50 essentials *on* science communication

edited by

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PREFACE

by JENS KREISEL & MARC SCHILTZ

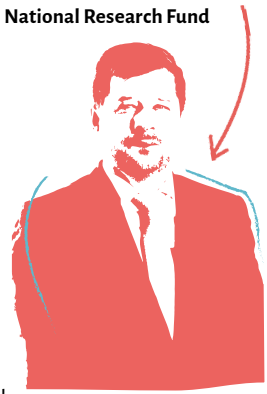
Science and research are fundamental to our modern knowledge-based societies. The ivory towers have had their day. Science wants to be explained and wants to explain itself, also and especially to the society outside the so-called scientific community. After all, science, its findings and the innovations derived from them shape all our lives. For the scientific community, hence the University of Luxembourg, the active involvement of the public is not an option, but a responsibility.

We conscientiously foster diverse formats and channels of science communication, spanning from school laboratories and training programs to captivating mediums like comics or video productions. Our mission is to share knowledge and collaborate with society in a dialogue that seeks to cultivate a better world. Through effective science communication, we strive to attain this vision. I am delighted by the release of this book, which embodies our aspirations, and which is now available to all incoming doctoral candidates, PhD students and researchers at the University of Luxembourg. To kindle dialogue and encourage active participation with and about science.

With best regards,
Jens Kreisel

Jens Kreisel
Rector of the University of Luxembourg

Marc Schiltz
CEO of the Luxembourg National Research Fund



Over the last 20-30 years, Luxembourg has built up an attractive and fertile research landscape, which has achieved high international recognition in specific fields. Our mission as the Luxembourg National Research Fund is to build – together with our partner institutions – a sustainable, world-class research system here in Luxembourg that not only produces high quality research results, but also generates societal and economic impact. And one of our strategic priorities is to anchor science in society.

We believe that science outreach is an integral part of the research activities and one of the multiple dimensions of research excellence that needs to be strengthened. By promoting open science, research culture, collaborations between science and society and by empowering researchers and science communicators to engage with the public, we contribute to shape a research system that brings value to society at large. And science communication plays an essential role in this effort. With this book, we hope to help scientists, researchers and science communicators around the world to take their first steps in science communication or to professionalise their skills.

With best regards,
Marc Schiltz

EDITORIAL

by JEAN-PAUL BERTEMES, SERGE HAAN & DIRK HANS

What do we know about the world, about ourselves, about reality? And from where do we know it? Of course, this is also closely related to the question of how superstition, conspiracy theories and persistent misbelief can become established. In the end, it's about understanding our existence and our ability to shape it – with all its consequences and by taking responsibility for our actions. Science is probably the most effective tool humanity has ever created to tackle these challenges. Science pursues a straightforward goal and has an almost sporting attitude: May the best theory win! And it will continue to do so until there is an even better one. In this context, *better* means that it – the new theory – describes the world even more accurately.

The knowledge of things, of existence and of our possibilities for shaping things must be made accessible to humanity, especially because only a few people, the scientists, are involved in the processes of scientific theory formation and its falsification. It is imperative to organise the transmission of knowledge and to transfer initially exclusive knowledge into an educational process that enables an informed and connected society to gain knowledge, to understand and to make the "right" decisions. This enlightening goal is arguably the most noble objective of science communication and makes every member of its guild stand before the auditorium with a proud chest and confess: I am a science communicator!

The fact that, today, science communication also pursues less noble, even downright profane goals, should be confessed right away in the introduction to this compact handbook.

Science has always competed for limited resources: Money and personnel. Money that flows into research cannot flow into the expansion of daycare centres. Likewise, a brilliant programmer who gets paid well working for a huge e-commerce company is no longer available to the university science system. The science sector therefore has to figure out its place in the world. As a result, science – and with it science communication – has no choice but to submit to the various mechanisms of marketing and the attention economy.

The conflicting goals of modern science communication – i.e. empowering society while at the same time optimising one's own image in order to maximise acquired resources – form the often uncomfortable balancing act of the working reality within this profession.

This handy booklet aims to empower the reader with 50 compact introductions to relevant topics, which aim to capture the essential mindset and diversity of working practice in contemporary science communication. It is aimed at researchers across all disciplines seeking further qualifications, entry-level employees in science communication departments and anyone who wants to take their first steps in the field. These 50 essentials offer an introduction to the tumultuous world of science communication – from the pens of many proven experts who have formed the team of authors.

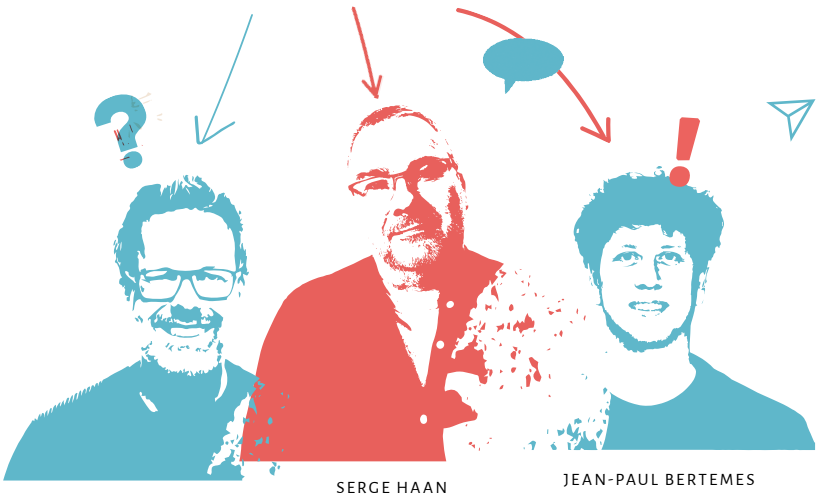
Those who have a good overview of the entire field and have reflected on the wealth of options in current science communication can make wise decisions about its design. Surprisingly often, it is a matter of leaving things undone. Identifying and excluding ineffective activities that only waste time and money. If you can avoid the "rat race" of science PR, you should. The art, if you like, is to find the right balance between benevolent science communication and goal-oriented science PR and not to get bogged down in too many parallel "construction sites" of communication. Careful consideration, prioritisation, and responsible decision-making are essential components of good science communication practice. We are therefore conveying the goals of science communication in

general to the readers and thus to the makers of the congenial and wondrous world of science communication.

We would like to express our sincere thanks to our project colleagues Oliver Glassl, Nicole Paschek and Céline Lecarpentier from the University of Luxembourg for their contributions and unwavering support. We are also grateful to the Luxembourg National Research Fund and the University of Luxembourg for their financial support, which has enabled us to carry out this project. And we would like to thank all the authors who have contributed their valuable insights and perspectives to this book. As editors, our aim was to curate a collection of articles that would inspire and engage the readers while preserving the individuality and authenticity of each author's voice. The diverse views and styles presented in this book reflect the multitude of facets, goals and circumstances within the field of science communication. While all the texts in this book come from the authors, the graphics mostly result from a collaboration between the editors and the graphic designers. So last but not least, we would like to thank HUMAN MADE for their outstanding creative input.

With the goal of inspiring and enlightening the readers, we aim to offer an enjoyable and educational experience. Finally, in the spirit of good edutainment, we also hope that you find great pleasure in the exciting journey of discovery that awaits you.

The **Editors**



DIRK HANS

SERGE HAAN

JEAN-PAUL BERTEMES

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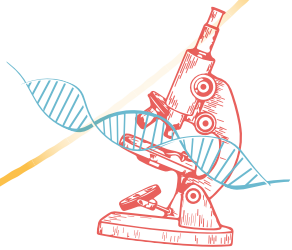
GOOD LUCK!

DEGREE OF ACTIVE PARTICIPATION →

Communication about research with the outside world.

BASICS



Science with and for society

by JEAN-PAUL BERTEMES

Research in an ivory tower? Almost everyone is in constant contact, whether directly or indirectly, with the results of research. Indeed, research can benefit from contact with society. It even has obligations towards society. After all, society places a certain amount of trust in science and provides public money for public research. In return, however, society also has expectations, like a certain return on its investment. Societal investments in research are investments in know-how. And in a knowledge society, it is essential that this know-how is actually made available to society and that it contributes to social, cultural and technological development. Science in an ivory tower belongs to the past. For some time now, the approach has been "science with and for society"!

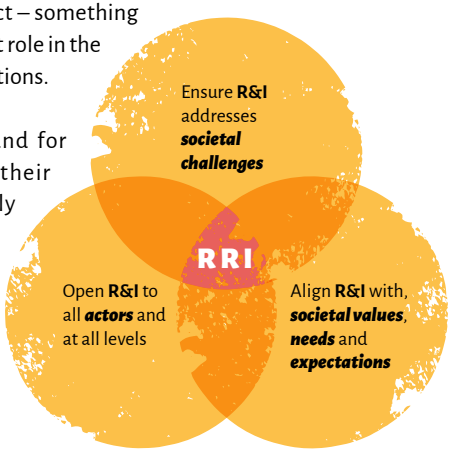
There are many people who are interested in new scientific findings, whether for professional reasons – such as doctors, engineers, farmers or policymakers – or simply out of curiosity, cultural interest or fascination. Science communication, open science, citizen science, science education and science engagement are important concepts for bringing society and science closer together.

However: Not every researcher has to engage with the public! Not every research result has to be communicated. And not every research project has to directly solve a human or societal problem. Researchers must have enough time to do their research, and basic research must not be sacrificed.

But science as a whole (not each researcher) should engage with the public. There is a need for structures that facilitate high-quality science engagement and communication, so that those who are motivated to engage with the public are supported, and so that relevant results and know-how can be shared with society in an appropriate way. Furthermore, science as a whole (not each project) should address societal problems in order to develop a better understanding or offer potential solutions, such as in the areas of environment, education, economy, politics, social issues and health. In all of this, it is important for research to be aware of society's values, needs and expectations and to integrate them into the research process in line with the RRI approach (Responsible Research and Innovation, as defined by the European Commission; see illustration).

Conversely, science can also benefit greatly from a high level of scientific literacy among the population, which has an enlightened, critical and at the same time appreciative relationship with science. One can assume that such a population will be more inclined to (critically) trust science and to grant it freedoms, such as allowing basic research and not only insisting on direct results. Science that is closely linked to society can also enjoy better access to data from the real economy and society, conduct research on society's problems and thereby create societal impact – something that is playing an increasingly important role in the evaluation of science by funding institutions.

In order for this dialogue to work and for researchers to continue pursuing their research, it is important to actively develop interfaces between research and society. And this includes: science communication.



Recommended reads:

- European Commission, Directorate-General for Communication, Directorate-General for Research and Innovation, *Responsible research and innovation (RRI), science and technology: report*, Publications Office, 2013, https://data.europa.eu/doi/10.2777/45726
- Schnurr J.& Mäder A. (2020), *Wissenschaft und Gesellschaft: Ein vertrauensvoller Dialog*. Springer Verlag. https://doi.org/10.1007/978-3-662-59466-7

What is science communication?

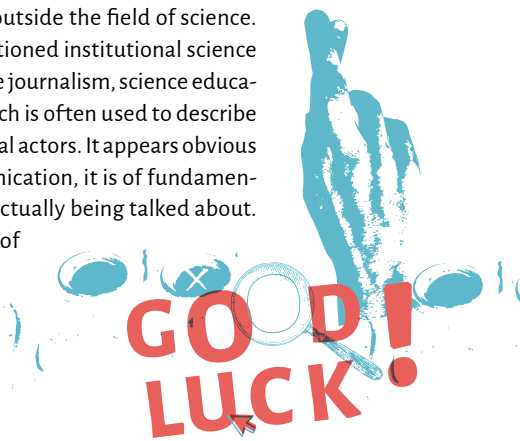
by DIRK HANS

A trivial question, you might think. Science communication is given when science communicates. But it is not quite that simple. Who communicates what, and to whom? Do scientists have to be involved, or is it enough if the content merely originates from science? Definitions remain inconsistent to this day. Bonfadelli et al. (2017), in their acclaimed edited volume *Forschungsfeld Wissenschaftskommunikation*, use the following definition: "*We understand science communication as all forms of communication focused on scientific knowledge or scientific work, both inside and outside institutionalised science, including its production, content, use, and effects*" (translated by author). Admittedly, this is an academically sophisticated definition, and one that can be confidently endorsed.

However, such definitions are often of little use, because they are simply too broad. Let's take a look back in history to gain a better overview of the popular terms and their meanings. Traditionally, the term "science communication" was used primarily to distinguish it from "science journalism" in the sense of "institutional science communication". It therefore encompassed all communication activities of scientific institutions or organisations (e.g. universities) towards a non-scientific public. This includes direct

communication by scientists, as well as mediated communication by the corresponding communications departments. In these cases, it is advisable to refer directly to "institutional science communication" in order to avoid misunderstandings. Currently, more and more experts are adding the term "science PR" (public relations) to the portfolio of terminology in order to make the immanent aspects of interest-driven communication, which is primarily aimed at building reputation, more transparent. This term is very helpful! And, to be straight, science PR is an important, sometimes dominant part of today's institutional science communication. But there are many other actors who can also engage in science communication, such as smaller associations, teachers, or even private individuals who simply want to share their fascination with science. This type of science communication is non-institutional and often close to what we like to call "science education".

And there is more. The dedicated exchange within the scientific community, such as at a scientific conference, is also often attributed to science communication. There are a number of helpful clarifications that we strongly recommend. In the latter example, we can speak of "internal science communication" or "scholarly communication". Of course, the complementary terminology of "external science communication" can be used to make it clear that science is aimed at an audience outside the field of science. And, of course, we have the aforementioned institutional science communication and science PR, science journalism, science education and even knowledge transfer, which is often used to describe communication with industry or societal actors. It appears obvious that when discussing science communication, it is of fundamental importance to first clarify what is actually being talked about. In this book, we use the terminology of science communication (SciCom) in the broad sense, but we always try to add the necessary specificity.



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- Cormick C. (2019), *The Science of Communicating Science*.CSIRO Publishing. ISBN:9781486309818
- Bennett D. J. & Jennings R.C. (2011), *Successful Science Communication*. Cambridge University Press. ISBN:978-0-521-17678-1

The history of science communication

by KAY YEOMAN

Before we can get to a history of science communication, we need to understand how science emerged, who was doing it and how they initially communicated. Science has a global history stretching back for centuries. But what we perceive as modern science in Western civilisation was born out of a cultural movement of the 14th to 17th centuries – the Renaissance. Part of this movement was a rediscovery of communication in the form of Greek and Latin texts. Ideas of natural philosophy were discussed between influential men in the popular coffee houses of 17th-century London.

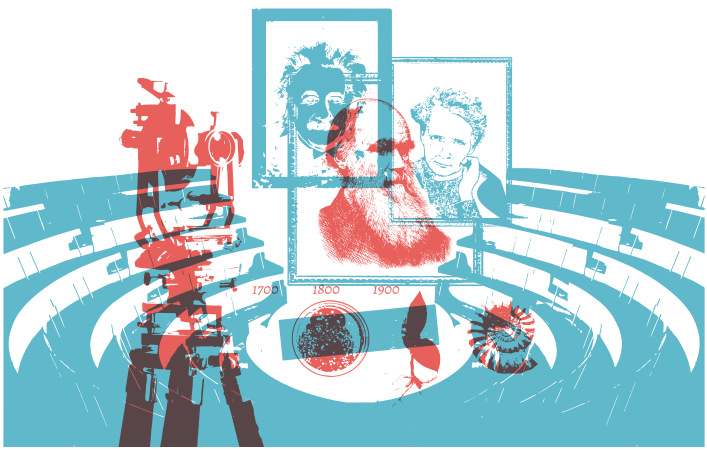
These verbal conversations gave rise to the Royal Society (1660), followed by the French and Berlin Academies of Science (1666 and 1700). Members of the Royal Society communicated their ideas to each other through letters, which formed the world's first scientific journal, the *Philosophical Transactions of the Royal Society*, and introduced the concept of peer review, making the published "scientific paper" not only a channel of communication but also a unit of productivity.

The "Grand Tour" offered wealthy young men the opportunity to bring back curiosities and specimens, forming "cabinets of curiosity", which enabled lively after-dinner conversations about the natural world. Public interest in science began to grow rapidly. In the 19th century, England, France and America were peppered with local science societies, offering an opportunity for more widespread communication and with it, education.

The first society aimed specifically at science communication was the British Association for the Advancement of Science (1831). Science had been professionalised much earlier by other European countries, such as the education and examination system in Prussia, which gave rise to the *Bildungsbürger*tum, the educated middle class. Despite these endeavours over the decades, the public

attitude towards science in the UK lagged behind that in other European countries, leading to a deficit model of science communication, the idea of which was developed in the 1980s to address the public's lack of scientific literacy. In the early 2000s, this model morphed into the public understanding of science, where scientists began to talk more to the public about their work and communicate through a much wider range of channels. This was seen as essential if the public were to accept new technologies such as nuclear power and genetic modification of crops. The fundamental premise was "the more you know, the more positive and accepting you will be". This model was also seen in other European countries: *vulgarisation scientifique* in France or *Wissenschaftspopularisierung* in Germany.

However, as we moved through the issues of the 21st century, it became clear that the acceptance of science and technology was far more nuanced than simply a lack of knowledge – there was also a cultural and ethical influence. Global issues such as climate change and the emergence of new infectious diseases and vaccinations have modernised the models of communication. There is far less emphasis on a deficit of knowledge or understanding and more on dialogue and debate, allowing the public to shape the future direction of science and technology.



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- Babbage C. (2013), *Reflections on the Decline of Science in England, and on Some of its Causes*. Cambridge University Press. ISBN: 9781139381048; https://doi.org/10.1017/CBO9781139381048

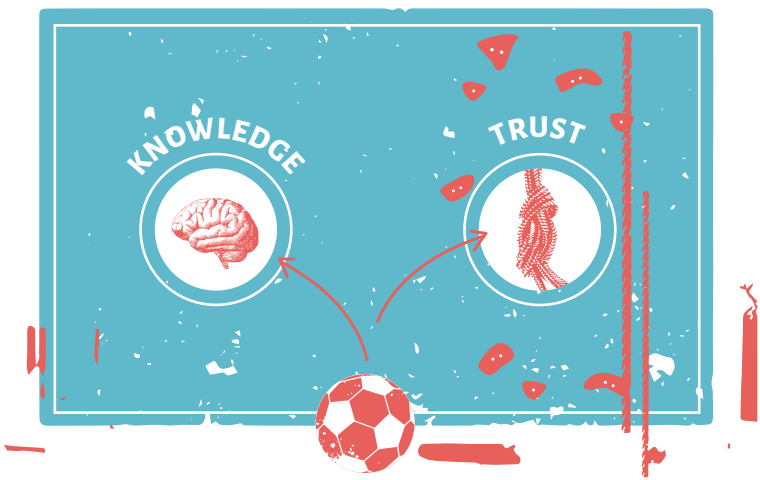
Goals of science communication

Disseminating information and building society's trust in science are the central goals driving science communication, and they are mutually reinforcing: In addition to the ethical obligation to inform the public about their research activities (see Essential 50), individual researchers and entire research institutions will increase their chances of being perceived as credible and trustworthy if they are visible and transparent towards the public. On the other hand, the information communicated will have a greater impact if the audience considers the authors to be trustworthy. Science will be discussed publicly whether or not scientists inform the public about their research. However, without clear and understandable communication from research institutions, universities or companies about their ongoing research, public discourse may rely increasingly on individual beliefs about research rather than on academic reality. It may also be more susceptible to misinformation, ignorance, denial, political instrumentalisation, and many other inappropriate influences. Recent public debates on climate change or vaccination are striking examples of how different actors and interest groups successfully use an increasing variety of media and methods to influence public opinion to support their own agendas, rather than to support informed democratic decision-making. Science communication is therefore a crucial tool for building stable public relations and a trusted brand [1,2].

However, the communicating party should be aware that science communication does not automatically contribute to more trust in science and clearer public opinion: Science cannot provide unambiguous answers, and even if scientific data were incontrovertible, individual or societal opinions will always be influenced by the political, social and cultural context, which is not necessarily scientifically justifiable [3], and they also tend to be issue-specific and dependent on a number of personal factors [4]. In this sense, science communication should not only disseminate information, but

also stimulate public critical thinking to nurture the understanding that uncertainty and ambiguity are constituents of science and research, and that any resulting controversy is a mechanism for finding scientific consensus [5,6]. This understanding supports a society's ability to put scientific results and many other pieces of information into perspective. Ultimately, this may be the most sustainable way to build society's trust in science. One appropriate way to achieve this is to engage in dialogue with the public, as it allows scientists to also consider societal needs when defining the scope of their research and it helps science communicators to understand what information is of interest to the public [3,4].

Science communication also serves the goal of creating a competitive edge in the field of science. However, this is the subject of a controversial debate, as it may interfere with the ethical obligation to communicate in an unbiased, truthful and accurate manner [1].



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- Hendriks F. & Kienhues D. (2020), 2. *Science understanding between scientific literacy and trust: contributions from psychological and educational research.* In *Science Communication*, De Gruyter Mouton, pp. 29-50. https://doi.org/10.1515/9783110255522-002

Inform, interact, involve

CLARIFICATION of further TERMINOLOGIES

There are many terminologies and concepts besides *science communication* when it comes to communicating science or engaging the public with science. But there are no unanimously agreed upon definitions.

So before we go any further, here are a few more descriptions of terms and concepts you will encounter in this book.

Let's start with **"open science":** This is about making research more accessible and transparent to other researchers and to society at large. It is a concept that embraces different means of opening up research. The umbrella of open science includes open access to scientific publications, openly available research data, educational resources, software and hardware. The fact that science communication, public engagement, citizen science and altmetrics (alternative ways of measuring the impact of research) are also part of the open science concept is less well known.

SciCom can be more or less interactive:

- **"Dissemination"** is characterised by one-way communication aimed at a recipient, such as press releases and popular science lectures.
- **"Dialogue"** invites all parties to play a role as both sender and receiver. Both researchers and the public can speak and take an active interest in each other's views, such as in science cafés and other engagement formats.
- **"Co-creation"** gives all parties the opportunity not only to express their views, but also to be involved in, participate in and thereby influence the research process.

