no single set of theories, concepts, or approaches that was repeatedly referenced when participants were asked about the intellectual tools they drew upon in their work. Science communication studies, as encountered in this research, existed not as a coherent field with a shared epistemology, but as a multi-discipline [Priest, 2010] in which scholars from different traditions work on the same topic. Of particular significance is diversity in how participants thought about the purposes of science communication. For some, science communication is fundamentally about “increasing knowledge and understanding” or ‘giving back’ to taxpayers, while for others it was primarily understood in terms of questioning powerful interests, enabling citizen empowerment, or ensuring that science is responsive to public needs and values [see Davies, 2021]. ‘Good’ science communication, and the stance it should have towards science, was therefore framed in very different ways by different interviewees.

Second, this picture of fragmentation is reinforced by accounts many interviewees gave of science communication teaching. Again there was a sense of a poorly networked community where different national traditions were key and where there was limited knowledge-sharing, cohesion, or agreement on best practice.<sup>4</sup> This is particularly the case in the context of training for scientists or other activities that lie outside the relatively small number of high profile Masters programmes that exist [see Mulder, Longnecker and Davis, 2008]. The vast majority of teaching around science communication, reported interviewees, is “a little bit hidden” from outside view, sitting within other programmes or by going by other names. Such activities comprise:

... the work that’s done by scientists within their own teaching programmes in chemistry or biology or whatever it happens to be, where they include an element of science communication. Sometimes naming the module as such, other times putting it in under interdisciplinary skills or transferable skills or whatever. And that is, if you like, below the radar and it’s kind of a bit artisanal, you know.

This notion of teaching as small scale and “artisanal”, as this interviewee described it, reinforces the picture of an educational landscape which is often ad hoc, dependent on the enthusiasms of particular individuals, and, as such, lacking coordination or coherence.

Third, and relatedly, we also find fragmentation when we look *across* the interview material to observe how different communities speak about science communication. In talking with, for instance, museums practitioners and science journalists we find focused visions of science communication practice oriented around their own domains. Just as science communication scholarship in Anglophone countries is often disengaged from that in the Germanophone world (for instance), museums practitioners and journalists operated as distinct communities, with limited cross-sector engagement. Museums professionals knew

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<sup>4</sup>A picture that also forms part of the rationale for recent efforts to stimulate international community-building in science communication teaching: see, for instance, a 2020 webinar (<https://www.youtube.com/watch?v=UNgQ0OegKH8&feature=youtu.be>) on teaching science communication.

about science communication practice in other museums, while journalists knew about science journalism more broadly, but there was more limited imagination of, and engagement with, a wider field of practice around science communication generally. Again, then, we observe a fragmentation between the diverse professional communities that comprise European science communication.

In sum, European science communication is both disparate and fragmented. It is diverse, holding to different (best) practices and epistemologies, and this diversity is poorly networked, with communities often more or less unaware of each other's existence.

### 3.2 *A landscape in transition*

A second theme that repeatedly emerged across our datasets is that science communication is at a moment of transition — sometimes even described as a moment of crisis. There was a sense of flux and of new norms and practices emerging, albeit with results that remain unclear or uncertain. This is instantiated in four key ways within this data.

First, it is clear from responses to our interviews that many working in or involved in science journalism report that the structure of the profession, its norms and values, and its funding are all undergoing dramatic shifts. As in other areas of the newsroom, there are diminishing resources available to reporters. And, in contrast with reduced capacity available to journalists, there is a burgeoning of science PR and promotion:

