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A Fragmented and Fluctuating Landscape of Science Communication in the Post-Truth Era

Science communication, understood as the social conversation around science, has been gradually expanding and evolving across the globe. As a result, research in science communication has attracted growing attention as well (Bucchi & Trench, 2021; Leßmöllmann, 2020). These developments are reflected in initiatives and programmes at national and international levels all over the world. For instance, in the late 1990s, the US National Science Foundation (NSF) introduced the Broader Impacts Criterion, emphasising the need for researchers to effectively communicate their findings to a broader audience (Roberts, 2009). The NSF also supports research that explores science communication strategies and evaluates its effectiveness. In Brazil, the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) began to support the popularisation and communication of science and technology from 2004 onwards (Massarani & Moreira, 2020), despite the fact that the organisation faced considerable financial challenges and uncertainties under then President Bolsonaro. In South Africa, the Agency for Science and Technology Advancement (SAASTA) was established in 2002 to coordinate public science engagement (Joubert & Mkansi, 2020). In 2008, the Korea Science Foundation, later renamed the Korea Foundation for the Advancement of Science and Creativity, began to offer support for public outreach and engagement with science (Cho & Kim, 2012). And finally, the European Union's (EU) initiatives have progressed from efforts to raise awareness of the European dimension of science (Third Framework Programme, 1990–1994) towards a more specific and directed focus on communication and public engagement in a number of later programmes such as FP6 (2002–2006) and FP7 (2007–2013) (Claessens, 2012). Most recently, the Science with and for Society programmes, particularly the SwafS-19 programme (2018–2020), addressed science communication specifically with funding dedicated to studying and developing the science-society interface (Roche et al., 2021). Following these developments, public communication about science in higher education institutions has diversified, intensified, and partly professionalised (Fürst et al., 2022).

Despite all of this recent activity, science communication remains a disparate and sometimes neglected field. Recent research in Europe indicates that science communication research continues to be interdisciplinary in its origins, including media studies, pedagogy, sociology,

psychology, and other disciplines (Gerber et al., 2020; Kessler et al., 2019), and consequently applying a variety of research methodologies to its objects of study (Rauchfleisch & Schäfer, 2018). In addition to the disciplinary orientation, research approaches are also determined by cultural environment, national context, language, and many other factors (Davies et al., 2021; Schiele et al., 2012). A positive perspective on the present state of European science communication research is that it is a "developing field with moving and porous boundaries and intellectually stimulating challenges" (Bucchi & Trench, 2021, p. 1). A more critical description is that the field of science communication research is fragmented and still lacks an interdisciplinary integration of the different research traditions that comprise it (Gerber et al., 2020).

This fragmentation also describes the connection between research and practice. Already in 2010, Priest was concerned with the gap between science communication scholarship and its practice. More than ten years later, this situation persists in the form of a double disconnection in which "neither scholarship nor practice adequately take account of the other side's priorities, needs and possible solutions" (Jensen & Gerber, 2020, p. 2). This discussion is tempered by Bucchi and Trench (2021) who contrast "administrative" research (solving real world problems) with "critical" research (generating theory and concepts), and by Leßmöllmann (2020) who asserts that practical problems do not necessarily lend themselves to scientific inquiry, and, likewise, concepts from research do not necessarily translate into practice. One of the consequences of this theory-practice gap is that there is no generally agreed-upon framework for good practice, except perhaps a general convergence toward engagement models (Davies et al., 2021).

The house is on fire

Today, science communication is confronted with a series of challenges, some new and some a long time in the making. Most explicit is perhaps the need to be able to respond to extraordinary scientific events such as the COVID-19 pandemic, which required scientists to bring their positions to the public sphere with no time for peer review, a situation that often led to argument and frustration on the part of the public. For instance, when public health measures changed in response to the evolv-

ing scientific understanding of the virus, these shifts were framed in public discussions as complacency and incompetence, resulting in anger and scepticism (e.g. Capurro et al., 2021; Madvig et al., 2022). This indicates that mainstream deficit and dialogue models may struggle to accommodate science in the making, and that more flexible models are needed to describe and direct the communication of non-routine science (Goulden, 2013; Madvig et al., 2022; Schmid-Petri & Bürger, 2020).