5.

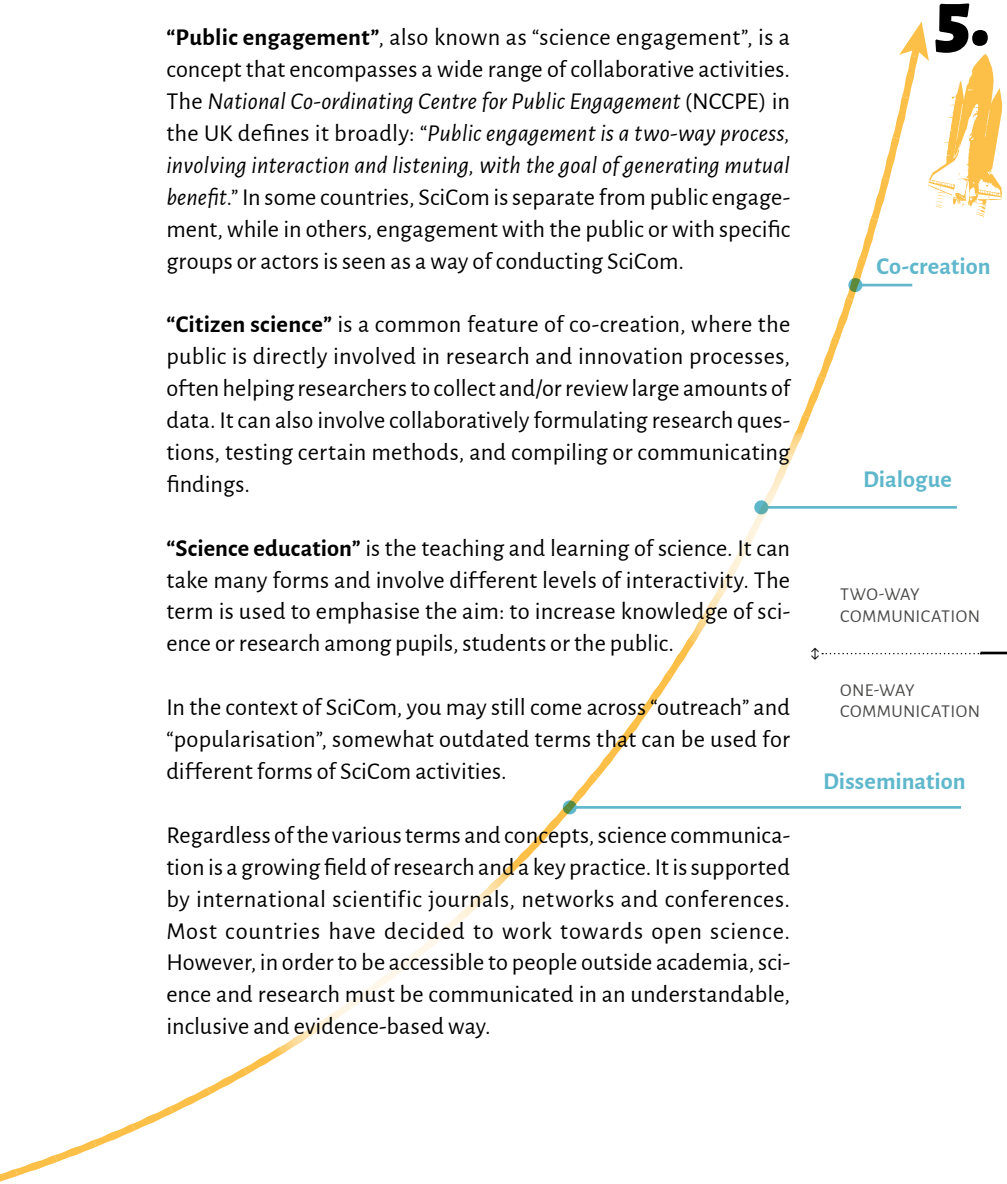
"Public engagement", also known as "science engagement", is a concept that encompasses a wide range of collaborative activities. The *National Co-ordinating Centre for Public Engagement* (NCCPE) in the UK defines it broadly: "*Public engagement is a two-way process, involving interaction and listening, with the goal of generating mutual benefit.*" In some countries, SciCom is separate from public engagement, while in others, engagement with the public or with specific groups or actors is seen as a way of conducting SciCom.

"Citizen science" is a common feature of co-creation, where the public is directly involved in research and innovation processes, often helping researchers to collect and/or review large amounts of data. It can also involve collaboratively formulating research questions, testing certain methods, and compiling or communicating findings.

"Science education" is the teaching and learning of science. It can take many forms and involve different levels of interactivity. The term is used to emphasise the aim: to increase knowledge of science or research among pupils, students or the public.

In the context of SciCom, you may still come across "outreach" and "popularisation", somewhat outdated terms that can be used for different forms of SciCom activities.

Regardless of the various terms and concepts, science communication is a growing field of research and a key practice. It is supported by international scientific journals, networks and conferences. Most countries have decided to work towards open science. However, in order to be accessible to people outside academia, science and research must be communicated in an understandable, inclusive and evidence-based way.



Recommended reads:

- UNESCO recommendation on Open Science -UNESCO Digital Library, https://unesdoc.unesco.org/ark:/48223/pf0000379949.locale=en
- Main open access or partially open access SciCom publications: JCOM (*J. of Science Communication*), *Research for All*, *PUS (Public Understanding of Science)* and *Science Communication*.
- Continuous updates on topical SciCom research, methods, activities, projects, courses and events: The global PCST *(Public Communication of Science and Technology) mailing list*: https://www.pcst.network/discuss/

Science communication and science journalism

Journalism is often referred to as the "fourth estate". Independent journalism is fundamental to democracies because it can provide factual information, reveal grievances and represent a diverse spectrum of opinions. It is not without reason that autocrats shun press freedom like the devil shuns holy water.

Science journalism is part of this "fourth estate". Given the enormous importance of science in our modern knowledge societies, it is currently all the more surprising how inadequately equipped – both financially and in terms of staff – many journalistic media are in the domain of science. Declining revenues in the media industry have played their part. Fortunately, compensatory structures such as Science Media Centres (see Essential 45) have emerged to help out.

However, journalism also feels threatened by the ever-increasing professionalisation of institutional science communication, i.e. the work of the highly qualified communications departments of research institutions, but also by the increasing number of social media channels, often run directly by scientists. News are disseminated without anyone checking the quality of the information, the honesty of the source, or its motivation. Without corrective action, boasting and false promises could become a profitable strategy and even tempt institutional science communication. The important function of journalism – to act as a filter and to separate the relevant from the irrelevant – is no longer fulfilled if science editorial teams of independent media outlets are no longer present or are bypassed.

6.

It is not uncommon to find former, often badly paid science journalists in the communications departments of well equiped research institutions. Indeed, articles in print magazines or video contributions from research institutions are often indistinguishable from articles in major newspapers or coverage on publicly funded television. But there is one very important difference that is increasingly being overlooked by uncritical recipients: independence!

The internal editorial team of a research institution is unlikely to carry out investigative journalistic research on data manipulation and misconduct by its own executives. Instead, they are more likely to present success stories to enhance their institute's reputation.

But should publicly funded science be afraid of independent journalism? Well – both journalism and science ideally pursue the goal of supporting an informed and educated society, so the answer should be "no".

In fact, science must allow itself to be asked the question: What are you doing for good and independent science journalism? Supporting institutions like Science Media Centres through financial contributions is one possibility for larger research organisations. Another would be to make press releases more transparent through a code of conduct, including information on conflicts of interest, third-party funding, animal testing or dual-use issues. And last but not least there is something to do for everyone: Subscribe to a good newspaper or online magazine that offers well-researched science journalism. We must all be willing to pay a bit for good journalism.

Recommended reads:

- Massarani *et al.* (2021), *Global Science Journalism Report: Working conditions and practices, professional ethos and future expectations*. SciDev.Net/CABI: UK. Available at: www.scidev.net/global/wp-content/uploads/Global-Science-Journalism-Report-2021.pdf

Science education

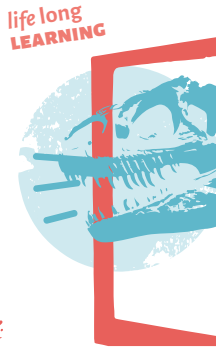
by CHRISTINA SIRY & SARA WILMES

"Science education" refers to the teaching and learning of science, beginning in the early years and continuing throughout life. Science education is a broad field that encompasses the content, processes and practices of science and – by extension – the pedagogy and didactics of teaching science. Science education in a broad sense can take place in formal and informal learning settings, such as forests, museums and playgrounds, and with a range of disciplines spanning physics, chemistry, biology, geology, astronomy and environmental sciences, for example. Learning science involves developing an understanding of the concepts, theories and laws of the natural world, as well as developing important scientific practices such as observing, experimenting, analysing and interpreting, and applying these practices through scientific critical decision-making processes [7, 8].

Science education should strive to nurture a sense of curiosity and wonder, as learners ask questions, design experiments, collect and interpret data, and draw evidence-based conclusions. At the same time, science education can also develop critical thinking skills and promote problem-solving abilities. A central goal of science education both in and out of school is to foster scientific literacy, which refers to the ways in which people can use scientific knowledge and skills to think critically, analyse data and make informed decisions based on evidence.

Science education should build upon learners' curiosity, interests and wonder, and science teaching approaches should ideally encourage active learning and discovery and emphasise the connection between scientific concepts and their applications in

everyday life. Inquiry-based learning approaches can help to achieve this goal, as they build on what students think about when examining questions that are relevant to them, and they engage critical-thinking and problem-solving skills. Science education plays a crucial role in developing an appreciation of the natural world and in preparing individuals for careers in scientific fields – as informed citizens who can engage with and participate in scientific discourse relevant to our rapidly changing planet.



Science is a dynamic and rapidly evolving field. Science education should therefore integrate new discoveries, emerging technologies, and contemporary scientific issues and challenges. To work towards contemporary scientific literacy, science curricula should be reimagined [9]. At the same time, it is critical to provide professional development for teachers in ways that integrate current scientific research into instructional materials and approaches.

Key issues in science education relate to equity, access and inclusion, as ensuring equitable access to quality science education is a significant challenge internationally. Disparities in resources, funding and opportunities to learn disproportionately affect students from marginalised communities, which leads to gaps in achievement across different groups. Females continue to be underrepresented in scientific professions. Addressing gender disparities and creating structures and approaches for fostering inclusivity in science is crucial to promoting diversity and equity in scientific fields. Addressing these disparities and fostering inclusivity requires recognition and collaborative efforts from educators, policymakers, scientists and the community at large. By working towards equitable access to science education contexts and learning resources, fostering inclusivity, promoting inquiry-based learning and keeping pace with scientific advancements, the field and practice of science education can better prepare individuals for the challenges and opportunities of the future.

Recommended reads:

- Adams *et al.* (2018). *The role of science education in a changing world.* Lorentz Center, Netherlands. https://www.lorentzcenter.nl/lc/web/2018/960/extra.php3?wsid=960&venue=Snellius

Authenticity in science communication

by SERGE HAAN

Authenticity can be defined as a true representation of a person, object or situation. In communication, it often refers to the perception of the communicator, the content or a message as being real or true. It is recognised that authentic SciCom increases the transparency of science, supports credibility and fosters trust in science. Establishing perceptions of authenticity is therefore a powerful tool for gaining trust and having an impact on an audience. But where can authenticity come into play?

First, there is the question of the authenticity of the content itself. Are the materials, the situation or location authentic? An audience that sees or touches a real object, rather than a replica or model, can often be fascinated and engaged much more easily. For example, the importance of authenticity in the appreciation of museum objects has been shown in a study of children's responses to authentic fossils compared to replicas [10]. Similarly, audiences often appreciate seeing real cells under a microscope, or even visiting a lab with real researchers, rather than watching a video. Of course, you cannot bring everyone or any size of audience to every location. Think about how you can adapt the use of materials or the location to suit your objective, activity and audience! Also, not everyone will value authenticity to the same degree. Furthermore, it is clear that a science show does not need an authentic location and that it is always a staged event. However, integrating authentic materials, machines or scenarios can be an option. The use of authentic real-life scenarios also makes it possible to build a bridge between school science knowledge and everyday knowledge and is especially important for making a task meaningful for pupils in an educational context [11].

Horseshoe crab found 1958, Mexico

Horseshoe crab found 1958, Mexico (replica)

A second important point is the authenticity of the communicators and protagonists. Here, authenticity describes the impression that these people are not influenced by external factors and present themselves as they really are. The key to reaching the audience is to avoid a teacher-student perspective, to break the emotional and

intellectual distance to the audience and to be recognisable as an individual with own values and interests. It has also been shown that first-person communication increases authenticity compared to third-person accounts [12]. However, the aforementioned aspects may hurt the perception of a neutral scientific report, and the communicator may need to consider this depending on the goal of the communication efforts. Authenticity and eye-level communication are cards that can be played easily during face-to-face communication or events, but also in social media formats or podcasts. However, web video formats and podcasts are often artificial in the sense that they are scripted or staged, and this can affect the perception of authenticity. For example, it is clear that a regurgitated, well-prepared text will be perceived as less authentic than an unscripted response. In these types of media, the conscious omission of staging or over-scripting, as well as careful post-production, can therefore support perceptions of authenticity [13].

One of the many reasons why researchers should contribute to SciCom efforts is that they can easily establish the perception of authenticity if they engage in communication about their own research. Even if parts of the audience do not understand all of the scientific details, they can still be captivated by the communicators' fascination and passion for a topic.

Recommended reads:

- Saffran *et al.* (2020), *Constructing and influencing perceived authenticity in science communication: Experimenting with narrative.* PLoS ONE 15(1): e0226711. https://doi.org/10.1371/journal.pone.0226711
- Åkerblom & Lindahl (2017), *Authenticity and the relevance of discourse and figured worlds in secondary students' discussions of socioscientific issues*, Teaching and teacher education 65: 205-214, https://doi.org/10.1016/j.tate.2017.03.025
- van Gerven *et al.* (2018), *Authenticity matters: Children look beyond appearances in their appreciation of museum objects*, International Journal of Science Education, Part B, 8:325-339. https://doi.org/10.1080/21548455.2018.1497218

The communicating scientist

by SERGE HAAN

Around half of all academics appear to be involved in some outreach activities, but only a small percentage are responsible for the majority of activities [14]. A study involving US academic biologists and physicists also showed that female scientists are significantly more involved in outreach activities than men (72% of women vs. 42% of men) [15].

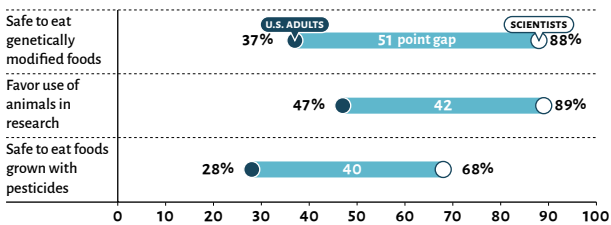
Why do researchers engage in SciCom activities? Reasons may include: presenting their own research; ensuring that the public is better informed about scientific issues; increasing the visibility of the institution; contributing to the recruitment of students; meeting the requirements of funding bodies, etc. It is becoming increasingly important for researchers to be good communicators. To raise money for their research, researchers often have to pitch their projects to investors, industry partners or funding agencies. Furthermore, science communication is increasingly seen as an asset in the processes of funding programmes (e.g. narrative CVs).

However, there are several barriers that tend to prevent efficient science communication [16, 17]:

Lack of time, institutional support and reward by the research system: Research is a time-consuming and highly competitive activity. When teaching and administrative tasks are added to the mix, many researchers are reluctant to take on an additional time-consuming task, even if many perceive it as rewarding. The underlying

Opinion Differences Between Public and Scientists

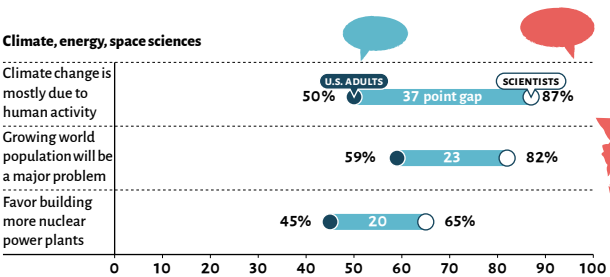
Biomedical sciences *% of U.S. adults and scientists saying each of the following*



(source: "public and scientists' view on science and society". Pew Research Center, Washington, D.C. (2015) https://www.pewresearch.org/science/2015/01/29/public-and-scientists-views-on-science-and-society/)

reasons may be a *marginal role of public engagement in institutional strategies and a lack of recognition*, either by colleagues or in the context of evaluations and career development, which tend to focus on scientific output. Obvious solutions are *clear recognition of outreach investments* by institutions and funding bodies to give SciCom its rightful place in modern research culture. Furthermore, the *development of support structures* for SciCom activities is essential for reducing the high initial time investment in developing outreach activities and for coordinating the efforts. Researchers should also seek cooperation, help and advice from professional science communicators, either within or outside their organisation, where possible.

Lack of skills and training: It is too easy to say that researchers are not good communicators. Communication towards peers, trainees and students is central to research and teaching. However, many researchers have never been formally trained to communicate in different contexts, and this often affects the communication towards lay audiences, where it is important to stimulate interest, adapt to the audience and hold their attention effectively. When communicating to lay audiences, researchers need to be aware that their perceptions may differ dramatically from those of the audience (see illustration). They also need to understand which tools and approaches are most appropriate for a given audience. Particularly at times when institutions seek to increase their visibility and funding bodies require outreach as a project deliverable, it is vital that appropriate training and support are provided.



Recommended reads:

- Mannino *et al.* (2021). *Supporting quality in science communication: insights from the QUEST project.* JCOM 20, A07. https://doi.org/10.22323/2.20030207.
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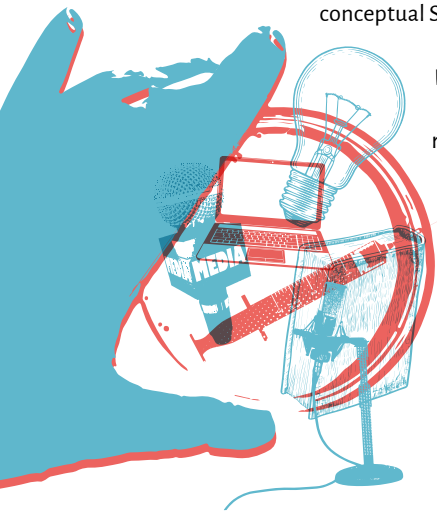
- Rose *et al.* (2020). *Scientists' incentives and attitudes toward public communication.* PNAS, 117: 1274–1276. www.pnas.org/cgi/doi/10.1073/pnas.1916740117

The science of science communication

by RAINER BROMME

The science of science communication (SoSC) has traditionally been seen as a sub-discipline of communication science, studying, for example, the coverage of science content in public media or the selection of science-related topics by newspaper readers. More recently, SoSC topics have been studied by other disciplines, such as psychology, sociology and science education. This development also reflects a broader perspective on the *conditions*, *processes* and *effects* of science communication.

For example, individual and cultural belief systems are studied as *conditions* for citizens' beliefs in the validity of scientific findings. Conversations on social media about science-related topics such as COVID-19 or climate change are examples of processes of science communication. In this case, the research topic is communication *within* the general public about science, rather than the provision of scientific knowledge by science communicators to the general public. Public trust in science is *studied* as both a condition and an *effect* of science communication. A wide range of research methods are used. Examples include content analysis, experimental laboratory and field studies, and representative surveys. Theoretical and conceptual SoSC studies are also carried out.



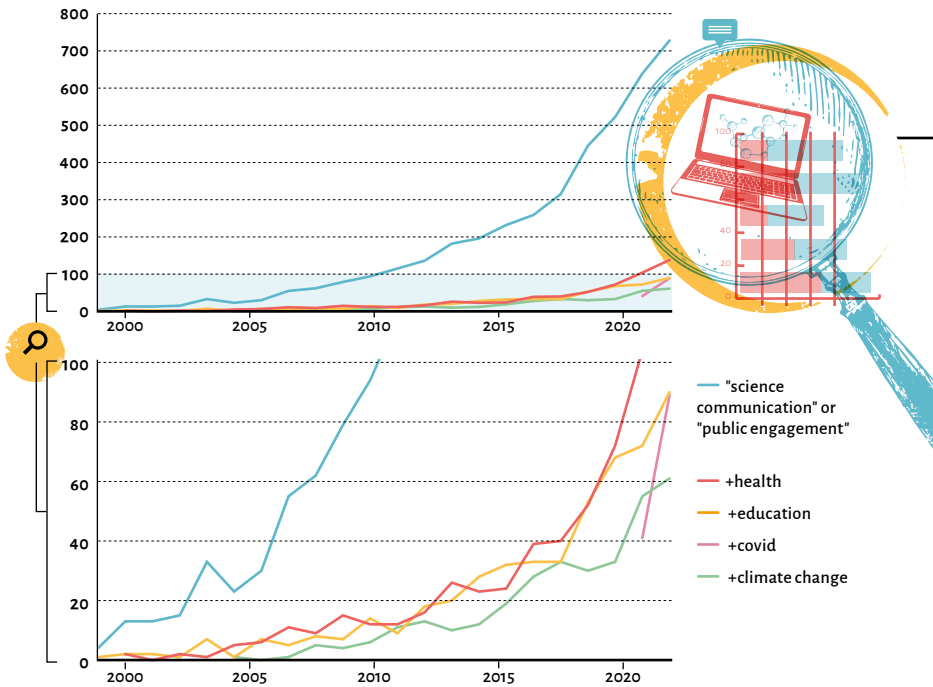
Due to the multidisciplinary nature of SoSC, the corresponding scientific community is defined rather vaguely and not as clearly organised as more established disciplines such as psychology or sociology. Nevertheless, it is growing, as evidenced by the increasing number of scientific publications on SoSC (see illustration).

10.