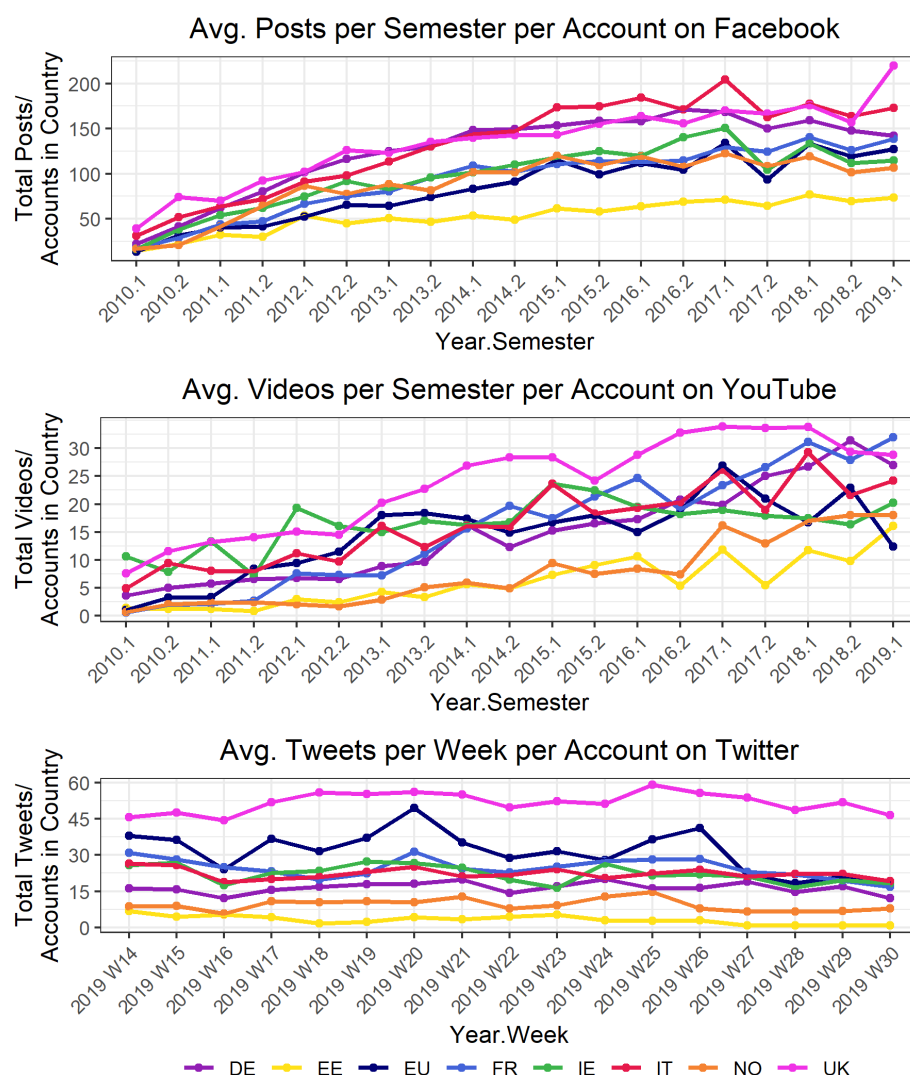
I'm aware of a big build up in the resources of the universities with regards to PR ... which I think is very interesting but I think it means there's a talent there of science writers who've gone into PR rather than become journalists ... For society I think it's a bad thing. For news reporting, you know for press releases to be lifted out of universities and not to be critically analysed, it leads to all sorts of bad practices

As the extract above suggests, there are concerns amongst science journalists that this developing imbalance between science PR and independent reporting is not healthy:

When you're news reporting, it's very tough. Especially if you're working on a desk at a national and you have to churn out a certain amount of stories every day or every week, you can start to rely on the press office press releases, or what the journals are putting out, and just not have time to do very much more than that. And that's a shame.

Cuts in news reporting and growth in PR activities was not the only way that science journalism was described as being in transition. Many journalists expressed concerns about the future of their profession with regard to the rise of digital formats and tools: as one interviewee said, "Each time a new technology comes along it changes the form and also the content of journalism". Here as well there was a sense of rapid change and uncertainty as to what the future would hold for the profession.

Second — and relatedly — we find substantial growth in social media activity concerned with science [Davies et al., 2019]. This growth occurred hand in hand with the growth of social media platforms: as they gained more and more users, more science accounts were created, and more content was published. Figure 1 highlights this growth, on Facebook and YouTube in particular. It also indicates that, interestingly, as science content on social media grows, some countries display a preference for specific platforms when it comes to publishing science content: Italy and Facebook, the U.K. and Twitter, France and Germany and YouTube. Again, it is unclear when and if this growth will stabilise or how trends relating platform use to particular national contexts will develop.