The challenges of the pandemic were exacerbated by the role of social media. Even though in pre-pandemic times many researchers perceived important democratising potentials in social media, these promises have not yet been fulfilled (Jaques et al., 2019; König, 2020). Indeed, the scientific community was less visible on social media than alternative science communicators such as journalists, media, and non-professionals (Weitkamp et al., 2021), indicating that already before the pandemic, scientists struggled to formulate and share strategies for social media use (Fähnrich et al., 2021; König, 2020). In addition, the blurring of boundaries between expert and layman, caused by the dilution of the gatekeeper function (Autzen & Weitkamp, 2020; Petersen et al., 2019; Weitkamp et al., 2021), meant that even before the pandemic, evaluating the validity and credibility of science shared on social media was difficult for non-scientists (Scheufele & Krause, 2019). When COVID-19 struck, these challenges became immediately and urgently apparent. Health authorities faced dilemmas in communicating the fast-changing knowledge about COVID-19 (Madvig et al., 2022). COVID-19 related misinformation was selectively shared on social media (Freiling et al., 2023), and discussions about face masks or vaccinations, for example, became polarised through echo chambers (Modgil et al., 2021). The complexity of the interplay between these actors, drivers, and information streams seemed to preclude simple science communication diagnoses or solutions.

In more general terms, the dominance of social media platforms in the last decade and a half has caused radical audience fragmentation, meaning, among other things, that larger and non-specialised audiences are harder to reach. More importantly, social media platforms have radically changed reading and searching habits which also influences

science-related news and information. Algorithmic architecture directs social practices toward being visible and noticed, which requires constant work and influences the consumption and perception of news, science, and social affairs (Jontes et al., 2023). These transformed habits and practices of (mostly younger) audiences have important implications for science communication.

Social media have also enabled the unprecedented circulation of unverified scientific claims. This challenge has gained even more momentum with the rise and popularity of tools of generative artificial intelligence such as ChatGPT. Although the short-term ramifications of generative AI for science communication are still unclear, practitioners and scholars should assess the technology critically in order to both embrace its opportunities and tackle the challenges it presents (Schäfer, 2023). Generative AI is and will continue to be of crucial importance to the practice of and research on science communication.

Climate change represents another and perhaps even more pressing challenge. Since the close of the nineteenth century, scientists have been concerned about the effect that humans might be having on the atmosphere through the emission of carbon dioxide and other greenhouse gases (Trumbo & Shanahan, 2000). The discursive struggles over the meaning of climate change and the problems it entails have been fraught from the very beginning. The notion of climate change has become invested with antagonisms that circulate in a range of social fields including academia, politics, everyday life, and the media (Filimonov & Carpentier, 2022). Furthermore, because climate change is not easily perceivable as it plays out over vast temporal and spatial scales, scientific descriptions of climate change and its effects are often complex and difficult to understand (Schäfer & Schlichting, 2014). As a result, many people learn about climate change almost exclusively from the media.[1]

Finally, although science scepticism and denialism has always existed, shifting values, growing inequality, and increasing polarisation created

1 For example, Romps and Retzinger (2019) focused on the presence or absence of basic scientific facts about climate change in New York Times news articles about this subject. In their analysis of nearly six hundred news articles in The New York Times that cover climate change, they established that, with one exception, basic climate facts appear in such articles with vanishingly small frequencies.

a societal backdrop. The 2016 presidential election in the US, the Brexit referendum (Lewandowsky et al., 2017) in the UK also in 2016, and the 2018 presidential election in Brazil (Reyes-Galindo, 2021) took place against this backdrop and functioned as tipping points to the current post-truth condition.[2] This situation has increased attacks on science and its legitimate impact on public discourse (McIntyre, 2018). Today, when scientists communicate findings that contradict people's beliefs, they may face a deliberate campaign of fake news, misinformation, and disinformation. Even if the scientists' findings are presented clearly and convincingly, they are unlikely to change the minds of people who feel threatened by them (Iyengar & Massey, 2019). Populist politicians, in particular, often use their social media platforms to target science and journalism, arguing that scientists and journalists are part of an "evil elite", deliberately misleading the public by spreading disinformation. While this type of discourse is highly concerning, we still lack empirical evidence on how these accusations affect the public perceptions of scientists and journalists (Egelhofer, 2023, p. 361).

Reinventing science communication?