SoSC has an impact on the quality of science communication. Testing the impact of science communication activities would be an example of practical, applied SoSC. The impact of SoSC on the practice of science communication is not limited to the conscious design and evaluation of communication activities or methods. It is also important to provide food for thought, as well as discourse on science communication and the relationship between science and society. In this respect, even basic (non-applied) SoSC studies are of practical importance. Conceptual/theoretical results, as well as empirical findings on the conditions, processes and effects of science communication, enable *thinking* and *arguing* about science communication to align with the topic in a *science-based way*.

Publication count per year in Web of Science (1999-2022)

Search items mentioned in the abstracts of the publications



Recommended reads:

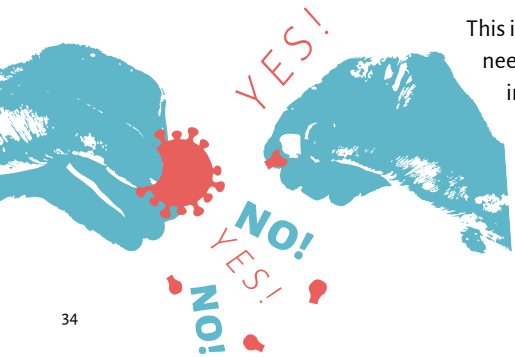
- Jamieson *et al.* (2017), *The Oxford Handbook of the Science of Science Communication*, Oxford University Press. ISBN: 9780190497620 ; https://doi.org/10.1093/oxfordhb/9780190497620.001.0001
- *Public Understanding of Science, Journal*, https://journals.sagepub.com/home/PUS
- *Science Communication, Journal*, https://journals.sagepub.com/home/scx

Trust in science

by DIRK HANS

Trust is needed from those who don't know or can't do everything themselves – in other words, from everyone. We delegate control because we have to. Two examples to begin with: Since we can neither build an aeroplane nor fly one ourselves, we have to trust the manufacturers and the pilots that we will somehow arrive at our holiday destination. If the WHO recommends a vaccination, it is up to us to trust it or not. In any case, we can't do the research that led to a vaccine ourselves, and we don't have the pilot's flight certificates shown to us before take-off. Therefore, the only thing left for the individual to do, as is so often the case, is to evaluate the expertise and honesty of the participants and make a decision. In a world that is as technological and complex as ours, in which our interactions with other people and machines are so varied, every second of our existence is interwoven with trust.

Science, with its sophisticated methods of generating scientific knowledge, is a particularly challenging case. Evolution, quantum mechanics, black matter and epigenetics – come on! With such "crazy" scientific theories, why trust anyone? Since there are probably only a few supporters of the Flat Earth Theory or climate-change deniers among the readers of this book, let's keep it brief: The scientific system, while not perfect, is the most reliable system we have – it is "fundamentally consensual" [18]. A high degree of trust can rightly be placed in the process of peer review and scientific discourse. And international studies confirm that societies around the world generally have a high level of trust in science and scientists [19].



This immediately leads to other aspects that need to be addressed in the context of trust in science: doubt.

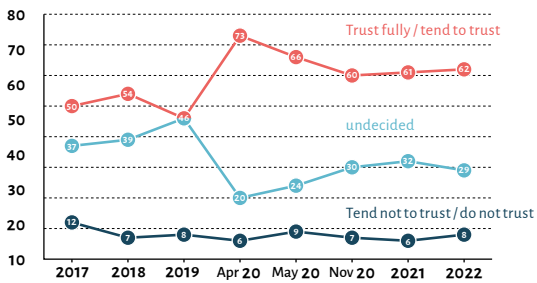
Doubt is important – it is a virtue.

Fortunately, many people become sceptical when dubious sources suggest that injecting disinfectants to fight SARS-CoV-2 might be a good idea. And it is perfectly clear that scientists can err and make mistakes. The COVID-19 pandemic, because of its remarkably public scientific disputes, shows us to this day how much science struggles for truth, and that competing theories and disputes about them are part and parcel of the scientific system. Doubt is already built into science and its theories. This is a strength! The fact that the reluctance with which many scientists present their scientific findings to the public is not a weakness. But this is often difficult to convey to a society that wants to know the "truth" – now, not tomorrow.

Those who want to promote trust in science in a sustainable way need to invest more in explaining the scientific system and the process of gaining scientific knowledge, and put less effort into boasting about the latest research results. Trust in science and a political system based on its findings are fundamental to a stable society that is focused on the common good. Trust in science saved countless lives during the pandemic. So perhaps the most important goal of benevolent SciCom is this: to promote trust in science.

How much do you ***trust SCIENCE*** and ***RESEARCH?***

Results from the German *Wissenschaftsbarometer* 2022



(adapted from [34])

Recommended reads:

- Oreskes N. (2019) *Why trust science?* Princeton University Press. ISBN: 9780691179001
- Hendriks *et al.* (2015), *Measuring Laypeople's Trust in Experts in a Digital Age: The Muenster Epistemic Trustworthiness Inventory (METI).* PLoS ONE 10: e0139309. https://doi.org/10.1371/journal.pone.0139309
- van der Bles *et al.* (2020), *The effects of communicating uncertainty on public trust in facts and numbers.* PNAS 117 :7672–7683. https://doi.org/10.1073/pnas.1913678117


II.
ZZZZ...
Your SCIENCE here
Your SCIENCE here
Your SCIENCE here
Your SCIENCE here
Your SCIENCE here
Who cares?

STRATEGY

Stakeholders of science

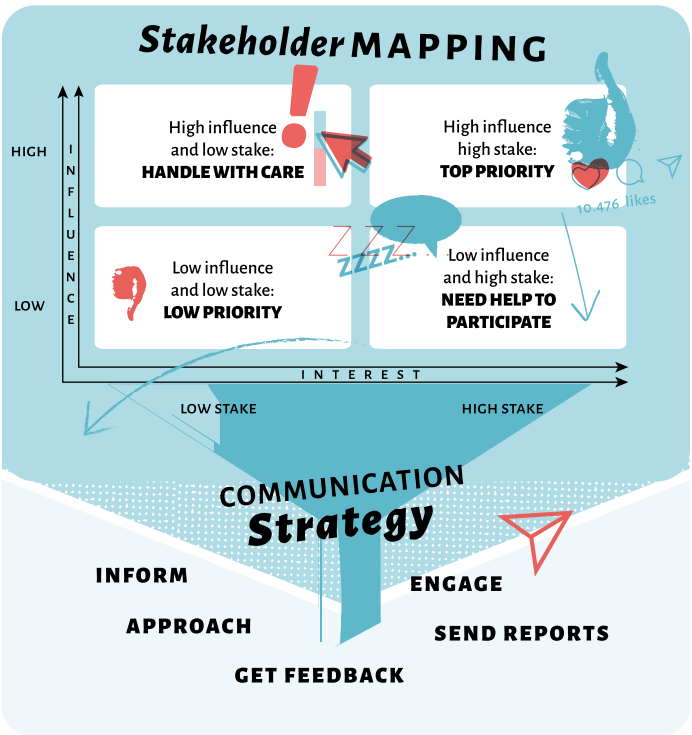
by MARKUS WEISSKOPF

For all those who communicate science, it is essential to know their stakeholders. Be they internal or external, influential or less important. Stakeholders are people or organisations that have a special connection to you, your institute or the institution as a whole. They can significantly promote or inhibit the development of individuals and institutions and are therefore crucial to success. That is why professional stakeholder management is essential, which of course includes good communication. But who are these notorious stakeholders really?

If you look at science as a whole, at scientists and scientific institutions, then society and every single citizen are its stakeholders. Especially in the case of the pandemic or issues such as energy supply, the essential role of science for society becomes clear. On the other hand, citizens somehow decide on the funding and direction of science at the ballot box. Or they get involved in citizen science projects, where they help researchers to collect or analyse data or even find new research questions. Or they protest against animal testing in research, against research on genetically modified organisms, or against vaccinations. Society is a powerful stakeholder, and this also highlights the importance of a good relationship between science and the public. Of course, this relationship shouldn't just be managed and seen in a one-directional way. Science must learn to listen, too. And, of course, the needs and moods of society must be captured with the appropriate analytical tools. Surveys such as the *Eurobarometer* or national science barometers can help with this, as can studies on general societal trends.

For many scientific institutions, an important role is also played by local and regional businesses, NGOs, cultural institutions and, of course, politics. It is important that they develop a detailed stakeholder map and define objectives for

relations with the respective actors. What do I want to achieve with my communication towards politics or business? Which people and institutions are particularly important for my institution? Who shares the same values? And what are the right measures for addressing them? Perhaps you could involve stakeholders in a transformative research or citizen science project. Or get them involved in the next construction project on your campus. But always remember that this is not a one-way street. Respect the needs and the perspectives of different stakeholder groups and do not hesitate to put the tough questions on the table.



Recommended reads:

- European Commission Report (2021), *Special Eurobarometer 516 - European citizens' knowledge and attitudes towards science and technology.* ISBN: 978-92-76-41143-7. https://doi.org/10.2775/071577
- Boaz *et al.* (2018), *How to engage stakeholders in research: design principles to support improvement.* Health Res Policy Sys 16: 60. https://doi.org/10.1186/s12961-018-0337-6
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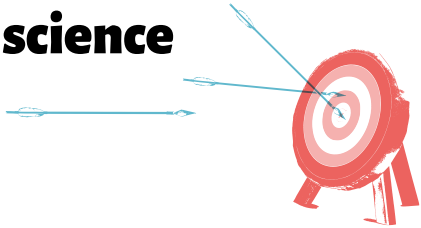
Target groups of science communication

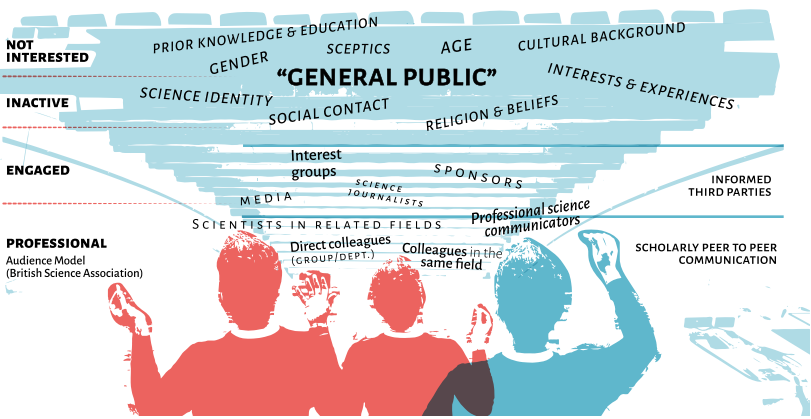


by SERGE HAAN

After defining the goal of your communication, the guiding question should be *WHAT* am I communicating to *WHOM*? These two aspects are strongly interconnected. For the *WHAT*, you need to decide whether you want to speak about a specific aspect/finding or whether you want to communicate about aspects of a particular research field, area, topic or project more generally. Specific findings are often aimed at a well-defined and more informed target audience, such as other researchers, sponsors etc. But even if you want to communicate a very specific finding to such a group, the target group will often influence the content… you might decide to emphasise aspects for one group, but may omit them completely for another. For example, two sponsors for the same project may have different interests/philosophies that you need to consider. In practice, this means you will often have to iteratively adapt the WHAT to the WHOM when planning a communication. Addressing a larger audience, you will often choose to communicate more generally about a topic. The larger the audience, the more heterogeneous it will be. At some point, the group becomes too large to be a suitable target audience. The best example is the "general public". If you state that your activity is aimed at the general public, you must follow up by defining the primary and maybe also the secondary subgroups that you are targeting. Also think about how to retain the audience once you have gained their interest. For example, if you expect families to attend an event, you can attract and retain them by adding an activity for children or young people. Each audience is made up of people with different knowledge, backgrounds and personal experiences, so *one size will not fit all*. A general, *dumbed-down* approach is therefore not the best way to reach even a lay audience: Try to build on your audience's existing knowledge and experiences wherever possible.

13.

Concepts such as the *science capital* or *science identity* of an audience are useful for reflecting on the heterogeneity of a target group, for helping to design targeting strategies for specific subgroups or for responding to an audience during an interactive activity. *Science capital* is a theoretical concept that aims to explain the science-related patterns of aspirations and educational participation of a group of people [20]. It considers the "scientific baggage" that a person or group accumulates over time, including scientific knowledge and education, experiences, beliefs and social environments. High or low *science identity* refers to the degree to which a person identifies with science and the extent to which science influences their thinking and behaviour [21]. In addition to aspects such as gender and age, scientific baggage will influence a person's attraction to and behaviour during a SciCom activity. Some people may be engaged, while others may be inactive or even disinterested [22]. The target audience also defines the place, medium, time and often the effort required for the activity. Find out as much as you can about your audience. Be aware that even defined groups can be very heterogeneous and that you cannot reach everyone at the same time. Think about the blend of *information*, *dialogue* and *involvement* that might be most appropriate for a given audience. If you are a researcher, consult professional science communicators within or outside your institution, if possible.



Recommended reads:

- Schäfer *et al.* (2018). *The different audiences of science communication: A segmentation analysis of the Swiss population's perceptions of science and their information and media use patterns*, Public Understanding of Science, 27(7): 836–856. https://doi.org/10.1177/0963662517752886
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Institutional communication strategy

by DIDIER GOOSSENS

Communicating the work of public research institutions to a wide variety of audiences is a complex task. What can be done to develop a comprehensive communication strategy for these institutions? This is the most important question for any institutional communications officer.

The key to developing such a communication strategy is to match the specific needs of individual researchers with the organisation's overarching communication objectives, which are defined in such a way as to best serve the institution and help it achieve its strategic goals. This requires institutions to interact closely with their researchers in order to understand their communication needs and to provide information about the institution's communication objectives. This is not always trivial, as researchers might have specific ambitions that may not appear to align with the institution's overall communication goals.

Another challenge is that institutions have to interact with a diverse group of stakeholders, such as members of the public, the research community and government officials. Each of these groups has unique needs and expectations for how information is conveyed, and institutions must be able to adapt their communication methods and tactics to accommodate these differences to suit the needs of each audience.

Establishing clear and consistent messages is essential for effective communication. This includes developing key messages that convey the institution's mission, its research and findings, as well as its impact on society. These messages should be aligned with the overall goals of the institution and communicated consistently at all levels, both inside and outside the organisation.

14.

To reach different stakeholders, it is essential to consider the various communication channels that will be used. These include traditional methods such as press releases and media relations, as well as digital platforms such as social media, the institution's website and e-newsletters. Each channel needs to be chosen based on its effectiveness in reaching the target audience and the type of message that needs to be communicated.

Communications officers need to build and protect a brand – and ensure that researchers are on board. It is therefore important to empower scientists and researchers to communicate effectively on behalf of the institution. This may include providing training and resources, such as advice and guidelines on communicating with the media, to ensure that they can contribute to the institution's key messages.

For any scientist working for an institution: If you want to engage in science communication towards people outside your institution, it is always a good idea to contact your institutional communications manager for advice and support, or just to inform them. And always bear in mind that the institutional context makes your personal communication more complex because of the various aspects that need to be considered.

Internal communication

by JULIETTE PERTUY

Not communicating internally is like going on holiday with a group of friends but being the only one who knows the destination. No one will be able to help you along the way, and your pals will have packed their snowshoes instead of their swimsuits. It could get messy! Even if internal communication is the last chapter you want to spend time on, diving into it can actually transform your external communication and its outcomes.

The concept of internal communication is quite simple: It is about getting your colleagues, staff and fellow researchers to understand what's happening in the institution, the projects or the working groups. The specific hurdle of working in science comes mainly from the complexity of the topics. You could say that this is true when communicating to an external, non-specialist audience, but in reality there can be so many different topics, experts and research teams in the same institute that scientific education is often needed internally as well.

Ideally, the content produced for internal communication is tailored to its audience, both from a technical and strategic perspective. So, what are the development goals at the institutional

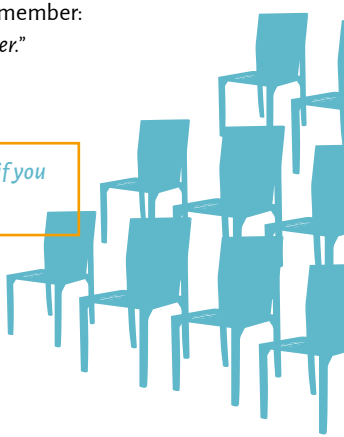
level? Is the main focus on transversal projects and collaboration between research teams? Do we want to foster collaborations with commercial companies? The stories that will be put in the spotlight internally will contribute to the creation of a corporate culture and foster motivation.

Informing everyone at the right time is the second key step of internal communication. This can be done through dedicated communication channels such as newsletters, the intranet, or information screens in the canteen. The main thing to remember here is timeliness. You would probably not be happy to find out that your child is getting married by reading the engagement announcements in the local newspaper. The same goes for your colleagues: So save them front-row seats for the show!

Finally, internal communication must ensure that everyone in the institution understands the *WHY* behind the activities. In other words, internal communication has to connect the dots between strategic decisions and operational projects. Understanding how and why each individual contributes to the success of the institute, project or working group paves the way for the creation of a community. Who better than proud and genuinely convinced colleagues to advocate the institution or project to external audiences?

Therefore, internal communication can, as a side effect, exponentially improve your external communication – and this applies not only to institutions, but to any initiative aimed at creating a community with a common purpose and shared values. So remember: "*If you want to go fast, go alone. If you want to go far, go together.*"

"If you want to go fast, go alone, if you want to go far, go together"



Communications departments

by ARNAUD D'AGOSTINI

In institutions such as universities and research centres, science communication in all its facets is a continuous process. To communicate effectively in a field as complex as science, research institutions typically organise themselves by establishing a dedicated communications department. The role of such a department can vary greatly depending on the research institutions' needs, resources, staff and even the commitment of C-level management to openness and transparency in research. In some cases, the communications department can take on a major role and become a key pillar of the overall corporate strategy.

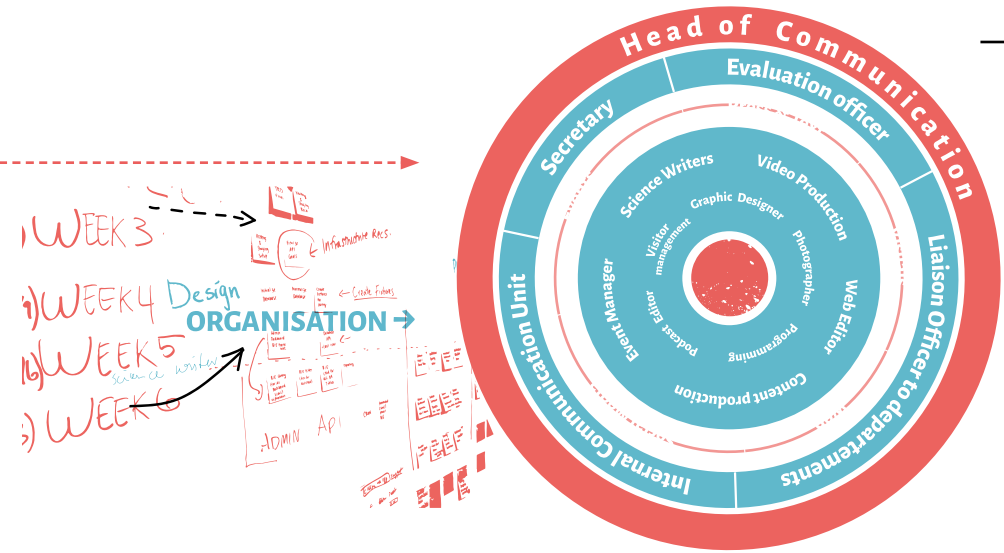
A successful communications department, and this is the focus of this chapter, requires a well-structured organisation with a well-defined departmental strategy that is ideally aligned with the corporate vision. Assessing the needs of the institution in relation to those of the communications department and setting common goals to position the department close to the core activities of the institution is crucial to supporting the full implementation of the corporate strategy and building its long-term reputation.

In addition to an experienced senior communications professional (e.g. communications director) who can advise the senior management, influence decisions and contribute to the overall strategy of the institution, it is necessary to have a team that covers a variety of skills and areas of expertise: science communicators with a scientific background, digital marketing specialists, public relations professionals, web editors, social media community managers, creative profiles such as graphic designers, event managers, etc.

A professional, competent and well-structured communications team should act as the main point of contact for all communication support requests. It can also act as a proactive advisor to researchers, helping them to choose the most appropriate

communication channels and tools to maximise the impact and visibility of their work and to create lasting and meaningful collaborations with external partners.

Positioning the communications department as a trusted and valuable contributor to senior management, scientists and their research projects is essential for adding value to their research activities and output (i.e. scientific publications). In large institutions, this requires the definition of a service catalogue that clearly outlines what the communications department can do for internal clients, the application of a project management approach, and the development and implementation of efficient processes and procedures. In some institutions, these services may even be outsourced to external service providers such as communications agencies and consultants.



Recommended reads:

- Rödder S. (2020), *Organisation matters: towards an organisational sociology of science communication*, Journal of Communication Management 24:169-188. https://doi.org/10.1108/JCOM-06-2019-0093
- Ojeda-Romano *et al.* (2022), *Organisational forms of science communication: the UK and Spanish European higher education systems as paradigms*. High Educ 84: 801–825. https://doi.org/10.1007/s10734-021-00801-9

Science as a brand

by DIRK HANS

Science locations, research institutions and even individuals (i.e. researchers) can be viewed and analysed as brands from a marketing perspective. Silicon Valley, Harvard University or Stephen Hawking are brands with reach and appeal. For many people, it is a goal to come into contact with these places and people and to connect with these brands. Simply making the casual remark at a conference reception about being a Harvard graduate can greatly enhance someone's reputation, even if nothing else is known about them. After all, anyone who has made it into Stephen Hawking's research group can't be that bad!

17.

When building a brand, the procedure of "branding" is important. That is why logos, acronyms and slogans are designed to be memorable and therefore recognisable. A brand only works if it "brands" itself into the memory. So be careful and don't cobble together a flimsy logo in your do-it-yourself workshop. Instead, take a professional approach from the outset. Brands are a promise of quality. They provide a cognitive shortcut that makes life easier: If it says MIT on it, it must be high-quality. But developing an established brand and being perceived as an attractive brand by key stakeholders requires a good image, and this requires long-term work. Modern science communication often includes essential aspects of branding, as the brand carries the reputation of an institution, research group or individual researcher out into the world.