**Figure 1.** Average science content produced by the accounts of each country in a given period (total of posts, tweets or videos divided by the total accounts of that country). Facebook and YouTube are shown on a quarterly basis, while Twitter is shown weekly due to the data mining limitations of the platform.

A third aspect of transition relates to growing awareness of questions of inclusion and diversity within science communication. This is perhaps especially apparent in the context of museums, where there is an increasing focus on the need to engage a wider range of audiences. From the data collected for the QUEST project, the dominant issue that emerged for science communication professionals working in

museums across Europe was that science museums must become more socially inclusive. As the interviewee below notes, this is something that is “new” and “difficult”:

This is still new and difficult for us. I wouldn't say we have found the right approach to reach as many diverse people as we would like to. I'd say that we still have work to do in that direction.

This is not a new concern, and has been highlighted throughout the last decade, perhaps most vividly by Emily Dawson in her ethnographic work with low-income and minority ethnic groups who described science museums as “not designed for us” [Dawson, 2014, p. 981]. The types of concerns that arose amongst museum-based interviewees ranged from whether their audiences were truly diverse to whether organisations were adequately prepared to engage different communities, if there was capacity to build new relationships, and whether museum facilitators had space for reflection and training on social and intercultural competence. To make progress interviewees felt the first step was to address barriers to inclusion and diversion, be they cultural, economic, geographical, educational, or any of a host of social factors spanning gender, age, ethnicity, sexual orientation, and religion. As such, there was a sense that science communication was — albeit slowly — in a process of change. Indeed, since the conclusion of data collection in 2019, the 2020 global pandemic has only exacerbated the need for museums to be more aware of the social justice perspective in their communication of science. This is reflected in the response of the biggest network of science museums and science in centres in Europe, Ecsite, which encouraged its members to react to the new situation by giving more consideration to social responsibility.<sup>5</sup> Now, more than ever, is “the moment to act with humility and courage, to reform our approaches, and become cultural institutions which welcome, support, and value all communities” [Brown, Roche and Hurley, 2020, p. 7].

Fourth, based on accounts of science teaching and education we can see that there is growth in such activities — even to the extent of there being a boom in dedicated Masters programmes around Europe — but that they remain (as Trench [2012] has written) fragile and, often, transient. As one interviewee noted, “Quite a lot of institutions have set up Master's degrees, [but] they tend to come and go a bit”. The landscape of science communication education was framed as one that was growing but that was fundamentally unstable, not least because such initiatives were often tied to the enthusiasms of particular individuals and were therefore dependent on their presence at a particular institution. It therefore remains unclear how this landscape of teaching and education will settle and stabilise, if at all.

In sum, the QUEST data repeatedly reveals references to, or evidence of, European science communication as being within a moment of transition or change. While this might be framed positively (as in the rise of attention to diverse audiences) or negatively (as in pressures on science journalism), one overarching theme is uncertainty as to what the endpoint of these transitions will be, and what European science communication will look like in the future.

<sup>5</sup>See: <https://www.ecsite.eu/activities-and-services/news-and-publications/digital-spokes/issue-63#section=section-indepth&href=/feature/depth/responding-pandemic-social-justice-perspective>.

