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# Introduction to the volume

To ask someone what "science communication" might be can bring surprising and very diverging results: some would call the communication of, say, a higher education institution a prototypical representative of this notion, as they conceive of "science communication" as something strategic. Others might say that a paper in *Nature* is an appropriate example, or a blogpost or an article in *Scientific American*, as both are very closely connected to scientific content, even though the communicative intentions are different. Others might name science centers or museums as good examples, as these institutions try to teach their audiences about science. Others might mention a new edition and translation of the work of Copernicus as a significant contribution in the field.

These few examples – there could be many more – show that science communication is a multi-faceted notion. This handbook embraces the multitude of meanings and hence addresses many diverse communicative acts that entail a relationship to scientific knowledge or work, stemming from institutions or individuals, addressing both scientists or the public, intending to inform, influence, enlighten, argue or otherwise negotiate about science. In these and many other aspects, the handbook takes a broad perspective: It looks at communicating individuals and institutions; it starts off from a broad notion of "science" – not excluding any scientific subject –, and it adopts an inter- or multidisciplinary approach to the field. In this introduction we will give the reader some basic guidelines and notions to grapple this multitude and to navigate through the book.

## 1 Internal and external science communication: broad notions

In modern societies a broad range of scientific disciplines produce knowledge, either as a value in itself or for the sake of practical utilization. In this handbook we use the term "science" as an umbrella term not only to refer to the natural sciences but, in its broad sense, to comprise the humanities, research on art, the social sciences, and other scholarly fields of inquiry, that are guided by principles of systematic research.

Given that, we also take communication to be a vital backbone of science: communication contributes in many ways to produce knowledge. It is also crucial in order to publish knowledge, to make scientific results available for scrutiny. In addition, communication is the basic tool to organize the process of scientific research itself. If one looks at science and its disciplines as a more or less closed system, one can term its communicative aspects as "internal science communication" or "internal scientific

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communication". However, science and scientific knowledge are also communicated to a wider public, science can become the topic of communication beyond specialized disciplines. One can dub these aspects and forms of communication as "external science communication". These two perspectives do not produce clear cut boundaries. There are various relations and there is a specific dynamic in the configuration of internal and external science communication.

Internal science communication has a lot to do with epistemic practices like taking notes, writing a lab journal, summarizing texts, discussing preliminary data, etc. It also deals with relatively formalized sorts of texts, like a paper in *Nature*. External communication flourishes with a wide spectrum of formats, but also of actors and institutions with their respective communication interests, be they strategic, popularizing, enlightening, dialogue-oriented, or else. External, in contrast to internal communication, cannot assume that communicative partners share the same scientific values, accept the same methodological principles or "speak the same language".

In this handbook, we touch upon both perspectives on science communication, the internal and the external one, fathoming a variety of aspects concerning the different communicative practices. In doing so, the handbook will also include the – presumably expanding – grey zones between internal and external science communication: On the one hand, internal practices like debating truth conditions or the substantiation of a scientific argument enter more and more the public sphere, which can be seen on debates about controversial issues like climate change or homeopathy on Twitter. On the other hand, social software and its instruments for counting and evaluating impact are entering and possibly changing the scientific field, e. g. by scientometric methods like *altmetrics*.

Within the last years, a new field labelled *scholarly communication* has emerged which focusses on open access, strategical planning of communicative infrastructures, the planning of administrative, financial and funding policies, library and digital services management, etc. In this handbook we stick to the term *scholarly communication* in its traditional meaning referring to all aspects and forms of communication within the realm of scholarly activities, without assuming, however, that this usage is exclusive.

In case our authors chose to use notions and definitions, mentioned here, otherwise, they explicitly refer to it.

## 2 Dimensions of science and science communication

The interrelation between science and science communication shows a number of important dimensions which generate perspectives of research on science communication. In this section, we mention some basic assumptions concerning this relationship.

## Epistemic function

The basic function of scientific communication lies in its role for the constitution, the systematic production and the scrutiny of knowledge. In order to fulfill this function, specific communicative tools have evolved over time, e. g. forms of language use, text types, spoken genres, forms of visualization, terminology systems, activity types like quoting or defining, etc. They form organized repertoires that answer discipline-specific needs. Besides, they are the product of historical evolution and in some cases the result of intentional design, and they are closely connected to technological development and media usage.