In response to the socio-cultural transformations described above, calls have been made for a new kind of science communication that renegotiates the role of scientists in the public communication process, as well as the entire figuration of actors, norms and communicative practices involved in science communication (Brüggemann et al., 2020; L'Astorina et al., 2018). This *post-normal science communication* should ensure that science remains an effective safeguard against political or commercial interests in the public sphere, but at the same time, avoid delegating absolute epistemic power to science (cf. Reyes-Galindo, 2021). Accordingly, it must acknowledge that (scientific) knowledge is never absolute, but always constructed at the intersection of individual, culture, society, and organisation. Post-normal science communication should thus be able to handle diversity, complexity, and incompleteness (cf. Dervin, 1998), which necessarily involves dialogue between construction and critique, and between coordinating pieces of evidence, and also the verification of how these elements fit together, which has

2 See also chapter by Marianne Achiam in this volume for further elaboration of the notion of post-truth.

been described in terms of "sensemaking" (Odden & Russ, 2018). Nevertheless, even though dialogue is one of the central approaches of European policy on science communication (Conceição et al., 2020), and even though three recent EU-funded projects (QUEST, RETHINK, CONCISE) worked specifically on designing and implementing new, more dialogical interfaces between science and society, there is still scant evidence of the spontaneous emergence of dialogical, post-normal science communication (Brüggemann et al., 2020; Nicolaisen, 2022). In summary, there is still a need for further reflection and scholarship on research, practice, and stakeholder perspectives (Kupper et al., 2021; Salmon et al., 2017).

It is beyond the scope of this introduction to offer suggestions for what a reinvented science communication approach might look like. Indeed, it is probably overly simplistic to think that a single approach or system of approaches can address the challenges we have outlined in the preceding sections. Nor do we think that these challenges can be ascribed solely to a general shortcoming of science communication. However, we do join our voices with all those who call for approaching science communication as an integrated field in which research and diverse forms of practice are more strongly interconnected (Davies et al., 2021).

Recently, "evidence-based science communication" has been suggested as one way to better connect research and practice. This approach involves the explicit and careful use of evidence from systematic research, combined with professional skills gained from practice, in planning and carrying out science communication (Jensen & Gerber, 2020). However, determining what constitutes satisfactory evidence in science communication is not an easy task. Because science communication is always embedded in broader societal, cultural, and disciplinary contexts (Davies et al., 2021; Nicolaisen et al., 2021; Schiele et al., 2012), and conditioned by variables such as actors, formats, and aims (Bucchi & Trench, 2021), it is difficult for any single researcher or practitioner – however well-informed – to distil generalisable lessons from particular instances. In the words of Bucchi and Trench: "the evidence agenda belies the increasing variety and cultural diversity of science communication practices on a global scale; standard recipes or gold standards can hardly be universally agreed and applied" (2021, p. 5).

Along these lines, Irwin (2021) observes that in science communication, there is no approach that is superior to others in and of itself. Instead, he suggests that "deciding what is appropriate to any particular situation must be a matter for contextual judgement but also recognition of the limitations and strengths of all approaches" (p. 156). Certainly, this was apparent during the COVID-19 crisis when strategic communication was at times prioritised by health officials in order to ensure compliance (Davies, 2022), thereby limiting democratic conversation in what could be considered a non-progressivist direction (Bucchi & Trench, 2021). Rather than attempting to reinvent science communication, then, we suggest that what might be needed is a means to systematically compare, contrast, and even integrate science communication across contexts, disciplines, purposes, and formats. In the final sections of this introduction, we use an ecology metaphor to frame and introduce the chapters in this volume. These chapters emerged from the papers presented by the participants in the Reinventing Science Communication conference that took place in Ljubljana, Slovenia during October 2022. The chapters thus represent a rich sampling of the diversity of science communication practice and scholarship developed by science communication professionals from different countries.

The ecology of science communication

The metaphor of ecology is a useful way to (attempt to) capture the diversity of the conditions that prompt, direct, or govern science communication. In a biological sense, the term ecology refers to the network of relations among organisms at different scales of organisation (Scolari, 2012). Extending this metaphor to science communication means that we can see science communication initiatives as being shaped by their particular ecological *niche*, that is, the specific set of societal, institutional, pedagogical, disciplinary, and modal conditions to which they are "adapted" (to stay with the ecology metaphor). These nested levels collectively describe the *ecology* in which a given science communication initiative is developed and "lives" (Achiam & Marandino, 2014). According to this metaphor, science communication entails more than just the linear translation of complex subject matter into familiar words and phrases (Priest, 2010). It involves the complex and multifaceted

evolutionary process whereby scientific knowledge, values, methodology, and/or practices (Davies & Horst, 2016) are adapted to a specific communication niche.

Society

Not surprisingly, pressing societal transformations that have marked recent years inspired many of the contributions to the Reinventing Science Communication conference. These contributions offer theoretical and practical responses to a range of cross-national upheavals. For instance, Marianne Achiam discusses how science centres and museums are in a unique position to enable equitable and democratic dialogue, and thus help address wicked problems such as pandemics, pollution, climate changes, and the biodiversity crisis against a backdrop of increased science scepticism.