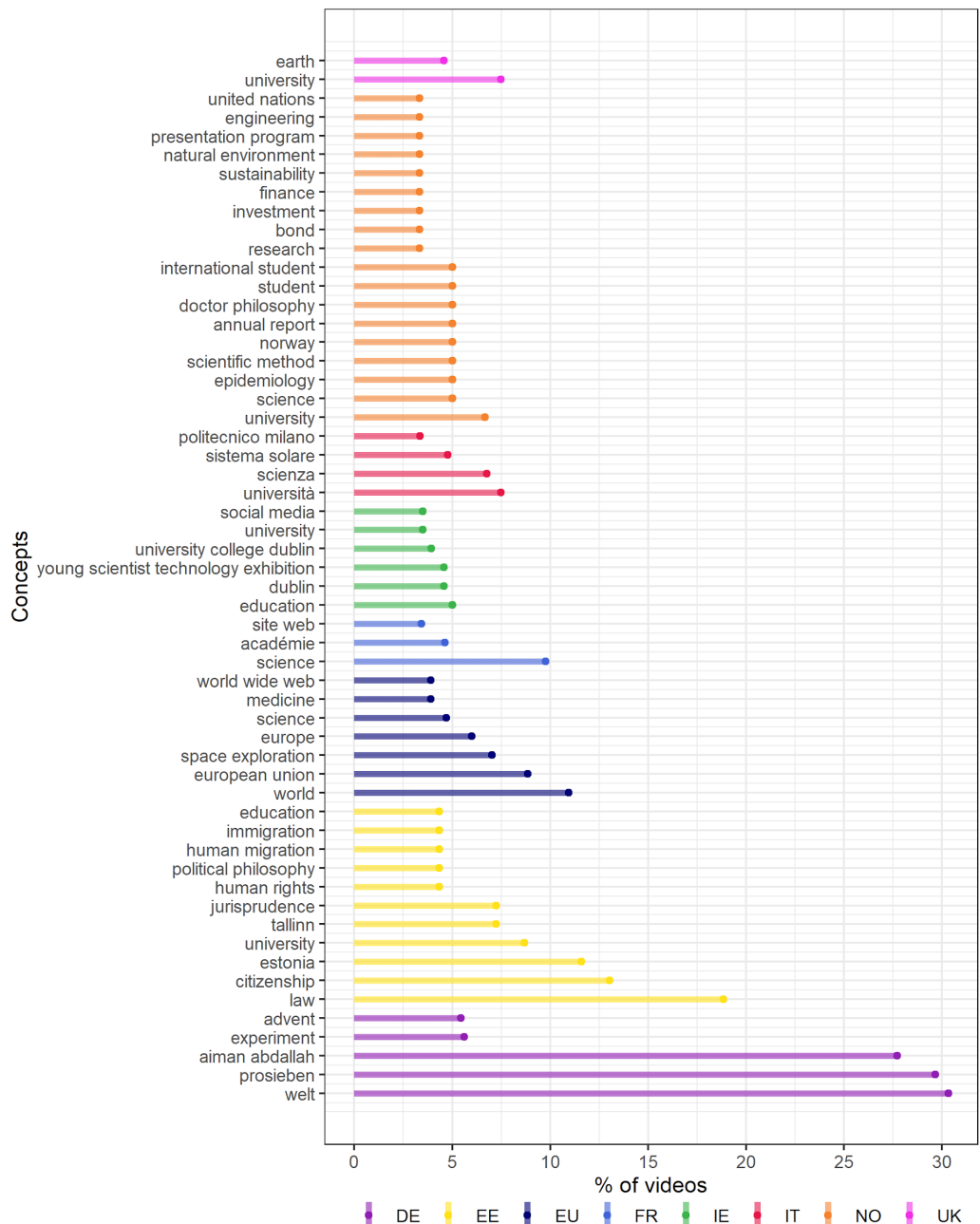
### 3.3 *Diversity and specificity: the importance of format and context*

Thus far in examining the landscape of European science communication we have found that this is fragmented, even at times divided, and that it is undergoing a period of change and transition. The third theme speaks less to the status of the field as a whole and more to the ways in which science communication is carried out and received. It emerged both as an analytical finding in our assessment of science communication practice and as a theme within what interviewees told us about best practice in science communication, and concerns the importance of format and context in the production and reception of science communication. Here, again, the emphasis is on the difficulties of generalisation: science communication is done differently in different places, platforms, or formats. As this is most apparent in the social media analysis, we will focus on this material.

First, analysis of science on social media clearly indicates that a diverse range of factors matter in engaging (specific) audiences: the characteristics of the social media platform selected, the relevance of the topic in the country at the time of publication, even the type of content produced (such as whether it is text only or includes multimedia content). The analysis is even more complex when we factor in the diverse range of science communicators present on social media — science journalists, universities, magazines, scientists/experts, companies, institutions/organizations/associations and science festivals — and observe that they also receive different levels of engagement. We find further differences in how science is presented between different platforms. Twitter allows for a more dynamic coverage of science topics, displaying more variety and a wider range, while YouTube is more limited in the variety of content produced (with Facebook falling somewhere in between). Overall, then, engagement is dependent on many different factors, from the platform selected to the type of actor doing the communication and the nature of the content.