## Communication and the social organization of science

In science, knowledge in itself is worthless if it isn't communicated to anyone in the field. (If the same statement is also true for the communication to the public is still a matter of debate.) For science, not communicating to the scientific population would mean to not acting scientifically. The other side of this coin is, that no science can be done without taking note of the work of others and referring back to it. The creation – via language and visualization, or, today, all multimodal tools at hand – and dissemination of findings and insights were always part of science, connected with different communicative acts: Certification (of a dissertation, or of an argument), conjecture and refutation (in a scientific dispute), contextualization (within a field), proving or substantiating (of a hypothesis), applying and pledging (for a grant), etc. The connection of scientific work and scientific communication is more than an addition. Communication can help to develop ideas, it can be an epistemic tool in itself or, at least, being supportive to the epistemic work of scientists. In short: for this handbook we assume that communication and science always belong together.

## Science and science communication in society

Science is an integral part of modern societies, it fulfills functions for society and its systems (e. g. economy, culture, sports, architecture, medicine, mobility, or education), scientific institutions are funded in and by societies, scientists are persons that have other social roles as well, and science relies on infrastructure that is publicly funded (e. g. libraries, data licences, research technology). These close relationships are mirrored by multi-faceted communicative ties, e. g. in grant proposals, budget reports or scientific reports, in the products of science journalism, "third mission" activities, knowledge popularization, or the scientific "voices" in public controversies over questions of general interest.

## The individual perspective

As a rule, individuals and institutions are connected within science communication. A prominent figure is the scientist her- or himself: Scientists are not born into this world as scientists. They have to acquire knowledge, research or writing skills, principles of conduct, a certain habitus, etc. Becoming a scientist takes many years and is often an important aspect of the life of an individual. His or her development is closely tied to infrastructure provided by society and by a huge number of acts of communication (e. g. writing papers and reading comments on papers). Being educated at school, studying at a university, starting a career as a researcher, and working as a scientist are in large parts communicative endeavours, that have an individual and a social side. Each aspect of this complex configuration is an object of study, e. g. the question how people acquire individual writing or publishing skills according to the (supra-individual) needs of a specific discipline or a research community.

## Medialization

Connected with questions of societal or technological development and embedded into a highly medialized world, scientific questions, methods and outcomes are more and more debated on a social and political level. Changes in the medial landscapes offer to virtually everyone the possibility to communicate, defend, argue, oppose, or overtly ignore scientific knowledge. How knowledge can be used and what a scientific argumentation is like is more and more not only a scientific matter, but also debated on the tribunes of the medialized world. Communication of and about scientific content with different publics are both politically fostered and on the rise in some countries (whereas in others, media are used to oppress communication on science). The communication types in different fields of external science communication are highly differentiated and medialized: from different styles and types of science journalism to strategic communication, e. g., of scientific institutions; from public talks of scientists to science slams and multi-medialized science centers and museums.

Equally, the medialization of internal science communication has changed during the last decades with a highly differentiated spectrum of new formats, new media and forms of communication and publication (e. g., video abstracts). The use of old and new formats is currently a matter of dynamic development, and publishing practices are constantly evolving. Different disciplines tend to prefer different publication strategies, and sometimes publication trends vary from country to country (like the usage of weblogs, the prevalence of book publishing or the urge to publish in high impact journals). Some fields turn towards open access journals or engage into pre- and post-publication discussions online. Many medialized communicative and epistemic practices emerged, from wikis and weblogs to social networks offering both a repository as well as a communicative function, like ResearchGate.

### Technological change and science communication

Both internal and external communication are often driven by the same type of technological change: both take advantage, e. g., of a broader bandwidth for data exchange, of social software technologies, of algorithms structuring information research, or of mobile media usage. Both struggle with analogous phenomena, e. g., the overflow of information and the fact that, without algorithms, nobody will find anything of relevance any more in the current information tsunami. However, technologies do not determine changes in science communication. They offer possibilities, affordances that human actors have to use in a productive way.

### Historical dynamics

The recent dynamics in digitalization are only one step in a long tradition of technological developments that have significantly changed scientific communication: the printing press, microscopes and telescopes, the x-ray technology, or presentation technologies, to name but a few. In a broader view, *all* aspects of science communication are subject to historical evolution, be it change or continuity: text types, oral forms of communication and presentation, terminology systems, forms of collaboration, types of visualization, the available media, etc. These aspects do not develop individually but as parts of complex configurations that evolve in time.

The dimensions described so far build up a complex architecture of (mutual) relationships, e. g. the intertwining of the individual and the social. In order to organize such a complex topic, different strategies are possible. These following strategies described in the next section form a blueprint for our handbook.

## 3 Perspectives on science communication and the structure of the handbook

For this handbook, we decided to combine a *first strategy* that looks at different research approaches and asks for their specific contribution to the study of science communication. This is the aim of section I. A *second and third strategy* is to describe main topics and central aspects of internal and external science communication. This is the aim of sections II and III, respectively: In section II the authors deal with text types, media, and practices of internal science communication. Section III is devoted to external science communication and the relation between science, scientists, and the public. A *fourth strategy* is based on an evolutionary perspective: How has science communication evolved, what are current trends, and what could or should be future developments? In sections IV and V the authors share an evolutionary perspective:

they deal with the history of science communication and with current and future trends.