The core aspect of building a good science brand, which is often underestimated by management, is the time factor. Continuous high quality must first get around. Because publicly funded research tends not to have large advertising budgets compared to those of soft drinks companies or sportswear manufacturers, the business of brand development in the field of science tends to be arduous. Yet the trust aspect is of paramount importance. Few things are as fragile as trust. It can take years to build, and it can be destroyed in an instant. If you try to build your brand on half-truths, you might just get away with it in the energy drinks business. In science, the consequences can be catastrophic and the damage to your reputation might be permanent. The scientific system is extremely unforgiving in this respect – which may well be recognised as a sign of quality.

But establishing a brand with a built-in promise of quality and reputation is precisely what can put a region, an institution or an individual researcher on the road to success: namely, a self-reinforcing mechanism. Good brands recruit better staff and attract more funding. And better staff attract even better staff and even more funding.

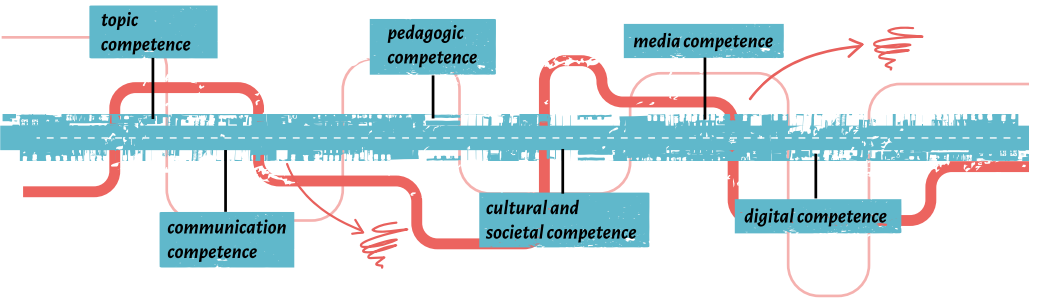
Recommended reads:

- Keller *et al.* (2012), *Strategic Brand Management. A European Perspective.* ISBN: 978-0273737872
- Merten W. & Knoll Th. (2019), *Handbuch Wissenschaftsmarketing.* Springer Gabler. https://doi.org/10.1007/978-3-658-25353-0

III.

GET STARTED

Learning science communication



by SERGE HAAN

The proliferation of communication platforms, each with its own specificities and pitfalls, is just one factor that illustrates the need for formal training and continuing professional development in SciCom. A relatively small number of science communicators (28% [23]) enter the field of SciCom with a degree in journalism or communication. A much larger number develop their skills through informal training, by observing others, or simply through learning by doing. However, the number of formal training courses is clearly increasing. These range from short introductory courses to entire masters programmes [24]. But what should be taught in this training, and who needs it?

Nobody will deny that SciCom professionals need to be familiar with SciCom concepts and their translation into practice, and that they must understand today's society and its dynamics. Ideally, the same will also be true for researchers engaging in SciCom. Although a quick practical introduction without much theoretical background may help researchers to survive some initial activities, a more wholesome approach is needed for lasting success and impact. An optimal approach provides a foundation of conceptual knowledge as well as hands-on training approaches. However, long courses tend to strongly discourage busy researchers from participating. It makes sense to propose a catalogue of smaller training courses instead of long ones. This helps researchers to manage their time and increase their SciCom competence gradually. In addition, those considering an alternative career in SciCom can take the first steps during their scientific career and get a feel for

the environment and the different jobs in the field. Courses range from basic to advanced, and they include media training, social media training, presentation training, individual coaching for outreach activities. Courses on inclusivity and cultural awareness are also very useful. Often more difficult for institutions to set up, but very important for those thinking about a career in SciCom, are internships in communications departments, museums or SciCom organisations, as they allow interested researchers to take the pulse of the SciCom system. Major barriers for early-stage researchers are the time investment and/or resistance from their supervisors, who often fear a reduction in scientific output. Supervisors may need to be convinced that SciCom training provides transferable skills that can increase the quality of research as well as its dissemination and impact. In doctoral education, the integration of SciCom courses in the catalogue of transferable skills trainings and the awarding of ECTS credits may help to valorise these courses. Starting even earlier, at bachelor's level, with a more general course in communication and extending it to science communication at master's level, could further prepare the new generation of scientists for their interaction with society.

AREAS OF TRAINING IN COMMUNICATION AND PUBLIC ENGAGEMENT
that respondents would be interested to undertake. Respondents could tick multiple answers.

(Source: Fähnrich *et al.* [23])

Recommended reads:

- Fähnrich *et al.* (2021), *RETHINKING Science Communication Education and Training: Towards a Competence Model for Science Communication.* Front. Commun. 6:795198; https://doi.org/10.3389/fcomm.2021.795198
- Longnecker N. (2022). *Twenty years of teaching science communication — a personal reflection.* JCOM. 21:C06110. https://doi.org/10.22323/2.21070306
- Baram-Tsabari *et al.* (2017) *Science communication training: what are we trying to teach?*, International Journal of Science Education, Part B, 7:285-300. https://doi.org/10.1080/21548455.2017.1303756

Media training

by DIRK HANS

Media training for scientists is being offered increasingly by universities, research centres, research clusters and funding organisations. The aim is to prepare scientists for contact with journalists so that they can communicate scientific content as competently and comprehensibly as possible. On the other hand, of course, it is also about presenting one's own research and institution in a favourable light.

Media training usually consists of a theoretical part in which the media's way of working and thinking is explained, and a practical part in which a professional appearance in front of a microphone and camera can be rehearsed. The training is supposed to be fun, even if the on-camera exercises can be a little bit intimidating. After all, you might embarrass yourself in front of your colleagues because the training usually takes place in small groups. As a result, there is often a slightly tense cheerfulness among the participants. The trainers are then responsible not only for imparting profound knowledge, but also for making the experiment enjoyable. Nobody is perfect, after all, and the training is there precisely to try things out and learn.

19.

The trainers are often science journalists. They tend to have the perfect double qualification: They know science and journalism very well. Training that takes place in larger groups typically lacks individual practice time. If it lasts longer than a day it may be useful for aspiring media professionals in science, but it is generally considered too time-consuming for many researchers. As there are a lot of trainers offering their services on the market, a careful comparison is recommended. The question of experience and previous clients should always be asked, as a bad training session will spoil the day for several scientists at once. In addition, when composing groups, which is usually done at the institutions, make sure that only people from one hierarchical level are put together. No senior professor likes to appear in front of first-year students as someone who needs tutoring.

And one thing is particularly important, and perhaps should have been mentioned at the beginning of the article: Media training teaches very basic communication skills that are not just helpful for dealing with the media. Anyone who can succinctly articulate why their research is important and exciting will also cut a fine figure at the next standing reception with the executive board and industry partners. So if you are a scientist interested in improving your communication skills, check out the opportunities at your research institution to take part in a media training course.

Recommended reads:

- Hayes R. & Grossman D. (2006). *A scientist's guide to talking with the media*. Rutgers University Press. ISBN: 9780813538587
- Von Campenhausen J. (2014). *Wissenschaft vermitteln*. Springer. https://doi.org/10.1007/978-3-531-19361-8

Public engagement

by DAVID SCHLEY

Planning and developing science communication for research should be part of your project from the outset, not just something that is thought about at the end. Being clear from the start about who you want to share outputs with, and why, will help you shape a better project and define how best to engage them. *If people are engaged with the question, they will be engaged with the answer,* so involve the groups you plan to communicate with, and involve them early.

> *But how do you do this? Which people should be involved and how do you determine that and find them?*

Here is a five-step process to help you plan a public engagement activity and involve the public you want to communicate with in co-creating communications of research or scientific insights. A co-creation process ensures that the activity is tailored to the needs and interests of the audience and has the right format to make an impact; presenting potential users with finished material for approval is not co-creation. The five-step guide consists of key questions that you should ask yourself before starting your project. These guiding questions will help you dig deeper. Your main target audience isn't just the general public. Who is particularly interested in your topic? The more of this five-step process you are able to do, the more successful your public engagement activity is likely to be.

20.

LOADING...

1.Scoping
Look at what people are saying and the underlying assumptions.

How is your research topic being talked about in the public domain? How well is information being used? What are the misconceptions? What context is missing? What are the key underlying assumptions?

2.Involving people
Work out the significance for different groups and how to involve them.

Which individuals and groups are most interested, concerned or involved in the issue? Who isn't but should be? Who is driving the public conversation? Who should be part of the project team? Who should you invite to user testing? Who can help you share your findings?

3.Planning
Propose content and formats that are relevant for the people accessing them.

What is the best format to communicate your research: website, graphics, video, events, publications? What is the key content and context you need to include? What language and style should you use?

4.User testing
Develop your material together.

How can you run user testing? Who should be involved? Which parts of your output should you user test? What questions can you ask?

Use the feedback from user testing to re-plan your science communication activity.

5.Dissemination
Continue to engage people and use feedback.

Who should know about your research findings? Who will talk about and publicise them? How can you share them with the media, with professionals, with the public?

The process should expand the scope for others to shape communication and increase the range of opportunities and conversations where this can happen.

Recommended reads:

- Sense about Science (2017), *Public engagement: a practical guide*, https://senseaboutscience.org/activities/public-engagement-guide/
- National Institute for Health Research (NIHR) Centre for Engagement and Dissemination (2012), *Briefing notes for researchers: How to involve members of the public in research.* https://www.invo.org.uk/resource-centre/
- The National Co-ordinating Centre for Public Engagement (NCCPE), *Engagement activity planning guides for universities.* https://www.publicengagement.ac.uk/do-engagement/planning

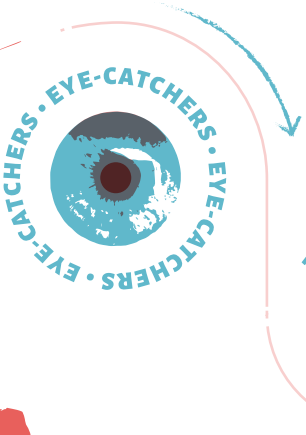
Inredients of a good story

by DIRK HANS

A "good" story – what is that meant to be? Probably something exciting, something entertaining, something you want to read or listen to. Maybe it has even been made into a film. But where does science come into play? Research rarely provides a James Bond plot. But science is full of great stories. A whole field of journalism thrives on it – science journalism. And there are piles of books about science, its achievements and its heroes. Easy to read, excitingly told.

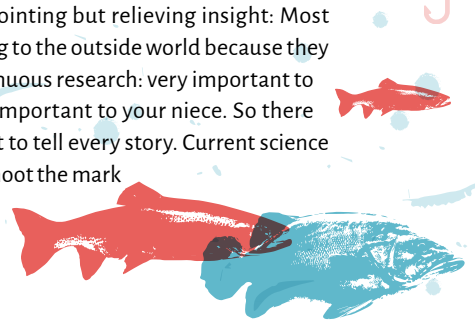
But what makes a good science story? The first thing to think about is who you want to inspire with the story. Who is the target audience? Let's focus on the big standard target group: the so-called "interested public". How do I tell a story so that people outside the scientific community are excited and want to know more? The key is to make the fish take the bait – not the angler! So what aspect of your research would be of most interest to your father or niece who is not a scientist? This is something you should definitely ask yourself before you start telling your story.

And it is also advisable – and this is practical knowledge – to include at least four factors in the story: topicality, proximity, emotion and eye-catchers. If the story contains these ingredients, the chances of getting undivided attention are pretty good. Let's look at the factors one by one, starting with "topicality". In our news-driven world, if something has just been discovered or a research expedition has just been successfully launched, this is potentially more interesting



than yesterday's cold cup of coffee. But relevance is even more important. The content has to be relevant to me – it needs to concern my health, my children or where I live. If this is the case and proximity is given, I really pay attention. Besides, we humans are emotional beings. If there is suffering, a rescue or a long hoped-for breakthrough in a story, empathy arises. If the story can then be enriched further with great eye-catchers like pictures, insightful infographics or captivating video sequences, success is almost guaranteed. Knowing these things will be very helpful to you in front of an audience at an open day, but it's even more important when writing good press releases. Include these four "magic" ingredients in your communications with the media and your chances of getting coverage will increase dramatically.

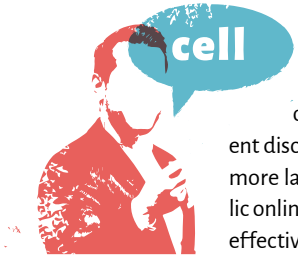
And one final, perhaps disappointing but relieving insight: Most science stories are uninteresting to the outside world because they deal with the minutiae of continuous research: very important to the scientific community – unimportant to your niece. So there is also a great responsibility not to tell every story. Current science communication tends to overshoot the mark here and often tries to make mountains out of molehills.



Recommended reads:

- Martinez-Conde S. (2017), *Finding the plot in science storytelling in hopes of enhancing science communication*, PNAS, 114:8127. https://doi.org/10.1073/pnas.1711790114
- Jones M.D. & Crow D.A. (2017), *How can we use the 'science of stories' to produce persuasive scientific stories?* Palgrave Communications 3, 53. https://doi.org/10.1057/s41599-017-0047-7

Language and simplification



by MICHÈLE WEBER

Language is a flexible tool with a wide range of functions, the most important of which is the transmission of information. A survey among 205 scientists from different disciplines around the world showed that almost half use two or more languages when communicating science to the general public online [25]. This trend helps to disseminate scientific findings more effectively – and more widely.

Besides using different languages (e.g. Spanish, English), the language of science is filled with technical terms that can vary so much from one discipline to another that even researchers working on interdisciplinary projects sometimes find it difficult to understand each other. Imagine how hard it must be for people outside the scientific community to follow a talk at a conference. If scientists want to communicate successfully with lay audiences they must use clear and concise language and adapt it to the target groups. They must simplify their communication, but not to the point that it is no longer scientifically correct. This is a real intellectual challenge and a skill that requires thought and time to develop.

Consider the following four key points. *(i) Avoid scientific jargon.* Or at the very least explain jargon in simpler terms when first using it. Research suggests that a text becomes difficult for a lay audience to understand if more than 2 percent of the words in it are jargon [26]. But sometimes it's difficult to know which words are scientific jargon. When communicating to an adult lay audience, imagine you are talking to a 14-year-old child, to whom even the word 'molecule' may need to be explained. If you communicate to children, you need to simplify your language even more. Reducing jargon can even be beneficial when communicating with peers in other fields. An analysis of 20,000 research papers indicates that scientists are more likely to open and read a paper if the title and abstract contain little or no jargon [27]. *(ii) Be aware of what the same word can mean to different audiences.* For example, when scientists use the word "theory", they usually mean an established, accepted

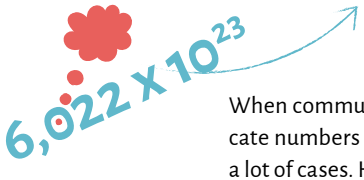
principle that explains a scientific phenomenon (e.g. Darwin's theory of evolution) and is backed up by scientific evidence. However, the general public often uses the word to describe what scientists call a hypothesis: an idea, opinion or abstract thought (He has a theory about why he caught a cold) that is mere speculation. Certain words can also be interpreted differently by people from different backgrounds, such as the word "cell". *(iii)* People may also *interpret what you say differently* because of their experiences or culture. Avoid language that might be alienating and take care to minimise value judgements. *(iv) Be aware of your language style.* Use short sentences. Choose simple words: use, instead of utilise; show, instead of demonstrate. And use the active voice, instead of the passive voice: we ran an experiment, instead of an experiment was conducted.

In summary, scientists should not be afraid to simplify their language and think carefully about how to adapt it to their target audience. This is particularly important when communicating with lay people, as it creates proximity and helps them to understand science and build trust in scientists. As for communicating with peers, they probably won't mind if their colleagues manage to get to the heart of their research in a simple and understandable way.

Recommended reads:

- *Engagement And Journalism Innovation For Outstanding Open Science Communication:* https://enjoiscicomm.eu/spis/
- *De-Jargonizer*, an online jargon detection tool [28]: http://scienceandpublic.com/
- Wissenschaftskommunikation.de, *Schwerpunkt: Sprache und Wissenschaftskommunikation* – https://www.wissenschaftskommunikation.de/schwerpunkt-sprache-und-wissenschaftskommunikation/

Numbers and statistics



by JEAN-PAUL BERTEMES

When communicating science, it is often necessary to communicate numbers and statistics, as they provide scientific evidence in a lot of cases. However, special care should be taken here, because it can't be assumed that every recipient knows the strengths and weaknesses of different statistical methods or has sufficient contextual knowledge to be able to evaluate numbers, statistical results or risks. Is a hundred deaths a lot or a little? Isn't a two-degree rise in global temperature actually quite pleasant?

When dealing with particularly large or small numbers, for example, it is important to give readers a sense of scale. The distance between the Sun and the Earth is about 150 million kilometres. That is hard to imagine. How long would it take to get there on a train travelling at 250 km/h? Nearly 70 years… that makes the distance more comprehensible.

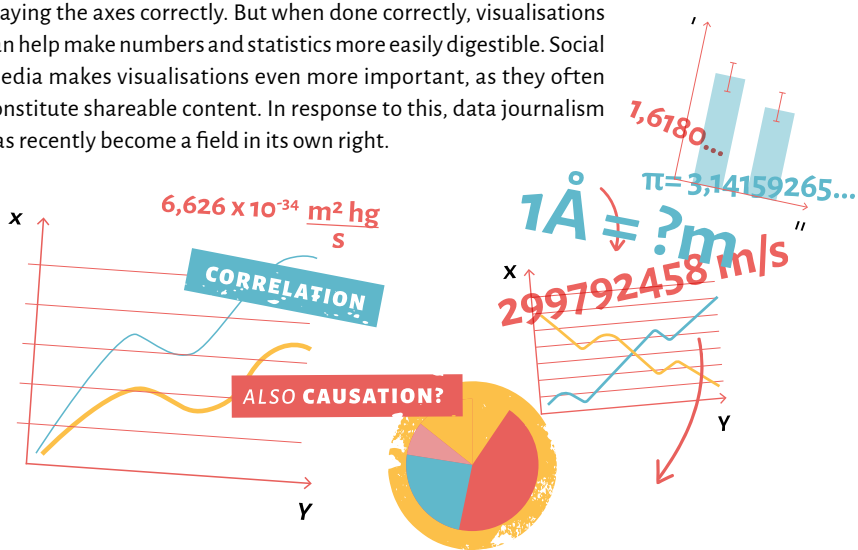
When using projections and simulations, it is important to communicate not only the result, but also the uncertainties and background information about the method. During the COVID-19 crisis, epidemiologists were sometimes accused of trying to predict the future like clairvoyants. Perhaps because the projections were sometimes poorly communicated by the media? "Scientists predict 20,000 deaths by March!" More nuanced information would emphasise that the model predicts a certain number of deaths based on the current state and data, assuming that nothing changes – and that changes in behaviour might have a significant impact on the results. For reasons of transparency it is also wise to emphasise uncertainties, by indicating for example the positive, negative and middle scenario. Otherwise, the risk is high that the next news is: "The scientists were wrong. Not exactly the predicted number…" When you indicate uncertainties, it is good to use numerical ranges rather than verbal statements [29].

23.

And when communicating statistics, be aware of the common risks of interpretation. For example, if a study finds that people who drink a lot of red wine live longer, does this automatically mean that it is because of the red wine or because of something else? People can be too quick to assume causation from a mere correlation.

In many cases, context is very important. This is the case when talking about risks, for example. What is the risk of a drug worth if you don't compare it with the risk of the disease it prevents? Only then can the recipient decide what risk they are willing to take. Or if you indicate growth as a percentage, it is important to also provide absolute figures as a reference. If a company increases its sales by 100 per cent compared to the previous month, it makes a difference whether the company sold one item last month or a million. Or, if the management of a company received a 5 per cent pay rise and the staff received a 10 per cent increase, it doesn't necessarily mean that the employees received more in absolute terms.

Visualisations are particularly important in this area. But beware of possible manipulations! For example, compressing or stretching graphs to make values appear more blatant or harmless. Or not displaying the axes correctly. But when done correctly, visualisations can help make numbers and statistics more easily digestible. Social media makes visualisations even more important, as they often constitute shareable content. In response to this, data journalism has recently become a field in its own right.



Recommended reads:

- Kerr *et al.* (2021), *The effects of communicating uncertainty around statistics on public trust: an international study.* https://doi.org/10.1101/2021.09.27.21264202
- Bauer *et al.* (2014), *Warum dick nicht doof macht und Genmais nicht tötet; Über Risiken und Nebenwirkungen der Unstatistik.* Campus Verlag. ISBN:9783593500300 ; https://doi.org/10.1101/2021.09.27.21264202

Communicating uncertainty

How to SAY "I am not sure"

III. GET STARTED
by DANIEL SARAGA

One thing is certain: nothing is. Science is an iterative approach of getting closer to "the truth" but without any hope of ever reaching it. It's about degrees of confidence and the perpetual refinement of our current understanding. Also, measurements are imprecise, samples are biased and models are oversimplified. You'll have to decide how much of these uncertainties to disclose.

First, know what you don't know. Establishing facts ("It is the skeleton of a Caucasian female child") is always probabilistic; and quantities ("The Earth will warm up by 2.5°C") are determined only within margins of error. This aleatory uncertainty can usually be estimated.

On the contrary, it is very hard to quantify *epistemic* uncertainty: the fact that models have gaps, that theories are disputed, that experts disagree. This does not prevent us from being transparent about existing debates and divergent opinions.

For aleatory uncertainty, you can provide the whole *probability distribution* or just its *mean and standard deviation*. Research suggests that some representations (*violin plots*) are better understood than others (*error bars in bar charts*) [30]. It is best to state the range of values (95% confidence interval or minimum and maximum values, etc.), but a range, even if unexplained, is better than nothing. When comparing different options (medical treatments, educational approaches or economic interventions), try to visually communicate the strength of evidence and effect size, to avoid the fallacy that all insights carry the same weight.