Relatedly, and as mentioned earlier, different countries display preferential use of different social media platforms for science communication. This is further reinforced by the engagement achieved by the content in those given platforms; that is, science content produced by actors in different countries on different platforms will receive varying levels of attention. For example, Facebook pages that are 'European' in their (self) framing are the most likely to go viral, while on YouTube it is German channels, with U.K. accounts being a close second on both platforms. Another example comes from comparing the engagement that results from content produced by different types of science communication accounts, for instance science journalists versus scientists and others with research-based expertise. While both types of accounts receive high levels of engagement on all social media platforms, scientists and experts are particularly successful on Twitter. Indeed, scientists on Twitter reach even higher engagement than science journalists, a phenomenon not seen on Facebook (where the reverse is true) or on YouTube (where scientists are almost entirely absent).

Further, different issues are currently key within different national contexts. From the Natural Language Processing (NLP) analysis done on the content of the data we find that there are clear differences between the main topics that are particularly common in the different countries studied. While diversity in the topics depends a lot on the social media platform used (as noted above, Twitter provides the most



**Figure 2.** Concepts that appear in more than 3.3% of the title and description of the videos of each country published in 2019 on YouTube. On the x-axis we can see the percentage of videos of that country that match the concept. Note that while most countries had more than three hundred concepts, Estonia and Norway, due to the lack of language support of the Watson Natural Language API only had 74 and 77 respectively.

diverse range of topics), and some topics are inextricably linked to real world events, the main concerns of each country — that is, the main concepts extracted from data from each country — present some interesting variations. Figure 2 shows this by representing the most common concepts found in YouTube content for each country.

In sum, what the social media analysis makes clear is something that we were also told repeatedly by interviewees: science communication is not (and should not be)

'one size fits all'. Myriad factors affect its reception, from the producer to the platform to the national context. Different people in different places are interested in different things. Indeed, this finding perhaps goes some way to explaining our earlier observation of fragmentation. If context and format are so vital to how communication is experienced (and how successful it is), it is not surprising that science communication practitioner communities are structured around particular contexts and formats.

### 3.4 *Science communication as (ideally) critical and dialogic*

A final theme is concerned with best practice in science communication. Despite profound differences between science communication in different national contexts, and between the different formats that communication may use, the empirical material does reveal repeated references to approaches that are critical, dialogic, and inquiry-oriented as being of high quality. If there is an overall trend driving contemporary science communication practice, based on these data it is one that mitigates against simplistic notions of communication as information transfer and towards good quality science communication as dialogic, critical, and participatory. Again, we can demonstrate this through three aspects of the data.

First, while those working in science journalism framed its practice as having multiple roles (including, at times, "translating science", cheerleading for it when it is being attacked, or promoting it to wider society), in many cases journalists emphasised the importance of independence and of 'watchdog'-oriented reporting. This required, where necessary, being critical and interrogating science and scientists. The response below reflects the need to balance these diverse roles:

My background is in news, hard news and investigation. And that is what I feel I've tried to bring to science journalism, that 'speak truth to power' element that is also really important because there are problems within science and within academia. Some quite deep rooted problems. And unless they're addressed and brought out into the open, they'll just never get fixed.

Similarly, there was concern about the way that science is reported in the wider media landscape, and particularly where the reporting was done by generalists who might not feel equipped to question what experts tell them:

When I read mainstream media about science I don't think they understand what they write, because as a source the scientist has so much authority ... [Journalists demonstrate] blind faith in their sources, and also blind faith in the press releases that come from the universities and the publishing houses.

This concern relates, of course, to assessments (discussed earlier) of a crisis in critical, independent journalism, debates about the fundamental role of the journalist in society, and the concurrent rise in PR-based approaches. Science journalists, in common with their colleagues in other subjects, are mindful of a need to build relationships and trust with scientists in order to gain access to their work, but they also repeatedly emphasised the need for science communication that remained independent of science, and that interrogated it as much as supported it.