The COVID-19 pandemic provided the prompt for Nejc Plohl and Bojan Musil, whose chapter studies the ways evidence-based recommendations were communicated to those sceptical of science during the onset of the pandemic. The communicative style of these recommendations was shaped by freedom-threatening language, choice-enhancing language, message framing, use of narratives, and empathy. The authors conclude that, in order for science communication to be effective, it must take into account and be tailored to the level of individuals' trust in science.

Finally, Tamara Dagen and Melita Kovačević's study how social factors affect distrust in science in four European transition countries (Croatia, Bulgaria, Hungary, Romania), and the effects of this distrust on attitudes about COVID-19 and vaccination in general. César Carrillo-Trueba also takes up the theme of societal information flow. He observes how scientific knowledge often becomes decontextualised as it diffuses through society with the implicit or explicit purpose of serving commercial, national, and sometimes even geopolitical interests. In response, he presents the notion of the "science critic" – a figure in society tasked with contextualising and validating scientific knowledge, and thereby helping to counteract post-normal situations.

Pedagogy

A number of contributions to the volume respond to the ecological level of pedagogy, or what might be called enacted principles for dissemination that transcend disciplines (Achiam & Holmegaard, 2023). Citizen science is a recent and innovative approach that promotes better understanding of research methodology across a range of scientific disciplines. In her contribution, Noemi Crescentini explores the potential of citizen science to bring scientists and non-scientists closer together in the research process. She focuses on the Italian context, drawing on interviews with citizen science professionals in order to generate findings that have the potential to enrich and inform citizen science research and practices in other contexts.

Another contribution focuses on European Researchers Night (ERN), one of the most significant and long-lasting initiatives to bring scientists and other members of society closer together. Authors Afonso Pais, Renata Ramalho, and Ana Sanchez reflect on the insights from their own experience in evaluating the ERN initiative in Portugal, particularly focusing on the feedback of participants. They observe how crucial it is to the success of this initiative that not only research results are communicated, but also the research process itself. This enables participants to understand the benefits of science and its impact on societal well-being. If participants are to become a part of the sensemaking process, the authors argue, the scientist must have a clear goal for their public engagement activities. It thus becomes imperative for scientists to be able to critically reflect on the relation between research, the politics of the field, the institutional context, and their own personal assumptions – in other words, the specific ecology in which research and science emerges.

Discipline

Finally, a number of contributions to the conference, and to this volume, are shaped by the ecological level of specific disciplines, and the conditions and constraints that such disciplines impose on science communication initiatives. Simon Goorney, Federica Beduini, Maria Bondani, Laurentiu Nita, Lydia Sanmartí-Vila, Zeki Can Seskir, Jacob Sherson, and Maria Luisa Chiofalo share their research on how to tell a

story about the complex field of quantum technology to make it more understandable and approachable for non-scientists. They develop the culture-scientific storytelling (CSS) theoretical framework and show that learning-by-doing is one of the most effective methods of successfully communicating science to audiences without formal education. The ides of citizens being active participants in the co-construction of knowledge is also a premise of the contribution by Fabiana Battisti and Marco Bruno. The authors analyse comments on social media related to mainstream-video-products on important issues (climate crisis and COVID-19) to make the hypothesis that irony – despite its sometimes controversial nature – can be a tool to deconstruct information clutter and promote awareness about serious topics. Petra Černe Oven takes these realisations a step further in discussing the use of arts-based techniques in science. She focuses on the role and potential of design by which scientists can make use of specific visual material to support arguments and transfer knowledge. Finally, the last chapter is a contribution by Cecilia Lartigue and Aquiles Negrete that takes us to Mexico City where water scarcity is a serious problem. The contribution presents a detective story, in the form of a comic book, that was carefully targeted to specific audiences to disseminate knowledge about water-saving practices. The authors offer compelling arguments about the efficacy of comic books in science communication.

Final remarks

The chapters in this volume provide rich evidence of the increasing variety and cultural diversity of science communication practices across the world (Bucchi & Trench, 2021). Collectively, the science communication initiatives described here exemplify a range of progressive approaches, including dialogue, active engagement, learning-by-doing, and co-construction of knowledge, that in various ways reflect re-inventions or re-imaginings of science communication. In addition, this collection of work points to the inevitable conclusion that dialogue is necessary not just between science and society but also between science communication practitioners and researchers from different ecologies – countries, cultures, institutions and practices. We thus see this volume as a contribution to longitudinal studies of science communication across contexts, disciplines, purposes, and formats. Only in this

way can the ecosystem of science communication continue to grow more diverse and self-reflective.

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