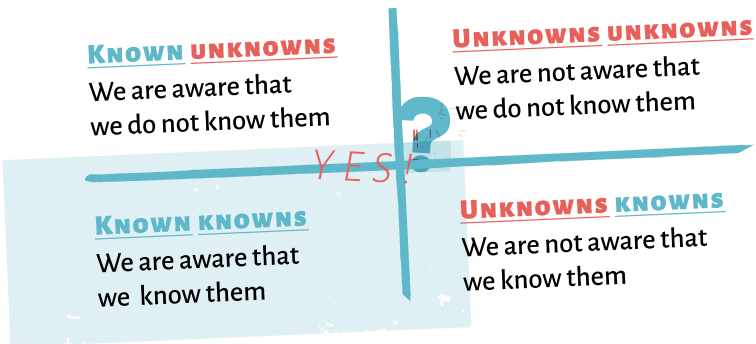
Studies indicate that numerical values of probability are usually better understood – even by people with *low* numeracy – than verbal descriptions ("approximately", "likely", etc.). The latter are interpreted differently by different people – or even by the same person – depending on the context.

24.

The IPCC has defined a glossary in which "very likely" means probabilities above 90 per cent, but readers tend to underestimate the term at 65 to 75 per cent [31]. The use of qualifiers blurs the intended communication of uncertainty, but – again – this is better than reinforcing, by omission, a dreamed-up certainty.

Does transparency about uncertainty increase trust in your message or does it encourage unfair dismissal of expertise? Current research, alas, presents diverging answers. It seems, however, that communicating aleatory uncertainty promotes trust and quality in decision-making [30]. Honestly addressing the struggle for certainty is a strength of the scientific method. In science communication, it is usually perceived as good practice.

There is a lot of uncertainty about the best way to communicate uncertainty, and you have to deal with that uncertainty – just like your audience does when you explain scientific knowledge. Now, some things are fairly certain, and you might state with confidence that "The Earth is not flat, climate change is real, and I have read this chapter".

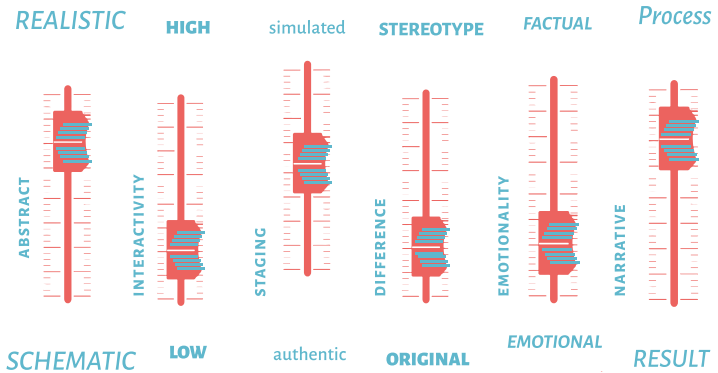


The famous Donald Rumfeld`s matrix of (un)knowns.

Recommended reads:

- van der Bles *et al.* (2019), *Communicating uncertainty about facts, numbers and science*, Royal Society Open Science 6: 181870. https://doi.org/10.1098/rsos.181870
- Dhami M.K. & Mandel D.R. (2022), *Communicating Uncertainty Using Words and Numbers*, Trends in Cognitive Sciences 26: 514. https://doi.org/10.1016/j.tics.2022.03.002
- Institute of Medicine (2013), *Environmental Decisions in the Face of Uncertainty*. Washington, DC: The National Academies Press., chapter 6. https://doi.org/10.17226/12568

Visual communication



(Siggener Kreis, adapted from [33])

by DIRK HANS

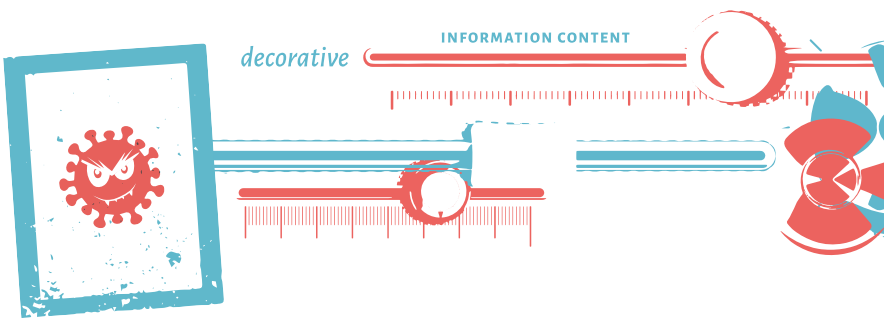
One thing in advance: In this article, the platitude "A picture paints a thousand words" will definitely not be used. Having made that clear, we can now systematically turn to the extraordinary importance of visual information in the context of science communication. Illustrations, graphics, cartoons, animations, photos and videos provide visual stimuli that can attract attention, excite, educate or manipulate, sometimes all at the same time. Visual information is processed incredibly quickly and often provides a much more complex pattern of information than text.

The consumption of visual information via image-based networks (YouTube, TikTok, etc.) continues to grow at an impressive rate [32]. In terms of quality, there is a considerable range: beautiful graphics, loveless photos, ugly logos and fascinating animations. All these adjectives are in fact expressions of an emotional involvement that occurs involuntarily in the recipients and is partly processed subconsciously. Our approval or disapproval, our trust or mistrust is significantly influenced by visual communication. It is therefore particularly susceptible to influence and manipulation. This realisation places a high degree of responsibility on all science communicators when using visual media to shape the "image of science" in the minds of people who only know science from the outside. The use of photographs, for example, raises the question of the extent to which an image should depict actual reality or only

a desired outcome, such as when it comes to the topic of diversity in research teams or even the set-up of workplaces in research. This is where the "danger of beauty" lurks. Ugly offices and shabby laboratories, which are part of the reality of science in many places, are hardly ever depicted. Is this the right strategy? This is the subject of considerable debate. The Siggener Kreis – a German think tank on science communication – states: "The aim of using images in science communication should be to depict science in its multiformity and make this publicly accessible" [33]. So a little more reality is probably called for...

Let's come back to the platitude from the beginning and also broaden our view once more in the direction of graphic-illustrative representations. Of course, visual information is very effective at helping us to cognitively process complex concepts. In science, literal description regularly reaches its limits. Animations of drifting continental plates or data visualisations on climate change provide an immediate "Aha!" moment. This quality – the instant enlightenment – should definitely be used in science communication, which is constantly trying to convey complex information.

The power of images is still too often underestimated and their effect diminished to the decorative. In this area, too, science communication would benefit from a greater degree of professionalism, in the sense of benevolent and sustainable use.

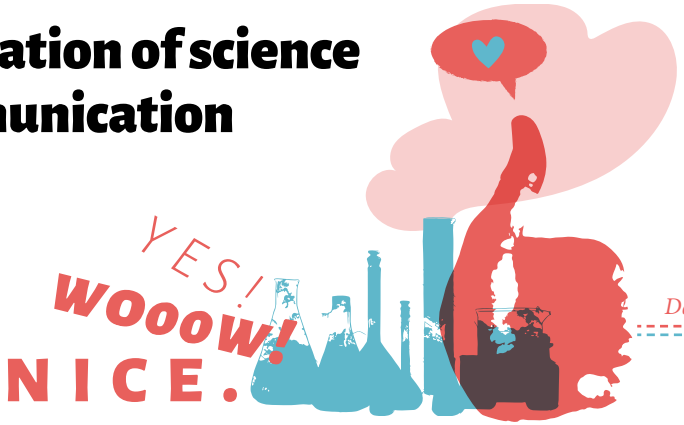


Recommended reads:

- Siggener Kreis, Siggener Impulse 2021: *Bilder in der Wissenschaftskommunikation*; https://www.wissenschaft-im-dialog.de/fileadmin/user_upload/Ueber_uns/Gut_Siggen/Dokumente/220223_Siggener-Impuls-2021.pdf
- Metag J. (2019), *Visuelle Wissenschaftskommunikation, in Handbuch Visuelle Kommunikationsforschung*, Springer Fachmedien. https://doi.org/10.1007/978-3-658-06508-9
- Pol A. (2014), *Menschen am CERN*. Lars Müller Publishers. ISBN: 978-3-03778-262-0

Evaluation of science communication

by RICARDA ZIEGLER



Scientifically substantiated evaluations are pivotal to ensuring the effectiveness and improvement of the growing number of science communication projects. Evaluation results can reveal what a science communication activity has achieved, who it has reached or what impact it has had.

However, evaluation is not yet common in science communication, and current evaluation practices are often flawed. Many projects lack concrete definitions of their objectives and target groups. This is problematic, because clear definitions are the necessary basis for assessing a project's success. In addition, evaluation designs and data collection methods are often not appropriate for answering the evaluation questions. This is especially true when trying to investigate the effects and impact of an activity. Such an investigation requires carefully developed data collection strategies – and, most importantly, data collected at more than one point in time – to enable meaningful comparisons.

Good practice in evaluating science communication does not necessarily consist of handing out a questionnaire to participants after the event. Rather, it starts with a clear articulation of the motives, interests and questions of an evaluation by all stakeholders involved. On this basis, the study design and data collection methods can be derived accordingly.

26.

Conducting meaningful evaluations in science communication therefore requires resources. These include time and money, but also people with the appropriate knowledge and skills. This might seem hard to achieve for smaller project-based activities with limited timelines, or for individual science communicators. Nevertheless, evaluation is the only way to really understand how a science communication activity "works", how the people involved experience it and whether it makes a difference.

As impact evaluation is an ambitious undertaking, practitioners who lack the appropriate resources or necessary skills are often better advised to focus on gathering descriptive data. This allows them to gain important insights about their participants and their experience, which is preferable to unreliable results produced by trying to capture potential effects with inappropriate designs and methods.

Ideally, insights from meaningful evaluation will also be shared with others. In the future, evaluation will hopefully no longer be seen as a mandatory task to amaze funders or supervisors with impressive numbers, but rather as a learning process for individual science communicators and the science communication community as a whole.

Resources

Methods

& Design

Recommended reads:

- Pellegrini G. (2021), *Evaluating science communication, in Routledge Handbook of Public Communication of Science and Technology.* ISBN 9781003039242
- Impact Unit: *Wie evaluieren? Tools für die Praxis.* https://www.impactunit.de/tools
- Ziegler *et al.* (2021), *Evaluation of Science Communication: Current Practices, Challenges, and Future Implications.* Front. Commun. 6:669744. https://doi.org/10.3389/fcomm.2021.669744

IV.

CHANNELS OF SCIENCE COMMUNICATION

Interpersonal communication

by DIRK HANS

Some days, you get so excited about science and research that you want to tell everyone about it. Research – wow! Enthusiasm is best conveyed face to face. So shouldn't science communication focus primarily on interpersonal communication as a success factor? Well… no!

Direct, interpersonal communication between individuals can be described as the most complex form of communication. In addition to word-bound information, facial expressions, gestures and voice modulation are exchanged with information about the emotional state of the communicating persons. Even the clothing and chosen setting play a role that should not be underestimated. Communication science and psychology offer a wealth of findings in this area.

A face-to-face encounter usually sticks in the memory longer than a read message, and if something is particularly important, we like to communicate it directly. But interpersonal communication requires work. Sending a message via a messenger app to a group of colleagues is much less effort than making phone calls or meeting all these people in person. For active communicators, therefore, one aspect in particular is central in the context of interpersonal communication: efficiency.

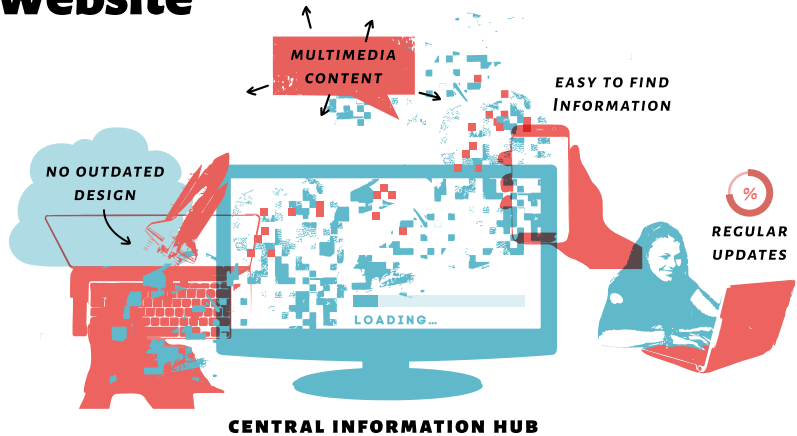
27.

Assuming that the goals of science communication are essentially to share knowledge and build trust, the various forms of science communication must always be weighed up against the costs and benefits. Especially when scientists communicate themselves and do not delegate the work, it must always be considered whether it is better to invest time in their own research or in communicating it. Science communication often gets the short end of the stick here, and rightly so. If I can reach millions of people with an animation on YouTube or an appearance on a popular TV show, the question of whether face-to-face communication would be an alternative doesn't even arise. Online information, brochures and flyers or even podcasts use communication channels that are open to hundreds or thousands in the online community. Especially in the case of primarily factual information dissemination (current state of research or ongoing projects), generally accessible information channels suitable for the masses are well suited.

When it comes to trust, the situation is somewhat different. Here, a balance has to be struck. When it's about gaining the trust of influential stakeholders – such as donors – interpersonal, direct communication is probably worthwhile. There is also no substitute for face-to-face communication when it comes to finding new partners in research or business. And one last practical tip: Beside the use of video conference systems for daily communication, compromise formats such as video or audio productions are particularly worthy of attention. If researchers present themselves in a video on YouTube with an exciting topic in good picture and sound quality, many aspects of face-to-face communication are conveyed in addition to the factual information. This can be very helpful, for example, when recruiting new team members for your own research group.

Website

by EMILY IVERSEN



What is the purpose of a website? In most cases, it is a central information hub. In the case of a research institution, it should contain everything from news, videos and infographics, to brochures, contact details and more. While social media has changed the way we use websites – it is often used as a tool to drive people to a website or to engage with audiences – websites continue to hold their ground. If you need information from an organisation, where is the first place you would look, knowing that you are likely to find what you need? Probably the website. Websites are a must for institutions.

But if you want to make a website for a smaller project, always remember: There are billions of websites in the world. Why should anyone look at yours? So a crucial question is: Will you be able to attract people to it? If you need to attract them to your site via social media, how much content will you create? Enough in the long run to create and maintain a following? These are questions you should ask yourself before creating a new website. In some cases, the answer will be: A website is probably not the solution. But there are certainly many good reasons for creating a website.

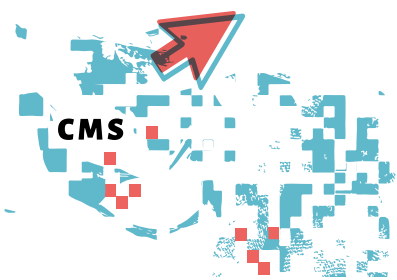
Websites can seem static – and for certain projects or objectives, this is perfectly fine. But for institutions, it is important to keep them engaging, otherwise why have one in the first place?

A regular flow of new posts and images on the site helps with this. As an added bonus, websites with regular updates are rewarded with better search engine rankings. What else is important? Functionality and design. If the website is frustrating to navigate or hard to read, it will not matter how often new content is added.

This brings us to first impressions: We make assumptions when we see things for the first time. If you don't know an organisation or project, what assumptions will you make if the website looks like it's 20 years old? Probably not good ones. Unless an institution or organisation has a history going back several centuries, with a pantheon of scientific celebrities: How a website looks and feels matters! If a new website looks old-fashioned (e.g. there is no mobile version or the design is outdated), it can harm its reputation. The look and feel of a website should always be kept up to date.

A website is never finished – it should evolve like the organisation or group it represents. This means ongoing maintenance, which costs time and money but is a worthwhile investment.

Functionality is just as important as design. This includes a clear menu and a good search function. As an exercise, try browsing your site as a "persona" – a person with a specific background looking for specific information. Try to do this for all types of visitors you want on your website. Try to map their journey – is it quick or slow, and do they find what they need? Larger institutions usually have a team of people who ensure everything we have covered here is taken care of. For smaller institutions or groups, there are many template options that will allow you to create a nice-looking basic website. Either way, think about what areas you can influence – things as small as keeping contact details up to date or a monthly newsletter can already make a big difference.



Social media

IV. CHANNELS OF SCIENCE COMMUNICATION
by ASWIN LUTCHANAH

"Social media" refers to digital platforms, tools and applications that enable people to create and share content in various formats (text, image, video, audio) in online communities. It has become a standard way of modern communication.

What makes social media different from traditional media is the social aspect. Compared to traditional media (TV, radio, newspaper), social media offers interactivity, providing instant and continuous feedback over time. This makes it both powerful and frightening. The more engagement a publication gets, the more it will reach a wider audience.

There is an additional layer of work as you become your own content distributor. Cutting out intermediaries may sound exciting and easy. But it is harder than you might think. You will quickly hit a wall that will prevent your content from achieving the success you expect. It takes a few minutes to create an account, but way more time to build a community and keep their attention.

Social media is a marathon. To get the results you want, you need to acquire the skills that intermediaries have: the editorial skills to create and distribute the relevant content to the desired audience and to build a bridge between what you want to share and what, how, when and where your audience wants to hear it. Not everyone can devote that level of energy to making it a success. Do you want to spend more time doing your research, or communicating about it on social media? The example of dating fits well when talking about social media. Imagine going on a first date with someone. Imagine that person telling you every single detail about themselves. If you get too much information in one go, you might quickly get annoyed. Would you go on another date? Probably not.

29.

Social media publishing is like a first date for your content. You want to attract the attention of your audience, get them to click on a link, watch the full video, like, share, repost or comment. You will then have to monitor so that you don't miss anything, seize an opportunity to engage in a conversation, right a wrong or provide additional information. Failure to do this can be harmful to your image and lead to a bad buzz.

In a world of infobesity (information overload), where a dancing cat gets more attention than almost anything else, you need to stand out by adding value with quality content. To start off, develop a social media strategy before creating social media channels.

Consistency will help you retain the attention of your audience. Quality content will keep your audience engaged. Posting regularly, but not too often, will maintain the relationship with them without boring them (making them feel spammed).Ask yourself the 5Ws to create a social media strategy: *Why, Who, What, Where & When?*

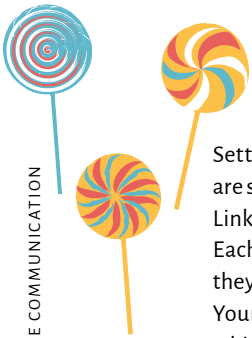
Get inspiration from others. Is it best to have your own new social media channels, or to use your organisation's existing channels? Multiplying channels can lead to a dilution of content distribution. Some keys to social media success are: investing time, investing more in visual content, building your community, identifying ambassadors and letting your channels breathe.

Recommended reads:

- Cinelli *et al.* (2022), *Promoting engagement with quality communication in social media.* PLoS ONE 17(10): e0275534. https://doi. org/10.1371/journal.pone.0275534
- National Co-ordinating Centre for Public Engagement (2018), *What Works Engaging the public through social media*. https://www.publicengagement.ac.uk/sites/default/files/publication/what_works_engaging_the_public_through_social_media_november_2018.pdf
- European Comission (2020), *Social Media Guide for EU funded R&I projects*. https://ec.europa.eu/research/participants/data/ref/h2020/other/grants_manual/amga/soc-med-guide_en.pdf

Channels of social media

by ASWIN LUTCHANAH



Setting up a social media appearance can be overwhelming. There are so many channels to choose from. Popular ones include Twitter, LinkedIn, Facebook, Snapchat, Instagram, YouTube and TikTok. Each social media channel has its own unique features (although they tend to copy each other), best practices, rules and user base. Your social media strategy will help you have a clearer idea of which channels to use. Choose those that best fit your strategy and the objectives you want to achieve. Consider the audience of the platform to ensure that it has the right demographics to help you reach your goals. Consider how much time you want to devote. In the beginning, when building a community, you will need to invest more time. This is a steep process. Consistency and regularity are key. Work out your ideal frequency. Don't be spammy. Don't post five times in one day and then go silent for four weeks. You could post once a week, every week. Consider your resources. Do you have the personnel and skills to invest in the platform? Some video-based platforms like TikTok and YouTube require more resources to create content. Social media platforms change quickly. You need to keep up to date with the latest features to take advantage of them and accelerate your "road to success".

Fill out all your profiles and check regularly that they are up to date. A complete profile conveys professionalism and shows that you are active on the platform.

Visuals are very important on social media. They attract attention and encourage engagement. Use the right ones. Check the required dimensions for each platform (profile, cover photo, feed, link). Using the right dimensions will optimise your content and make it more effective.

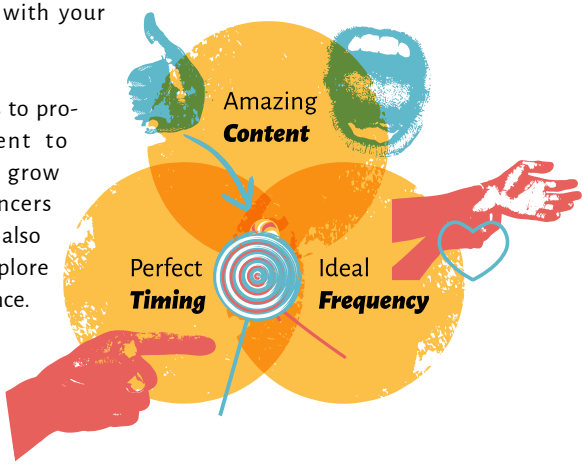
30.

Be authentic! Do not use language that is not yours. Show your achievements rather than telling what you can do. Use your keywords to have an impact on your audience, but don't use/overuse buzzwords. Always think about your followers and what they will gain from your publication. Don't make it all about you. Remember that social media is about social contact, and people love to connect with other people rather than brands and/or organisations. Have the personal touch that makes your brand/organisation more human.

Your voice is your mission statement and your tone is the execution of that mission. The same content will be disseminated differently depending on the audience and the platform. You need to tailor your content to the platform and audience. You need to connect with your audience to keep the sparkle in their hearts. They will love you more and engage with you more.