Second, museums practice similarly highlights the importance of valuing visitor knowledge and perspectives, promoting discussion and dialogue, and engaging with audiences in active, curiosity-driven ways. Facilitating an inquiry-based approach to museums and science centres is becoming more common across Europe. QUEST interviewees thus felt that communicating science in a museum setting should take the form of a dialogue, rather than a traditional teaching approach — as in the quote below:

It's much more about encouraging critical discussion around scientific topics and bringing people together from diverse backgrounds to do that. We don't want to teach or educate people about science, we just want to open up conversations.

Museum professionals suggested that this approach, when done right, can empower audiences to follow their own curiosity and to be more active in their experiences at museums. As well as seeking to diversify their audiences and employ more creative approaches to engagement, European science museum interviewees also emphasised the particular value of dialogic approaches for new, more diverse, audiences. As one interviewee noted, an ideal science museum event is one:

where different perspectives are offered and it's a safe space — where everybody feels safe to offer their perspectives and their opinions are valued.

This emphasis on dialogue and the presence of diverse perspectives thus intersects with an earlier theme, that of a change in science communication towards heightened sensitivity to questions of diversity and inclusivity.

Finally, while science communication scholarship is fragmented, one of the rather few widely referenced central concepts was a move from a 'deficit model' of public audiences towards models of engagement and multi-way communication. Researchers and teachers of science communication mentioned literature that has framed best practice in science communication as dialogic and participatory, and talked about their own efforts to teach this in the training activities they were involved in. For one science communication teacher, for instance, it was vital that students stopped seeing themselves as scientists: science communication professionals, she said, "need to stop thinking like a scientist, and be able to critique science as well as critique its relationship with wider society". Or, at more length, another researcher criticised what they saw as (still) being the bulk of science communication practice:

Science communication usually is just the transmitting of science concepts ... and this is a very limited view on science communication. ... [P]oliticians are convinced that they must do some things just to protect the acceptance of science in society. But science communication is not a tool for doing that.

Here, again, we see several of the themes previously discussed converging: not only do these quotes confirm our brief summary of the literature above, which

framed dialogue as well-established as European 'best practice' in science communication, but the latter extract hints at concerns about science communication as PR (particularly in the reference to 'politicians' who just want to ensure 'acceptance of science').

In sum, the QUEST material reinforces the existing emphasis, in research and practice, on science communication as ideally critical, dialogic, and participatory. Journalists and museum professionals both emphasise the importance of these approaches to their work, and scholars continue to reference and teach dialogue as best practice. Importantly (interviewees said), these approaches should be distinguished from science communication that seeks only to 'transmit' scientific concepts, or to persuade audiences of science's benefits without open societal discussion.

## Discussion

The empirical sections above have outlined four broad trends that we find across the QUEST project data: European science communication as fragmented and diverse; as being in a moment of transition and change; as heavily dependent, in its nature and impacts, on format and context; and as, ideally, being oriented to dialogue and critical engagement with science. In this section we want to briefly discuss some of the wider meanings and implications of these findings.

First, and to return to the phrase with which we opened the article, we can use these results to reflect on the question: What is this thing called science communication? More specifically, is it a (singular) thing at all? Our findings have repeatedly revealed deep chasms between diverse aspects of science communication in Europe. We have identified distinct professional communities, national traditions of practice and scholarship, and loosely networked training and education in the field. We have also seen that specificities of format and context are central to how science communication is instantiated: science on social media, for instance, is done differently in the U.K. and Italy, or on Twitter and YouTube. In this respect the research adds new dimensions to existing concerns about gaps between scholarship and practice [Gerber et al., 2020; Miller, 2008; Priest, 2010], given that we have demonstrated not just this form of fragmentation but divisions along linguistic, format, and disciplinary lines. One question these findings raise is thus whether it makes sense to think about 'science communication' as a single, stable field at all. Can we ever capture the very diverse ways in which science communication is carried out when we talk about as a general category, or should we abandon efforts to talk about 'European science communication', and instead think of this field of practice and research as a set of different activities connected by loose threads of terminology and focus? Is 'science communication', in other words, a useful or an obfuscating term?