Diversify the types of content to take full advantage of the platform. Think about providing content at the right time and the ideal frequency. Adapt your posting strategy as your channels grow. Use the platforms' analytics to help you. Experiment to fine-tune your strategy. As your community grows, the effort needed for community management will increase: respond to comments and private messages, and interact with your audience.

Consider paid campaigns to promote your page/content to potential followers and grow your community. Influencers and micro-influencers are also opportunities you can explore to reach your target audience.



Videos

by DIRK HANS

Moving image content is part of the standard in science communication. Researchers and institutions that don't have decent video content and aren't represented on YouTube today are simply not up to date. People's media behaviour has changed significantly over the past two decades. Among 14- to 29-year-olds living in Germany in 2021, 59 per cent use video platforms such as YouTube frequently or very frequently [34] to obtain information about science. This makes it the number one channel within this group. Other video-based social media channels are currently reinforcing this trend. If people want to gain a rudimentary understanding of how a particle accelerator works or how to fight viruses, they look for information on the web – and sometimes directly on the websites of relevant institutions such as CERN or the WHO. If a suitable, often internally produced video clip is found there, it is readily clicked on. It promises to summarise the most important information in a reasonably entertaining way. The term "edutainment" applies to video formats perfectly.

Of course, there are not only good videos – there are also terribly bad ones. Worse still, there are very well-made videos that distort facts and deliberately misinform. These videos are highly problematic when they encounter a credulous audience. As serious players in science communication, there is not much we can do about this except to produce even better videos and counter them.

It is often said that a video should not be longer than two minutes, otherwise no one will watch it. This is utter nonsense! If people are really interested in something, they may spend days reading a book about it or watching an hour-long documentary. The idea that science communication must always work in tiny chunks is misleading. But it makes perfect sense to reduce the amount of information, to focus and to allow for cognitive connectivity. Content must be presented purposefully. Structuring a story in the

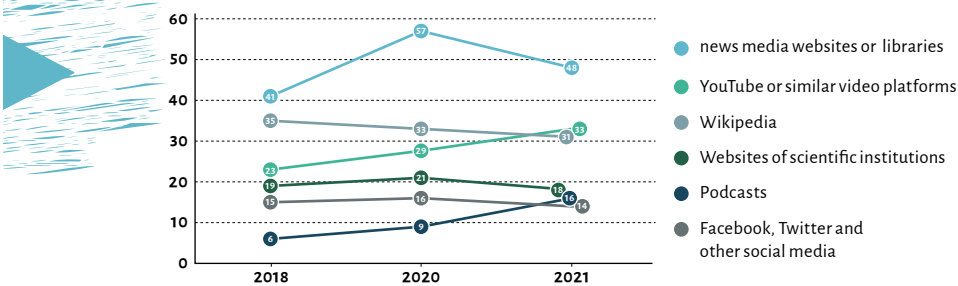
right way is good work. Sometimes two minutes is enough for a video clip highlighting a research project or presenting a new science institution. Other times, you give it 15 minutes, or even more.

And, of course, there are some technical challenges to in-house video production, even though more and more people are gaining experience of using mobile phones for it or even small video drones. There is a reason why professional video productions are often produced with teams of three or more experts (camera, editing, etc.): the quality improves. But unfortunately also the price. Producing nice material with a small budget is an art. Feel free to try it yourself. But be aware that there's a fine line between sympathetic authenticity and image-damaging clumsiness. But if you have good video material, use it! Don't hide it in the far recesses of your website. Link it to other media, such as via QR codes in brochures or on posters. Use your social media channels to promote it.

Last but not least: Good video footage of scientists presenting themselves and their work is an excellent way to attract the attention of journalists, who – especially if they work for TV – look for experts who are comfortable in front of a microphone and a camera.

Use of online channels for **INFORMATION** on **science** and *research*

Results from the German *Wissenschaftsbarometer* 2021



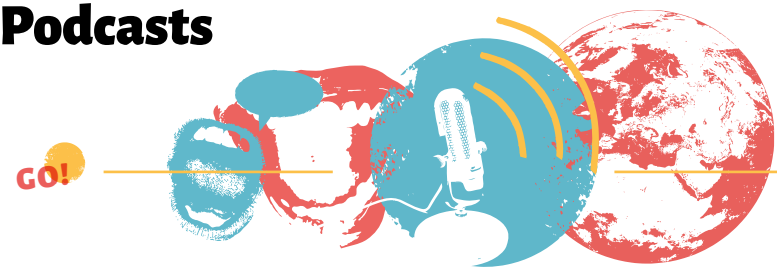
(adapted from [34])

Recommended reads:

- Hayes R. & Grossman D. (2006), *A scientist's guide to talking with the media*, Chapter 5: Mastering the interview. Rutgers University Press. ISBN 978-0813538587
- von Campenhausen J. (2014), *Wissenschaft vermitteln*, Kapitel 12: Wissenschaftler ins Fernsehen, Springer Fachmedien. https://doi.org/10.1007/978-3-531-19361-8

Podcasts

by LISA BURKE



The number of science communication podcasts has grown exponentially since 2010 [35]. Most are aimed at a public audience. The use of video to produce a vodcast has peaked and declined again, which suggests that people listen to podcasts while engaged in other tasks that require them to see what they are doing. The majority of science podcasts are hosted by scientists, with the aim of building trust among the public and getting people interested in science [36]. The decentralised nature of podcasts allows for the democratisation of information [37], although it also means that engagement metrics are hard to tabulate. Of the natural sciences, chemistry is the most underrepresented, but podcasting has also proved to be effective for niche subjects and for young people too. Students rate podcasts as a better way to revise than textbooks [38].

Podcasting is relatively easy to test as a science communication tool, as it is easy to get started and not much equipment, production or editing are required. What's more, you can also reach a global audience and receive instant feedback via social media – it becomes a two-way dialogue, which can build trust. It should be noted that podcasting will put you in the public eye and you therefore have a corresponding responsibility. Posting and replying on social media also takes more time than many people expect, as does preparing a podcast, of course.

Science podcasts come in a variety of styles: monologues, informal chats, professional science news, panel shows and comedy. Indeed, humour is a very effective way to convey scientific information. Most produce weekly, and about half add show notes and hyperlinks.

32.

How to start your own podcast

Start by defining your concept and audience. Research your competition and look for an underserved niche, be it a topic, an age group, a location or a language. Podcasts are often affiliated with an organisation, rather than being totally independent. And around a quarter have external financial support [35].

Each show needs a general structure and tone. You can establish a relationship with your audience fairly quickly through social media and refer to any interesting comments each week (weekly being the most common "drop" rate).

Podcasts are generally conversational and not overly scripted. Even if your audience is knowledgeable, it's best to explain acronyms, for example, when using them for the first time, as people from outside of your field, language or region might be listening.

The technology required doesn't have to be too complex. You should invest in a good microphone and headphones. Then think about how to soundproof your room like a studio. Some hosts literally record in cupboards or under blankets!

There are many (often free) editing tools. When editing, leave natural gaps in speech and don't remove all "mistakes" or it will sound unnatural.

There are a number of podcast hosts which will get your podcast onto Apple Podcasts, Spotify and Google Podcasts. It's important to launch on one of the main platforms in order to reach a global audience, but also for metrics.

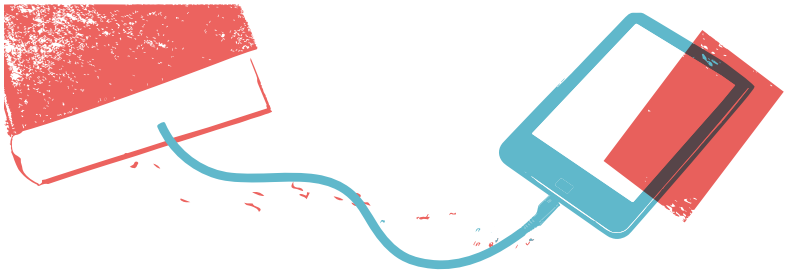
And finally, it's time to publish (aim for the same time each week for a good rhythm). Use social media and websites to promote yourself, your guests and your department.

Recommended reads:

- MacKenzie L.E. (2019), *Science podcasts: analysis of global production and output from 2004 to 2018.* R. Soc. open sci. 6: 180932. https://doi.org/10.1098/rsos.180932
- Quintana D.S. & Heathers J.A.J. (2021), *How Podcasts Can Benefit Scientific Communities.* Cell Press, Trends in Cognitive Science 25(1):3-5. https://doi.com/10.1016/j.tics.2020.10.003.
- Yuan *et al.* (2022), *Listening" to Science:Science Podcasters' View and Practice in Strategic Science Communication.* Science Communication 44:200-222. https://doi.org/10.1177/10755470211065068

Print materials

by OLIVIER MARQUIS



Millennials are the first generation to grow up being alarmed about global warming. They are also the generation that has seen the internet and digital communication emerge and develop at an astounding pace and challenge the communication tools of the 20th century, especially print.

Just as the music industry has been challenged by streaming giants, the print industry has suffered and had to adapt to these changes. More responsible solutions, such as FSC-certified paper, have emerged and become interesting alternatives. Content has also evolved and been redesigned. Texts are shorter, brochures are thinner, and more attention is paid to graphics and illustrations.

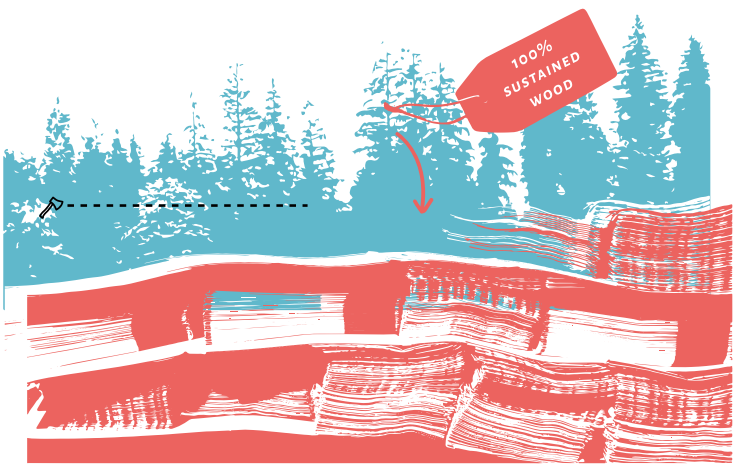
Print is no longer the preferred primary solution, but it stands out from digital and makes sense when it can add value. Good communication must awaken our senses. And here, paper has some advantages over digital. The smell or touch of an old book or scented paper will provide sensations that digital can't yet match.

Print can also be a good choice for certain target audiences. Although it is certainly no longer the first choice for a young audience, paper is still appropriate for niche communications and makes recipients aware of its importance. This is why it is still widely used in the luxury sector. A personal invitation to a premium event, a publication or a beautifully illustrated book remain must-haves. Printed articles are becoming collectors' items that can be produced in limited editions and personalised through digital printing.

33.

In the 21st century, now that letterbox advertising is finally becoming obsolete, it is no longer a question of handing out flyers at trade fairs. Instead, print and digital media work well together to leave an impression on visitors. To avoid regular reprints, printing a QR code on a neat, minimalist flyer is an excellent option. It redirects viewers to a web page where the texts can be easily updated and which can accommodate different types of digital media (videos, podcasts, animations, etc.).

At a time when many companies are talking about going "paperless", digital is not yet able to meet all communication needs. Print remains a relevant tool in the communication plan if it offers added value compared to digital. Its use must therefore be considered. It must be well thought-out and adapted to its target audience. In the end, the media evolve, but the ABCs of communication remain the same.



Science comics

by SERGE HAAN

Popular science books and comics are excellent examples of popularised science communication. This article will focus on science comics and cartoons. Whereas comics refer to longer stories, cartoons usually consist of single-panel illustrations. Here, the term science comic will refer to both comics and cartoons with scientific content or a scientific message.

The increasing use of animated comics in scientific TV shows and documentaries illustrates that this medium is generally well received by many viewers. Science comics are also being used increasingly in science education and public engagement activities. They are particularly appealing to children and teenagers and may therefore be an ideal tool for stimulating interest in science among this audience. There is also evidence to suggest that, in particular, teenagers with a low science identity (see Essential 13) are more likely to continue learning about a scientific topic if they have learned about it from a comic rather than an essay [39].

Science comics come in many shapes and sizes, from single panels to entire graphic novels. They combine written and visual communication and can embed the scientific content into a compelling story with strong visual metaphors that still leaves room for own thoughts and imagination. Comics can convey scientific information either entirely as part of the story, or by adding the information as extra blocks of text or diagrams that are not part of the story and

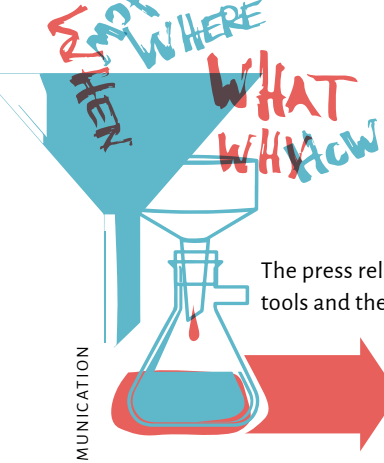
appear as an insert or digression [40]. In the case of the former, it is important to ensure that the story is understood in the intended way by the reader so that the scientific content or message (intended inference) is conveyed. The latter strategy may increase the scientific content but also has the potential to break the flow of the story. Care must therefore be taken to ensure that the reader understands how this additional information relates to the story. The relation between the text and the pictures proves crucial for the correct transmission of information. None of these elements are isolated and they only make sense in their mutual context. In science comics, the link between text and pictures can be affected by the scientific content of the text. It can therefore be useful to draw attention to visual elements in a speech bubble to incite the reader to make the connection between text and image [40].

Storytelling and character development are crucial. In the same way that a good storyline stimulates interest and encourages readers to develop their own questions about a topic, a poor storyline can be confusing and lead to misinterpretations when filling in the gaps. Furthermore, developing compelling and relatable characters will also engage your audience. Read up on storytelling and do not hesitate to seek help from experts, both for the storytelling and the visuals.

Finally, a word of caution. It is inherent in comic book production to take advantage of powerful visuals and metaphors. However, think twice about how you portray science and scientists as there is a high risk of reinforcing existing stereotypes. Of course, this cautionary advice is not only applicable to science comics but to every visual science communication effort.

Recommended reads:

- Farinella M. (2018), *The potential of comics in science communication*. JCOM 17 (01), Y01. https://doi.org/10.22323/2.17010401
- Tribull C.M. (2018). *Sequential Science: A Guide to Communication Through Comics*. Annals of the Entomological Society of America, 110, 2017, 457–466. https://doi.org/10.1093/aesa/sax046
- Friesen *et al.* (2018) *Communicating Science through Comics: A Method*. Publications, 6:38. https://doi.org/10.3390/publications6030038



Press releases

by BRITTA SCHLÜTER

The press release is one of the most widely used communication tools and the classic interface between science and the media. It is intended to arouse the interest of journalists and provide them with ideas for their stories.

Media coverage (e.g. TV reports or newspaper stories) provides an opportunity for researchers to generate more awareness of their activities – from other disciplines, funding agencies, industry, potential donors or students. Being present in the media can lead to new contacts, even influence scientific citations of findings, and increase the chances of funding. Press releases that generate media coverage are therefore an indirect tool for engaging in dialogue with the general public – often with the aim of promoting understanding and trust in research and research institutions. The news may be about important research findings, grants or awards. However, to stand a chance in the daily competition for attention, the press release needs to deliver a message that is relevant to a broad audience and is easy to understand. Think about the purpose of the text, as well as the news content: Can you say it in simple terms in 30 seconds? Always remember that you are addressing a large lay audience. You therefore need to tailor your story to that audience.

Incidentally, it happens every day at larger research institutions that scientists ask the communications department to produce a press release and the communications experts immediately realises that the topic is not of interest to the media. In such conflict situations, communications professionals often have to compromise, as they don't want to overwhelm journalists, but they don't want to upset the scientists either. The solution is often to produce a news item for the university's or research centre's website. The news is published without the push procedure of sending out press releases.

35.

A professional style, illustrations and a well-chosen occasion and timing will greatly increase the chances of media response to press releases. Nevertheless, there is no guarantee of publication, but you should be prepared for follow-up questions from journalists and even critical coverage. If you are a researcher and part of a research institute or university, seek advice from your institution's press office as early as possible.

Writing a press release is a unique style of communication with clear rules and reduced jargon. In the first few sentences, the text must answer these questions: Who? What? Where? When? Why? How? It is very important to put the most relevant information first, then add important details and finally background information, according to the principle of the inverted pyramid (see diagram). In most cases, the text is the product of a collaboration between the researcher and the press office, in which both contribute their expertise and make compromises, sometimes after tough discussions. The final text is sent out by the press office to selected media or international news distribution platforms. However, even if you offer the media a great topic with beautiful visuals, success is still not guaranteed. If the Queen dies on the same day, you don't stand a chance!

Recommended reads:

- Kwok R. (2018), *Press ahead. Public information officers can help scientists to share their research more widely.* Nature 560: 271-273. https://doi.org/10.1038/d41586-018-05896-2
- ESA press release guidelines: https://esahubble.org/about_us/scientist_guidelines/

Press invitations and conferences

by PATRICK MICHAELY

What researcher doesn't dream of making a groundbreaking scientific discovery and publishing it in a prestigious journal after years of hard work? So why not have the institution's press office quickly call a press conference to announce to the assembled press members how the discovery came about and what the future implications of the discovery will be for the research discipline, the institute and, of course, the researcher's own career?

However, press conferences are a double-edged sword and there is a clear risk of failure. Journalism has changed a lot in recent years and journalists rarely have time to leave their desks. It is therefore vital that press conferences are only held if they are really relevant to the journalist and if the press conference is of real value to them. There is no guarantee that a press conference will be a success. Many factors have to be taken into account and not all of them can be directly influenced. What do you do if a member of the press can't make it because of their schedule, or worse, doesn't want to come because they're not interested? Is it necessary to send out a press kit? Couldn't you have left it at that anyway?

Press conferences are fairly laborious. They have the character of an event because many people have to be involved, from the head of the institute to the hall technician. The organisational effort is therefore relatively high.

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However, a successful press conference is always beneficial to the host institution. The presence of a reasonable number of representatives from the press ensures a guaranteed response from the press, unlike a press release that is simply sent out and has to compete for attention with many other stories in the newsroom. The press conference also provides an opportunity to place the project presented in a wider context and to allow various participants – such as the director of the institute, project partners or even political representatives – to have their say. Very often, after the official part, personal statements are taken that enhance the topic.

If the spokesperson has good contacts with the press, this can help. But some scientists have also cultivated their contacts with the press beforehand and have been able to arouse their interest in the project. In any case, it is important to consult with the spokesperson well in advance.

The decisive factor, however, is probably that the topic presented has sufficient relevance to the press and that the press conference offers clear added value. This could be the groundbreaking research itself, or the presence of a high-level politician who is using the project as an opportunity to explain their research policy. If it is too obvious that the event is just rehashing or repeating what has already been announced in detail in the invitation, it will not be interesting enough for many members of the press. In this case, a concise press release will suffice.

So think twice before calling a press conference. But don't be afraid to make contact. It is always in the interest of journalists to publish a good story.

Recommended reads:

- World Health Organization. Regional Office for Europe. (2017) . *Strategies used by journalists during interviews or press conferences: World Health Organization vaccine safety supporting document*. https://apps.who.int/iris/handle/10665/345934

Events

by SONIA RAMOS

There are a wide variety of event formats: Award ceremonies, conferences, trade fairs, festivals or even a fireside chat can be considered an event. Typically, more than two people would be expected to attend an event, but it can involve thousands or even hundreds of thousands. Events can take place on site or in the digital space.

The central aspect of many events, especially when they take place on site, is the facilitation of interpersonal communication: Meeting in person creates an emotional and physical connection, as human interaction is at the core. This offers enormous advantages, since trust can be built up here in particular. Successful events are status-laden: An institution that is able to stage outstanding events can greatly increase its esteem with relevant stakeholders. Successful events leave a lasting impression. Sometimes, the pleasant and extremely interesting evening is still talked about years later. This is where events clearly stand out from other traditional media.

But where there is much to gain, there is usually much to lose as well – and this is exactly the case with events. The amount of work, pressure, energy and dedication that goes into putting on a successful event is often underestimated. When everything runs smoothly, this effort is usually not seen or appreciated.

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A failed event, on the other hand, can damage an institution's image for years to come. A minister or major sponsor who had to deliver a speech to a half-empty auditorium with a faulty microphone is unlikely to be very forgiving. Another major danger lurks in invitations: Forgetting people who are particularly important – or at least think they are – can lead to lasting diplomatic upheaval. It is therefore essential to avoid inadvertently overlooking particularly powerful stakeholders.

In conclusion, a well-planned event is like a masterpiece painting: Every detail counts. From the choice of venue to the content, food and entertainment, everything should be carefully considered to ensure a memorable experience for all participants. And if your research centre is publicly funded, make sure that the costs stay low and you follow the rules. Otherwise, you could find yourself in trouble for wasting taxpayers' money.

Besides all that, it is essential to ensure that you don't get bogged down in this multitude of details, at the risk of pulling out a few hairs and having some sleepless nights in the process… event planning doesn't have to be all work and no play. On the contrary, injecting a little fun and creativity into the planning process can make it an enjoyable experience for everyone involved. So, if you're planning an event, take your time, pay attention to the details, and don't forget to have some fun along the way.

School lab

by THIERRY MEYRATH

Among the many extracurricular learning places, school labs play a particularly important role. Generally affiliated with a university, a research centre or a science museum, such labs offer hands-on learning experiences for entire school classes or individual students, with a general focus on the STEM disciplines (i.e. science, technology, engineering and mathematics). The first labs emerged in the 1990s and were founded by dedicated individuals with the main aim of promoting interest in natural sciences, rather than being initiated by education policymakers or education scientists. Since then, the number of labs has risen sharply and there are now more than 400 school labs in Germany alone [41].

School labs come in various forms. Their offerings can differ from lab to lab, ranging from one-off events to full-day workshops that are held on a daily basis and must be booked in advance. The content covered generally includes relevant topics from the STEM disciplines, although some labs are also dedicated to social sciences and humanities. In addition, the topics are often aligned with the school curriculum and complement the school lessons. All school labs share the common mission of getting children and young people interested in science. This is achieved by following an enquiry-based learning approach and allowing visitors to experience science in a hands-on way through independent experimentation. Transferring knowledge by involving participants in

experimental activities is a central pillar of all school labs. Another common aspect of the labs is to provide an authentic approach to science in an appropriate environment, such as a professionally equipped laboratory. Personal contact with experienced scientists and researchers who supervise the students during their visit adds to the authenticity of the learning experience. Besides providing learning opportunities, school labs also convey a modern image of science and technology and their role in today's society. Furthermore, they provide an insight into scientific activities and careers, thereby encouraging young people to take up STEM subjects and studies, thus helping to address the general shortage of skilled workers in these fields. By supporting and complementing schools in providing professional orientation, the school labs also assume a social and economic role.

Overall, the concept of school labs has proved to be very successful, and they are often so popular that they are fully booked for months or even years in advance. School labs present an authentic out-of-school learning environment with a hands-on approach to science, and various studies have suggested that they have the potential to increase students' interest in STEM (e.g. [42,43]). A visit to a school lab is therefore an enriching experience for students and a valuable addition to regular school lessons.

Recommended reads:

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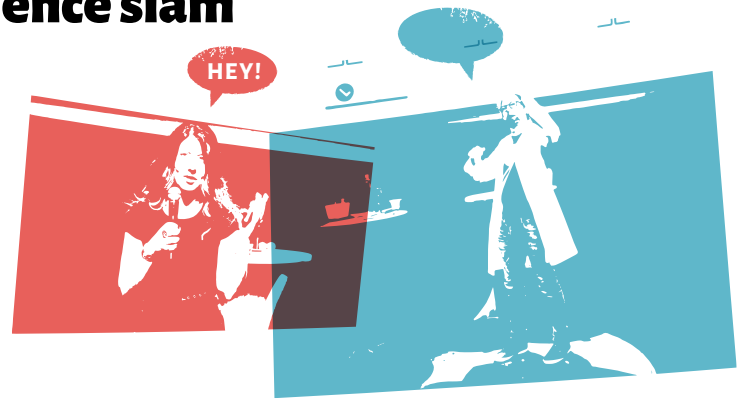
Science slam

by JULIA OFFE



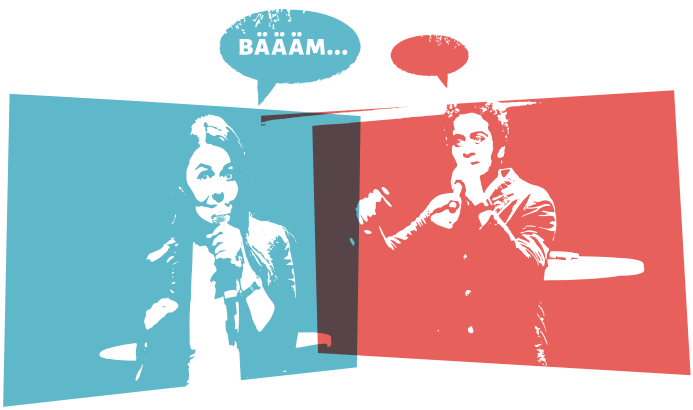
At a science slam, young scientists present their own research projects in entertaining and engaging talks and attract a diverse audience: young and older people, students, as well as non-academics, science nerds and slam fans. The idea comes from the poetry slam, an event that has been popular throughout the world since the 1980s. In a poetry slam, young writers take to the stage and read their own texts. Time is limited to five minutes, and the audience gets to vote on whose performance they liked the best. A science slam is similar: Typically, about six young scientists present their own research projects, the time is limited to ten minutes, and the audience gets to vote. That sounds easy…

But it can also go wrong: If you plan an afternoon event, you only recruit the slammers from your own institute, and you have a random member of staff moderate and serve still water in the institute's lecture hall, you will fail with this format.

The key to a great science slam is the choice of venue and moderator. The venue should ideally be a music club, a bar or a theatre. The moderator should engage the audience, create a good atmosphere and ask for lots of applause for the slammers, without talking too much or trying to take centre stage. To get the audience to actively engage with the topics, the scoring system should encourage discussion: Sets of voting cards are distributed to the audience, and after each presentation, the moderator asks the card holders to talk to their seat mates for a couple of minutes about how many

points they would like to award to that particular talk. The fact that the audience (not a panel of experts!) forms the jury ensures active engagement of the audience with science and creates an interactive, lively atmosphere. At the same time, it encourages the slammers to present their research in a way that is understandable and entertaining to a general audience – because even if there are a lot of young academics in the room, a biologist might have trouble understanding the research of a legal scholar.

Furthermore, the moderator should also make it clear to the slammers that the voting system is there to engage the audience, that it can never be completely fair, and that it says nothing about the quality of their research and certainly nothing about them as a person. The atmosphere among the slammers should NOT be competitive. Prizes should be kept simple (books, chocolate, cups, etc.). And remember: A preparatory workshop in which the slammers get creative together and help each other to get the best out of the performances helps a lot with team building. In a science slam, everything is allowed: props, presentations, experiments. It is not one of those formats that tries to make the performance as difficult as possible for the scientists instead of looking for what's best for the audience.



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Science shows and festivals

WHAT one-off events can do that schools can't

by JOSEPH RODESCH

The lofty goal of science festivals and shows is to get as wide an audience as possible interested in science and perhaps convince some younger visitors to choose a career path in the sciences. However, some critical voices claim that these events are preaching to the converted and are unable to make a lasting impact. Sure, they aren't the only effective method. But in the following, we'll offer some reasons for why these events have their place in society.

Although science festivals and shows have been around for a while, they are still growing in popularity all over Europe. These events have become a hotbed for innovation, where researchers and scientists can showcase their work to a wider audience. However, science festivals are no longer just about natural sciences. In a lot of science festivals, researchers in the humanities and social sciences are making big efforts to design workshops in their field to ensure that everyone can get involved.

Science festivals and shows can also help to break down negative perceptions of science in society. Many people still see science as difficult, boring or inaccessible. By showcasing the exciting and practical applications of science in everyday life, these events can help to dispel these myths and promote a more positive image of science.

While it is true that many visitors already have an above-average interest in science, you can try to invite a broader audience by inviting whole school classes on dedicated days, for example. It's also important to remember that these events are not just about reinforcing what people already know. They are an opportunity to present the latest scientific advancements and to show that science is a field in constant evolution. In addition, many festival booths or show experiments exhibit common scientific concepts in new and

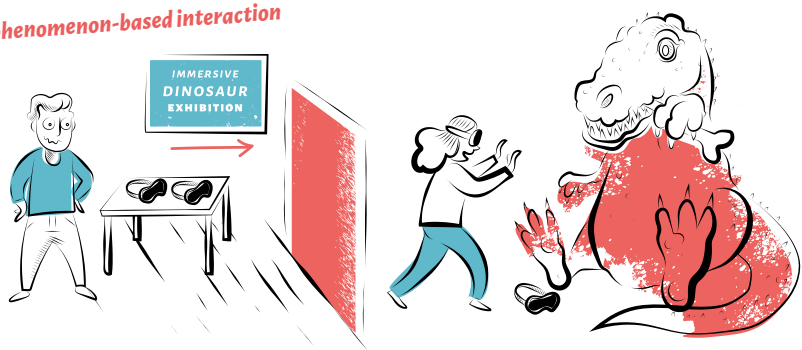
exciting ways, demonstrating great creativity and innovation. This is crucial for maintaining public engagement and ensuring that society continues to see science as an exciting and relevant field.

Science festivals and shows offer a different type of learning experience than schools. They offer a more relaxed and informal atmosphere where visitors can explore science at their own pace and in their own way. This can be particularly important for reaching those who may not excel in traditional classroom settings or who feel intimidated by science. Furthermore, by combining science with fun and positive emotions, trust in science and scientists can potentially be established, which is crucial in a world where science is a key tool for solving complex societal and environmental problems such as climate change.

Science centres and museums

by JULIEN MEYER & GUILLAUME TRAP

UNLOCKING CURIOSITY: FROM *wonder rooms*
TO *phenomenon-based interaction*



The history of science museums and science centres dates back to the 16th century with the emergence of cabinets of curiosities. In these hodgepodge collections of disorganised rarities, the desire to disseminate knowledge to a wider public was born. The idea gained further traction during the 19th century: The upheavals of the Industrial Revolution meant that natural sciences and technology gradually became more prominent as they increasingly influenced people's daily lives. This resulted not only in the first world's fair, the Great Exhibition of 1851 in London, but also in the emergence of natural history and science museums.

To this day, these temples of science house enormous collections representing the diversity of flora and fauna and of technological and scientific achievements. As well as being on display to the public, they are the backbone of original research.

Science centres only emerged in the second half of the 20th century, with the Exploratorium in San Francisco often being regarded as their pioneering archetype [44], although it borrowed many innovative features from precursor European institutions (Urania Berlin, the Deutsches Museum Munich, the Children Gallery of the Science Museum London, the Palais de la découverte Paris [45]). Unlike traditional science museums, science centres prioritise

visitor engagement with natural phenomena and technological principles through the presentation of hands-on exhibits and interactive activities.

Science museums and science centres both pursue an educational purpose. As places of informal learning [46], their primary goals are to engage, educate and inspire the public about science and its relevance to everyday life. Through engaging exhibits, interactive workshops, live demonstrations and educational programmes, science museums and centres aim to foster scientific literacy and critical thinking and to nourish the visitor's curiosity about the fundamental principles that govern the world.

Comparing the ways in which knowledge is communicated in both types of institutions, it can be seen that the boundaries are blurring: In recent years, numerous museums have embraced interactive exhibits as an integral component of their educational approach. Conversely, the principles of museum pedagogy and scenography have found their way into the communication strategies of many science centres. However, their didactic concepts still rest on two different foundations: the preservation and display of original collections on the one hand, and the immersive experience (see illustration) of phenomenon-based exhibits on the other.

Apart from their collections and exhibitions, the success of science museums and centres often depends on the personal interaction of visitors with scientific mediators, who act as the missing link between the often deep and complex scientific phenomena and the public. Rather than being as exhaustive and precise as possible, their goal is often to spark emotions and inspire curiosity when interacting with visitors, while still being scientifically accurate [47]. In this sense, while science museums and centres strive to captivate audiences, it is crucial to ensure that they don't become mere playgrounds where lab coats are handed out as dress-up costumes, leaving little room for scientific depth.

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- Falk J.H. & Dierking L.D. (2011), *The museum experience*, Howells House. ISBN: 0-929590-06-6 ; https://doi.org/10.4324/9781315417899
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- Wagensberg J. (2007), Cosmocaixa: *The Total Museum: Through Conversation Between Architects and Museologists*, Sacyr. ISBN: 978-8461126248


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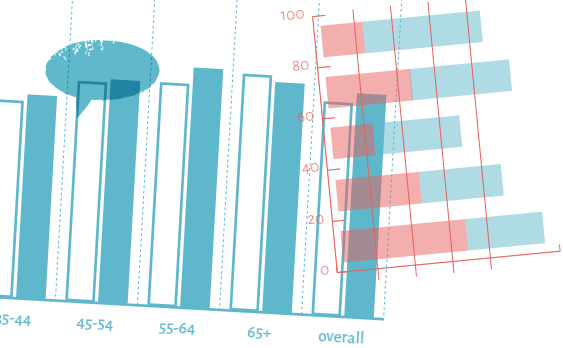


HOT TOPICS

Competition in science communication

by ELISABETH HOFFMANN

It is said that competition is good for business. Whether science is a business or not, competition exists, and hardly any other discipline benefits as much from it as communication. Doing good science and talking about it seems to be the formula for success. Accordingly, communication activities are booming, especially in highly competitive situations. Of course, the new cluster needs a fancy website accompanied by social media, the study programme must now be sung about on TikTok, and rehearsing for a press photo can sometimes take hours, especially for collaborative projects.

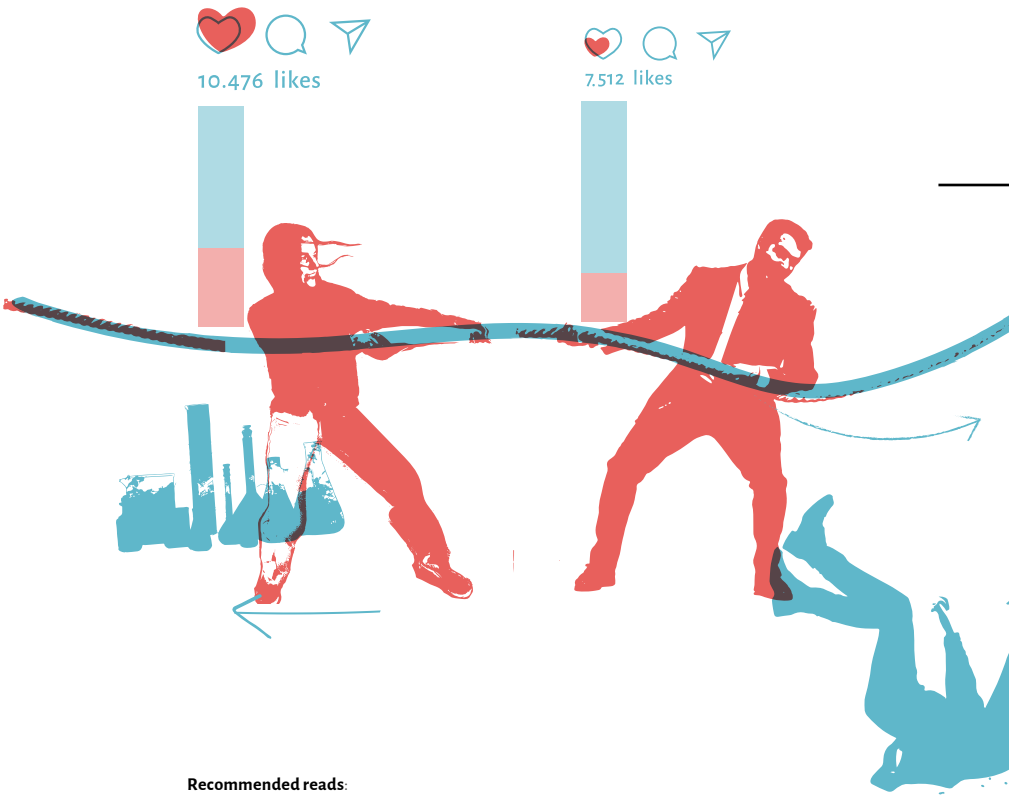
Meanwhile, the introduction of alternative metrics for assessing the performance of academics has strengthened communication at the individual level as well: A higher "social impact", as measured by Twitter retweets and likes, for example, may help in the competition for a professorship. In the best case, the public benefits through more and better information, more creative formats and new opportunities for participation.

Unlike in corporate marketing, however, competitive or "strategic" communication in science also has undesirable side effects. It can be tempting to exaggerate results, conceal failures, and understate risks. At the individual level, it can reward braggarts.

Most people are very good at seeing through product advertising. They know that the sugar content of their breakfast cereal is only listed in small print on the box, and that they don't automatically get a buzz just because the slogan promises it. With science, it's a different story – the claims are expected to be true. In surveys on possible reasons for not trusting science, citizens cite its potential dependence on funders as the most important reason [34]. Competitive communication makes precisely this dependency visible. It can be damaging. Just one example: It is not without reason that the German PR Council, the self-regulatory body for the PR

profession, recently issued its own guideline on science communication. Between 2019 and 2022, three research institutions or their communications agencies have been reprimanded.

So what can be done? Ignoring competition is not helpful. Good science communication is like good science: self-critical and reflective at a high level. It considers all the consequences of its actions, and the more effective they are, the more carefully it acts. In case of doubt, this means foregoing a snappy headline, a cool picture or a new channel, even if others are already using them.



Recommended reads:

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Bad science and misrepresentation

by JEAN-PAUL BERTEMES

Science aims to generate new knowledge with the utmost care and methodological rigour. Unfortunately, misrepresentation of research results and the publication of bad studies or false information also occur in science. This is a major challenge for science because it undermines trust. How do these "mistakes" happen?

Mistakes leading to misinterpretations happen at different levels

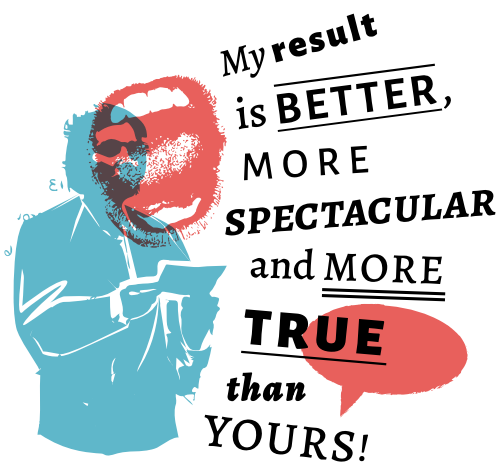
At the level of science: "Publish or perish" describes the pressure on scientists to publish a lot because, unfortunately, their quality as researchers is still too often measured solely by the number of papers they publish. This leads some scientists to publish study results that wouldn't stand up to peer review in so-called predatory journals – journals that claim to be serious academic journals but don't provide peer review or editorial services. This is called bad science. In the worst case, these "bad studies" are picked up by the media. Even if only a small fraction of researchers choose this path, the damage to the scientific community is great. But even serious scientists can make more or less intentional mistakes. To increase the likelihood of being accepted by journals and picked up by the media, scientists may be tempted to make their research results more positive than they are, either through exaggeration or spin. A correlation may sometimes be turned into causation, a finding in animal experiments into a confirmed finding in humans…

At the level of communications departments: Further errors can occur when study results are translated into press releases, either by the journals themselves or by the scientific institutions. A 2014 study found that the majority of press releases about selected medical trials contained exaggerations [48]. Social media posts also run the risk of contributing to misrepresentation, such as through

oversimplification. Science communicators, sometimes urged by their superiors, therefore have an important responsibility to check claims carefully before publishing.

At the mass media level: The media can also contribute to the misrepresentation of research findings, such as by using oversimplified language, avoiding complexity, exaggerating and sensationalising. One study showed that this is much more likely to happen when exaggeration has already occurred at the level of the press release [48]. Such exaggeration can be damaging, as it can create false hope, spread fear or destroy trust in science, for example.

Manufactured doubt: Finally, science can be deliberately misrepresented through manufactured doubt or fake news (see Essential 44). The term "manufactured doubt" is used when known facts and empirical evidence are deliberately altered to promote an agenda, often to make a company or a whole industry appear in a better light. The manipulated version of the facts is very close to the truth but difficult to identify as a lie [49].



Recommended reads:

- Goldacre B. (2008), *Bad Science*, fourth Estate, London, ISBN: 978-0-00-724019-7 https://archive.org/details/bad-science
- Sumner *et al.* (2014), *The association between exaggeration in health related science news and academic press releases: retrospective observational study.* BMJ 349:7015. https://doi.org/10.1136/bmj.g7015
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Fake news, misinformation and disinformation

by JEAN-PAUL BERTEMES

Fake news is a phenomenon that has proliferated rapidly in recent years with the growth of the internet and social media. It poses a major challenge to our democracy, journalism, science and science communication, among other things. According to "The Debunking Handbook", fake news is "false information, often of a sensational nature, that mimics news media content". More commonly used terms are misinformation ("false information that is disseminated, regardless of intent to mislead") and disinformation ("misinformation that is deliberately disseminated to mislead") [50]. A scientific study has shown that false information spreads much faster on social networks than true information, and tends to reach a lot more users. The reason for this doesn't seem to be the algorithms themselves, but mainly psychological reasons: People share false news more than truths. [51]

Of course, disinformation is not just limited to science. But science is vulnerable. Science can easily be misused to lend credibility to disinformation and to deceive people. During the pandemic, we all saw how disinformation can spread doubt and mistrust about science, or even lead people to use dubious methods or drugs with no proven benefit to protect themselves. Disinformation is also fuelled by social bots. One study found that a quarter of the tweets they analysed about climate change came from automated social media bots, many of which sent climate denial messages. [52]

An important question for the readers of this book is: *Is it a duty of science communication to fight misinformation, disinformation and fake news?* It's certainly not an easy task. Fake news headlines are often snappy, shocking, highly emotive and very catchy. The information and the outrage are immediately burned into the reader's memory. When science communication then tries to set the record straight, it is much more difficult. Nuances have to be added, false claims

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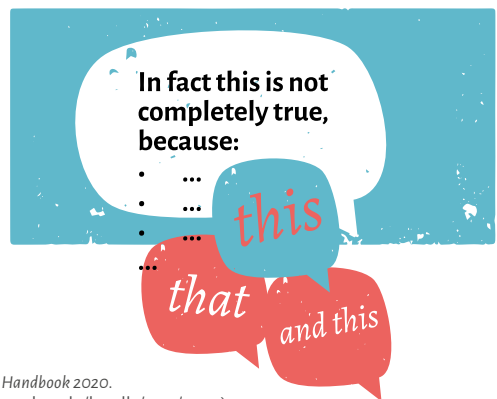
corrected, possibly complex phenomena explained. This takes time and often isn't as memorable. If it goes wrong, the fake news is remembered, the correction is not.

About 10 years ago, there was a certain fear among debunking experts that trying to debunk fake news could backfire: By repeating the false claim while debunking it, you make it even more prominent. But recent studies suggest that this backfire effect isn't as strong as first thought, and debunking is actually very effective when done properly. For example, it helps to stop people from spreading misinformation [50].

But how do you debunk properly? Again, the Debunking Handbook provides some advice: Ideally, recipients of misinformation should be stopped from blindly believing it in the first place. This might be achieved by explaining the argumentation strategies used by manipulators, in order to make people immune to it. But once misinformation is out there, what should you do? First, check if the information is worth debunking. If only a few people have noticed it, why make it more prominent by debunking it? But if it's worth debunking, then do it: First "state the truth", then "point to the misinformation (but don't repeat it, once is enough)", then "explain why the misinformation is wrong" and finally "state the truth again" [50]. A common problem is that debunking often only reaches the "already converted". Although it is very challenging, science communicators should therefore try to reach out to audiences outside the "science bubble".