The findings described here should certainly give us pause for thought. As we noted above, European science communication appears to be a set of largely independent fields and activities, with little cross-community interaction. If there is no shared imagination of 'science communication', and no contact between different groups, then it is questionable how meaningful either policy or research that focuses or seeks to impact on the field as a whole is going to be. As we have observed, one size never fits all, for policy as much as for practice. But our view is that, despite the fragmentation that defines the field, it would be

counter-productive to abandon thinking about ‘science communication’ altogether. Even if communities of practice and of scholarship are unaware of each other, or even see each other as irrelevant, there are key commonalities between them, most particularly in the aims of their activities [see Davies, 2021]. For Bruce Lewenstein, science communication stems from the belief that “the world would be a better place if more people had access to the kind of reliable knowledge about the natural world that people we call ‘scientists’ produce” [2011, p. 18]. Seeking to better network, and to enable mutual learning amongst, the diverse practices and communities that share this belief is thus perhaps the most obvious way forward for policy makers and others concerned with supporting and developing ‘European science communication’.

We should also, however, take care not to lionise networking and mutual learning as an end in and of itself. Diversity, differentiation, and, to some extent, fragmentation are inevitable within a complex, global field of study and practice. Indeed, such diversity within practice also offers important benefits. Science communication that is carried out in ways that are specific to particular national or cultural contexts allows for specialisation and for local needs and interests to be met. Similarly, a field of practice that draws on different forms of disciplinary knowledge, different ideas as to best practice, different techniques or formats, and different educational practices and opportunities is likely to be more flexible and resilient in the face of changing circumstances. In recommending stronger networking across European science communication we are therefore not arguing for homogeneity. Rather, our point is that communities that are currently dispersed — English, German, and Italian-speaking science communication, for instance, or science journalists and science museum professionals — might benefit from a greater awareness of each others’ existence and practices. The result would not, we hope, be homogeneity, but rather a community around European science communication that is aware of, and can more consciously benefit from, its diversity.

Which leads us to a second point for reflection. How distinctively ‘European’ are the results we have found, and how do they relate to science communication across the globe? As a recent book outlining international science communication [Gascoigne, Schiele et al., 2020] makes clear, both histories and current practices in science communication vary greatly. While Gascoigne et al. identify ‘pioneer’ countries — particularly the U.S. and Germany — it is in fact difficult to see global patterns taking shape; rather, different nations and regions have quite different traditions and imaginations of public communication of science (compare, for instance, the imaginations and histories behind ‘scientific temper’ in India and *vulgarisation* in France: chapters 13 and 16 in Gascoigne, Schiele et al. [2020]). We should be wary, then, of generalising too far from the material discussed here, though it is likely that at least some of the dynamics we have charted resonate beyond Europe. Gascoigne et al. write that, around the world:

the overall pace is quickening. Countries that have not in the past invested resources into science communication increasingly see it as a pathway to prosperity, with economic, social and environmental benefits accruing to countries that apply and use science wisely [Gascoigne, Schiele et al., 2020, p. 49]

Our findings echo this sense of acceleration. Concerns about crisis, change, and transition, as well as the explosion in social media content oriented to science, present science communication as a practice that is growing but also changing. More anecdotally, we also suspect that the notion of dialogic communication as best practice goes beyond the European context (though it is a particularly well developed framework here; Mejlgaard et al. [2012]), not least because of its dominance in English language academic literature [Trench, 2008]. What we cannot say, and do not want to speculate on, is the degree to which science communication is fragmented and heterogeneous in other regions beyond Europe — though this would seem to be a key avenue for future research.

## Conclusion

In sum, this article has presented findings from a study of the landscape of European science communication, outlining a number of key commonalities or practices across different aspects of the field (museums, science journalism, social media, and research and teaching). While these findings are far from definitive, and while there continues to be a need for large scale, longitudinal studies of science communication in different contexts [Gerber et al., 2020], they do at least offer food for thought. Dynamics of fragmentation and transition appear to define the field, while science communication (best) practice appears to be highly context and format specific. We leave it to the reader, and to the JCOM community more broadly, to decide whether this lack of uniformity should be viewed as a problem or an opportunity.

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