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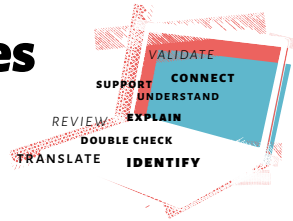
Science Media Centres



by VOLKER STOLLORZ

Journalism about science faces two main barriers. One is that modern science is intrinsically complex and organised into a multitude of disciplines, making it difficult to evaluate domain-specific expertise from the outside. The other is that new scientific knowledge often runs counter to public opinion, so journalistic education must first find a receptive non-scientific public.

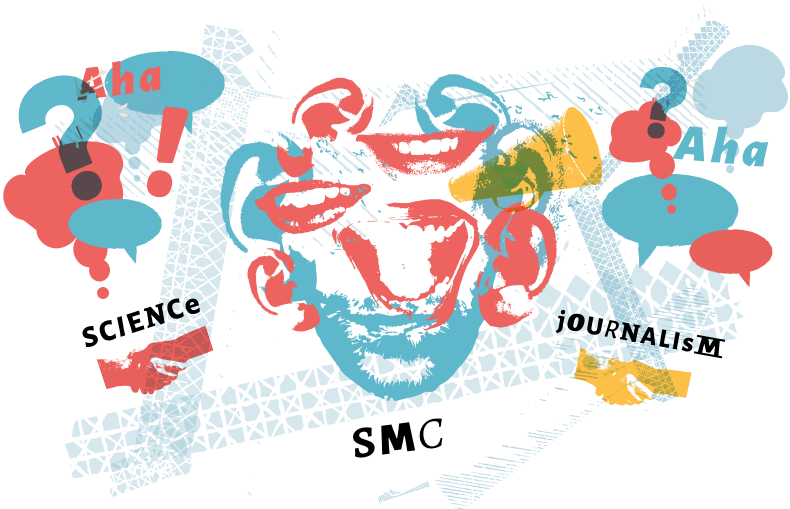
Because modern societies rely on robust scientific knowledge and reputable expertise for individual and collective decision-making, Science Media Centres (SMCs) have been created as new intermediary organisations between science and journalism, with the sole mission of independently informing public debate and discussion on the major issues of the day by injecting evidence-based science into headline news, with a focus on journalism (SMC Charter 2022).

The idea of Science Media Centres was first born in the UK in 2002, but today there is a whole family of independent organisations, such as the Science Media Centre Germany, founded in 2015. Operated by science journalists, it helps journalistic media and ultimately the public to access the best science more easily. Each SMC has a different organisational and funding structure, but they all work proactively with journalists to find third-party expert commentary on relevant scientific discoveries under embargo, to provide credible expertise and scientific commentary on breaking news, or to provide context for complex or controversial public issues such as nuclear energy, embryo research or artificial intelligence.

To gain the trust of journalists, an SMC must remain independent of science PR and science communication departments in order to provide a useful, free, honest brokerage service when science hits the headlines. To do so, SMCs create databases of knowledgeable scientific experts to connect them with journalists on deadline,

with the ultimate goal of helping to get more relevant science and credible researchers into news stories. Recruitment is done mainly by checking websites, scientific databases and bibliometric tools, but researchers at least at postdoctoral level who are willing to engage with SMCs are welcome to submit a CV. The international network of SMCs exchanges local scientific expertise on topics relevant to other publics.

Research on the impact of SMCs on science and journalism so far is rare. For example, Rödder (2020) sees the British SMC as an entirely new, distinct organisational form of science communication that is not subject to the logic of larger media organisations such as science journalism, nor to the logic of larger science organisations such as science PR. Broer and Pröschel (2022), on the other hand, describe the German SMC as a "broker of resilient knowledge, trust, and scientific values".



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Engaging with policymakers

by JEAN-PAUL BERTEMES

Politicians have the authority to make decisions that affect society – decisions in areas that are often complex, high-tech or research-intensive. With a view to evidence-based decision-making and the societal impact of science, it seems worthwhile for researchers to share their knowledge with policymakers. The pandemic has shown that close interaction between science and policy can be fruitful, but that it also presents many challenges. So what do you need to bear in mind when engaging with policymakers?

First consider who is really the best person to engage with. The members of parliament themselves, or will the impact be greater if you target the staff behind the scenes? Or is your local mayor the best person? Or a politician known for their commitment to a particular issue?

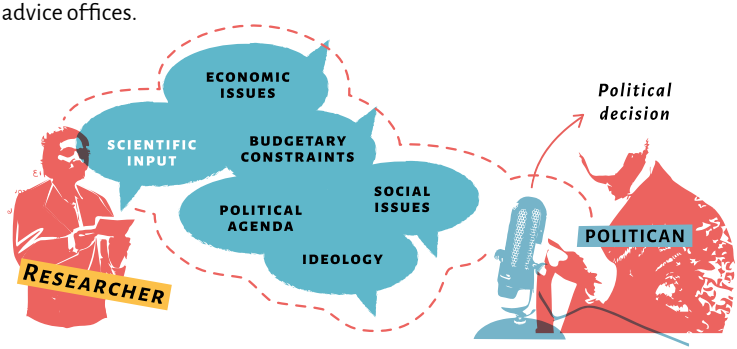
Secondly, it is crucial to focus on the needs of policymakers. Researchers and politicians work on very different timescales. While many research projects run for one or more years, politicians often have to react very quickly to current events. If a politician has to prepare a speech on an issue or is working on a piece of legislation, they may need scientific input on the issue – now or very soon, not in a few months. And while researchers are experts in a particular field, politicians often have to deal with a wide range of different issues. This makes it crucial to be on-point and relevant to the politician, otherwise you are likely to get ignored.

Thirdly, don't be naive. It is not the role of scientists to make political decisions. Nor is it the role of politicians to do exactly what scientists tell them to do. Ideally, politicians can take the scientific evidence on an issue into account before making a decision. But they also have other parameters to consider: budgetary constraints, their party's political agenda, economic and social issues, and even ideology. Also, in many cases, the scientific evidence is not that clear-cut, so science cannot dictate what exactly should be done from a political perspective. Or, the same scientific evidence

allows for different policy solutions. For example, to slow down a pandemic, epidemiologists and virologists may say it would be beneficial to vaccinate as many people as possible with a safe and effective vaccine, if available. But how do you ensure that enough people even *want* to get vaccinated? By providing transparent information, or by legally forcing them to? This is a political question – or, in scientific terms, a psychological or sociological question – and different parties may have different solutions to it, even if they are based on the same scientific evidence.

Lastly, it is crucial to be aware of the role you want to play when engaging with policymakers, and that there is a risk of being "used" for political reasons. You can take a very neutral position, simply explaining the data: what is known, what is not (yet) known. Or you can be more specific and offer options or recommendations. If you focus too much on the data alone, you may not really be responding to the needs of policymakers and you risk being ignored. If you lean too far towards making recommendations, you may leave your neutral role and interfere too much with the policymakers' role. In the book "The Honest Broker", the author explain different roles in policy advice.

Policy advice can be seen as a specific form of science communication for a specific target audience. There are many structures that specialise in policy advice, often staffed by former scientists or journalists. Examples include the research services of many parliaments or governments, whole networks of policy advisors (e.g. EPTA) or specialised NGOs, or even universities with dedicated policy advice offices.



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Risk communication

by HANNES SCHLENDER

Humans are poor at accurately assessing risks (and opportunities) [53]. We tend to focus intuitively on the biggest accident we can imagine – and overlook the daily hazards that are much more likely to occur. Just one example: Think of large-scale research facilities such as a nuclear research reactor: There is, of course, a danger that a very fast military jet could crash into the reactor and release large amounts of radioactivity. Or that genetically modified organisms might escape from a high-security laboratory. The probability of these things happening is not zero – but it is very low, at least in times of stable social conditions.

Of course, society reacts very differently to different risks: What is worse, a higher probability of a serious risk, or a very low probability of a catastrophic risk? There is no right or wrong answer to this.

The role of risk communication is to think through such scenarios before they occur. You need to develop strategies to provide appropriate information about these risks. You need to inform stakeholders about (a) the likelihood of occurrence, (b) the impact in the event of an emergency and (c) precautionary measures, and you need to (d) develop plans for crisis communication – i.e. for the event that the risk event actually occurs. However, the focus must not be exclusively on unlikely worst-case scenarios [54]. Those responsible for risk communication must also consider the much more likely complications and accidents: What about the fire in a laboratory building near the nuclear research reactor? The tragic and fatal work accident in the reactor building that has nothing whatsoever to do with radioactivity? All these things can happen – and they are much more likely to happen than a plane crash.

47.

Those who develop strategies for crisis communication within the framework of risk communication need a broad focus: employees, neighbours, authorities, partners and the media all belong on the list of potentially affected people and institutions [55].

Comprehensive, easily understandable and accurate information must be available to them at all times. Good risk communication also builds personal, trusting contacts with key people in this circle of relevant stakeholders. If the worst comes to the worst, they are the basis for effective crisis communication. Precisely tailored messages must then be communicated professionally by pre-defined contacts at any time of the day or night. Only with such a broad approach can the real risk in risk communication be minimised: the surprise in the event of an emergency.

Recommended reads:

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Crisis communication

by BRITTA SCHLÜTER

Faked research results, an explosion in the chemistry lab, improper animal testing, data theft or workplace bullying – any incident in the scientific community can become a crisis that happens unexpectedly, leads to instability and criticism, and threatens operations, personal and institutional reputation, or even health and life. You don't want a crisis, but it can't be ruled out.

The goal of crisis communication is to minimise the perception of an incident as a crisis and thereby help to manage and overcome the incident. This does not mean lying or hiding grievances, but trying to stay operational and prevent a situation from escalating further. Because crises create an immediate need for information, this calls for quick action. The key is to communicate proactively and with a single voice, thereby controlling the interpretation of the incident. If an issue is likely to be reported in the media, you should be the first to break the news. Those who stay silent will lose control and trust. Competitors, the media or politicians will fill the vacuum with their own version of events.

Even if the expected crisis never happens, institutions should plan for the worst. This is mainly the responsibility of the management. Ideally, a university or research institution will have a crisis manual with protocols, roles and messages for the scenarios most likely to occur and most damaging to its reputation. Well-trained teams, checklists, pro-forma statements and pre-designed websites are of great help. If you are a researcher and a crisis occurs, contact your institution's press office early, utilise their expertise and develop a plan together: How can the crisis be managed? What are the potential threats? What questions are likely to be asked, and what would your answers and arguments be?

48.

In an actual crisis, you should cooperate with the management but should also expect support. Crisis communication is a team effort. The press office needs to be involved, statements need to be agreed and a spokesperson needs to be nominated. The spokesperson needs to keep a cool head and a calm tone: Stick to the facts. Depending on the case, consider taking legal advice. Do not speculate or publicly accuse third parties. If false rumours are circulating, correct them promptly. Make it clear that the problem is being dealt with and say what remedial action has been taken or is planned. Show empathy towards those affected. Always inform internal staff first and keep all relevant stakeholders updated. There is a lot to do and to keep in mind – but remember: You're not alone.

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- Coombs W. T. (2021), *Ongoing Crisis Communication: Planning, Managing and Responding*. Sage. ISBN: 9781483322674
- Swedish Emergency Management Agency (Ed.) (2008), *Crisis Communication Handbook*. NRS Tryckeri, Huskvarna. ISBN: 978-91-85797-11-0 (download: https://www.msb.se/RibData/Filer/pdf/23992.pdf)
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Animals in research

by SERGE HAAN & MICHÈLE WEBER

Animal testing in research has been a controversial and passionately debated topic in science and science communication for many decades. And just to be clear: Researchers do not enjoy killing animals. Great efforts are being made to reduce or replace animal experiments where possible. But in certain cases, animal testing is considered to be of great value and ethically correct.

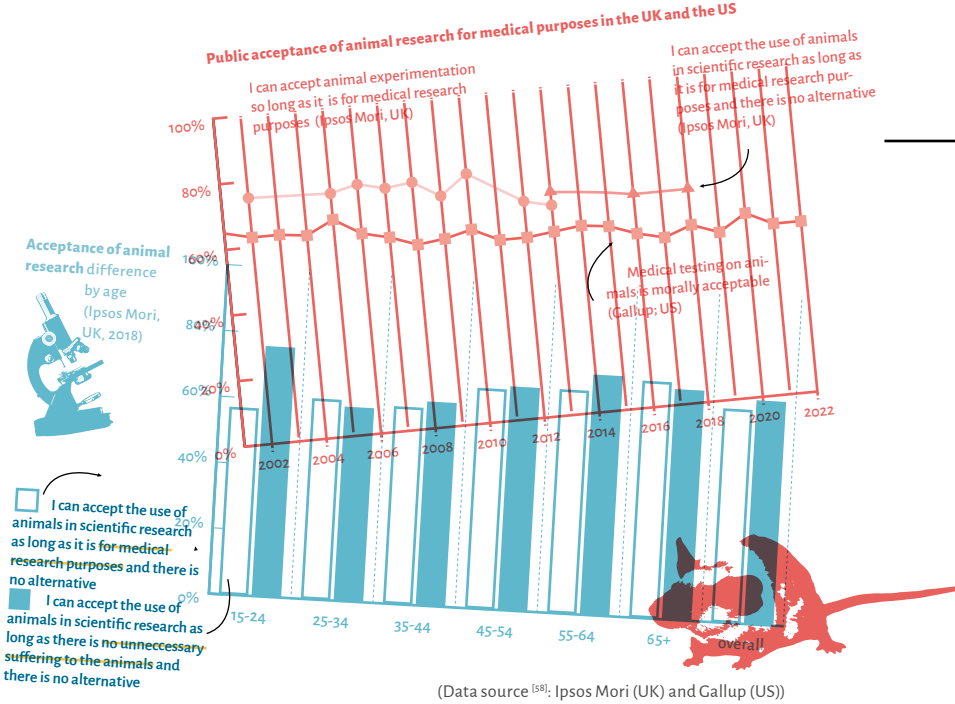
To be able to discuss this topic as a scientist – regardless of whether your research involves animal experiments or not – you need to be aware of how it is perceived by society. There are many people who have no problem with animal research as long as the control mechanisms work and the aims are noble (see illustration). Others are not OK with it and would accept the consequences, and others are even militant. Public perception can vary from country to country and change over time. If the research you are communicating involves animal testing, you should prepare your communication around this work accordingly.

Do some background research/reading: *(i)* If you head a communications department, you need to ensure that a communication strategy around this topic is in place. *(ii)* If you are a researcher, you need to align your communication with the institution's communication strategy. *(iii)* Know how animal testing is regulated in your institution/country and be familiar with the 3Rs (replace, reduce, refine). *(iv)* Research some facts, figures and myths. For example, cats, dogs and non-human primates account for 0.2 per cent of animals used for research in the EU (2019) [56] and animal experiments for cosmetics have been banned in the EU since 2010. *(v)* Understand public opinion and be aware of different perceptions. For example, in the US, 60 per cent of men in a survey said they support the use of animals in research, but only 35 per cent of women said the same [57]. There are significant cultural differences regarding what is considered necessary for animal welfare. And empathy towards zebrafish or dogs also varies widely.

49.

Prepare your communication: *(i)* Focus on research results rather than the technical approach. *(ii)* Be prepared if the topic comes up in an interview with a journalist. Check if your institution has a dedicated webpage or fact sheet that you can refer to. *(iii)* Put things in perspective: Many animals are killed for food/hunting/clothing or in car accidents. *(iv)* Avoid getting involved in lobby/opinion debates (for/against animal testing). *(v)* Consider the factual and emotional side. *(vi)* Mention the 3Rs principle.

There is more and more proactive communication around this topic, as the research world has recognised that it can only rectify the false images and misconceptions that the public might have by being more open and transparent. Eight European countries have now signed transparency agreements to communicate more openly about animal research.



(Data source [58]: Ipsos Mori (UK) and Gallup (US))

Recommended reads:

- https://www.understandinganimalresearch.org.uk
- https://www.animalresearch.info/en/
- https://www.nc3rs.org.uk/

Ethical perspectives

by OLIVER GLASSL

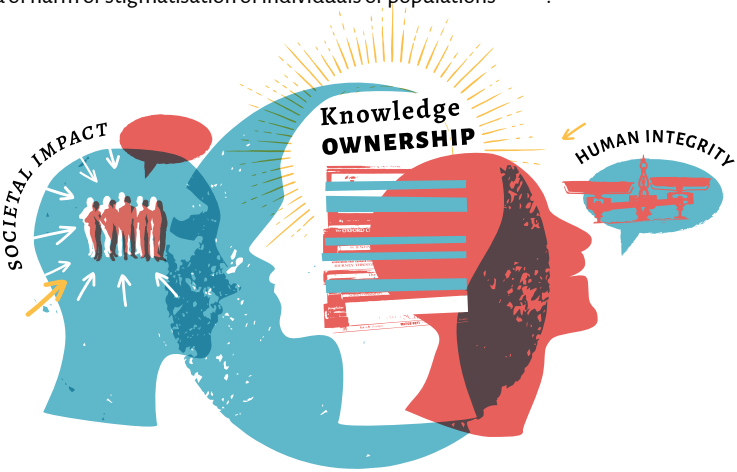
Ethics is the systematic study of the rules, beliefs and values that determine human behaviour in a given social context and the attempt to derive specific principles to support decision-making. These principles are usually referred to as ethical theories [59]. Dating back around 2,500 years, it is probably one of the oldest scientific disciplines. Applied ethics also plays a key role in academia: Today, a significant portion of research projects must be approved by an ethics committee before they can be carried out, taking into account the potential for harm to individuals and entire populations. Consequently, ethics is also important in science communication – and as science communication draws from numerous disciplines, relevant ethical challenges should also be discussed from various perspectives [60]:

One perspective is that of the *ownership of knowledge*: Given that research significantly shapes our world and can have a major impact on the life and autonomy of individuals, the public has a right to be informed about research activities and results in an understandable way. This is particularly important in democratic societies, which rely on informed decisions by their members [61, 62]. But open access to any kind of knowledge can also be problematic: Should the public be informed in an easy read on how to build a biological weapon just to respect the principle of common knowledge ownership [60]?

Another angle to consider is the potential *societal impact* of science communication: The science of science communication has become a well-established discipline that has yielded numerous instruments to make science communication more effective. Institutions and companies invest considerable budgets, as they have understood its potential to support their mission [62]. Science communication has become an influential element in modern societies, constantly catalysed by ever-developing new forms of

electronic media – the communication of research results increasingly determines political discussions and decisions. However, communication about a specific research result could also compete with institutional or individual interests of the communicating party. Irrespective of the source of funding, whether public or commercial, the communication of scientific findings carries the potential to adversely impact future financial support: Research is characterised by uncertainty of outcome [63, 64], which poses the risk that a research result may interfere with the objectives of the funding party. The decision of what to communicate and what not to communicate is therefore already ethically charged.

Finally, the style of communication should consider the recipients' *human integrity*: Conveying complex content to lay audiences requires simplification, contextualisation and framing, which increases the risk of message bias (e.g. towards a desired effect) [62]. Being aware of the challenges in the competitive field of science, the science communicator should nonetheless strive to communicate in an unbiased, truthful and accurate way while respecting the harm limitation principle [60], which is best achieved in institutions where such a culture is well established. As a basic principle, science communication should support human integrity and avoid any kind of harm or stigmatisation of individuals or populations [1, 60, 62].



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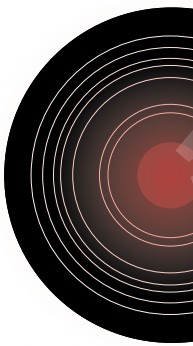
AI in science communication

This article was generated in January 2023 using the prompt "write 3000 characters on the use of artificial intelligence in Science Communication" ... feel free to rechallenge the bots over time.

by chatGPT



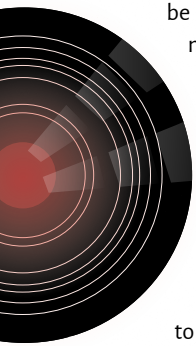
Artificial intelligence (AI) has become an integral part of science communication in recent years, transforming the way we share and disseminate scientific knowledge. From analyzing data to predicting future trends, AI is helping scientists and science communicators to understand complex information and communicate it to diverse audiences. In this article, we will explore the various ways AI is being used in science communication.

One of the primary applications of AI in science communication is data analysis. AI algorithms are used to analyze large datasets, enabling scientists to discover patterns, trends, and relationships in the data. This can help researchers identify new scientific insights and communicate their findings to the wider public. For instance, AI can be used to analyze large sets of medical data to identify patterns and potential treatments for different diseases. This analysis can then be presented in a way that is accessible and engaging to the general public, providing them with valuable information on the latest medical research.

Another important application of AI in science communication is in natural language processing. This involves the use of AI algorithms to understand and analyze human language, enabling computers to interact with humans in a more natural and intuitive way. This

is particularly useful in science communication, as it allows for the creation of chatbots and other AI-powered tools that can answer questions and provide information to the public. For instance, a chatbot could be designed to answer questions about climate change, helping people understand the science behind the issue and the potential impacts of global warming.

AI can also be used to create more engaging and interactive science communication content. For example, AI-powered virtual reality (VR) and augmented reality (AR) experiences can provide users with an immersive and interactive learning experience. This could be used to create virtual labs where students can conduct experiments, or to simulate scientific phenomena that are difficult to observe in the real world. This type of content can be especially useful for engaging younger audiences, who are more likely to be interested in interactive and visually engaging content.



Finally, AI can be used to analyze and predict audience behavior and preferences. This is particularly useful for science communicators, as it enables them to tailor their content to specific audiences. For example, AI algorithms can be used to analyze social media data to understand what types of science content people are interested in and how they engage with it. This information can then be used to create content that is more likely to be shared and engage with a wider audience.

In conclusion, AI is transforming science communication by enabling scientists and communicators to analyze and understand complex data, create engaging and interactive content, and tailor their messaging to specific audiences. As AI technology continues to evolve, we can expect to see even more innovative applications of AI in science communication in the future. However, it is important to note that AI should always be used in a responsible and ethical manner, with a focus on promoting scientific accuracy and promoting public understanding of science.

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