Below we will sketch the content of the sections in more detail.

## Section I: Perspectives of research on scholarly and science communication

This handbook takes communicative acts, their role and their organization in science communication as a starting point to bring together current research on the topic, giving linguistics, media and communicative sciences a certain priority. But a major purpose of this handbook is to show the disciplinary variety within the field sometimes called "science of science communication", i. e. we asked not only linguists and media or communication scientists, but also philosophers, mathematicians, psychologists, sociologists, political scientists, information scientists, visual scientists, and scholars of Science and Technology Studies to spell out the theoretical, methodological and empirical approaches to the field of research on science communication. If "the science of science communication" can be a considered as an emerging field, we decided to explore this field from many relevant perspectives.

Section I is gathering disciplinary approaches to science communication that seem most relevant to us. It starts with philosophy of science "in twenty-two questions" by Gregor Betz and David Lanius, presenting and discussing notions and questions from epistemology and theory of science, like the role of Popperian falsificationism, and their relevance for science communicators. In Chapter 2, Friederike Hendriks and Dorothe Kienhues open up a rich empirical overview on psychological and pedagogical literature concerning science literacy, the way children deal with science, and bounded rationality. Chapter 3 discusses the notions of medialization in the light of visualization, popularization and digitalization from a media studies perspective (Hans-Jürgen Bucher). Mapping the field of the vast empirical literature in communication science is the task Mike Schäfer, Sabrina Kessler and Birte Fähnrich took over in Chapter 4. In Chapter 5, also rooted within communication science, Hannah Schmid-Petri and Moritz Bürger presents a model to grasp the complexity of science communication via network theory. In Chapter 7, the contributions of Science and Technology Studies is presented by Gábor Zemplén, also including the historical development. Chapters 7, 8, and 9 take up the linguistic perspective: Chapter 7 covers linguistics and semiotics including a historical review (Nina Janich); Chapter 8 examines the sub-discipline of terminology research (Britt Schuster), and Chapter 9 presents empirical research on how students grapple with writing tasks in the academic realm (Thorsten Pohl).

## Section II: Text types, media, and practices of science communication

This section is dedicated to internal scholarly communication in the sense discussed above: communicative products of and acts between scientists from the same discipline or from different fields are at stake here. Thomas Gloning (Chapter 10) opens up the section with an overview and a discussion of epistemic genres in science communication. Luc Pauwels presents his approach on visual representations in knowledge production in Chapter 11 and gives an overview of research in the field. Henning Lobin (Chapter 12) points out the fruitful links between presentation and rhetorics in the context of presentation technology. Sylvia Jaworska (Chapter 13) offers a rich overview on empirical work on spoken language, which she characterizes as a late-blooming field. In Chapters 14 and 15, Gerd Fritz is investigating two important forms of communication in science: reviewing, as a discipline specific way of commenting and quality checking in science, and scientific controversies, both from the point of view of linguistic pragmatics and action theory. Chapters 16 and 17 are closely linked, as Thomas Gloning gives an introduction into symbolic notations in several fields, also including historical perspectives, and Michel Serfati specialized on the rise of symbolic notation in mathematics. Finally, Benedetto Lepori and Sara Greco present their approach to grant writing in Chapter 18.

## Section III: Science, scientists, and the public

The authors of this section deal with prominent, disputed, and sometimes neglected aspects of science communication in the public sphere. Wolf-Andreas Liebert (Chapter 19) starts out from traditional popularization strategies from a linguistic point of view, describing basic prototypes of popularization in different settings. Sharon Dunwoody (Chapter 20) traces the development of science journalism and its challenges globally and especially in the digital age. Holger Wormer (Chapter 21) makes a strong argument for independent and sceptical science journalism and the conditions for academic teaching of this subject, which could be a model for journalism teaching in general, also in the field of data journalism. Charlotte Autzen's and Emma Weitkamp's contribution (Chapter 22) can be read partly as a counterpoint to Wormer's, as they focus on the blurring boundaries between journalism, PR and science communication in general – boundaries he considers essential. Philipp Schrögel und Christian Humm (Chapter 23) offer definitions and clarifications in the sphere of advocacy and advising and discuss the question if scientists should, or should not, try to speak truth to power. Philipp Niemann and his colleagues (Chapter 24) present empirical findings relating to newer formats like scientific web videos and science slams and the question how they are perceived and understood by the viewer.

## Sections IV and V: evolutionary aspects of science communication

As mentioned above, sections IV and V share an evolutionary perspective: the authors deal with the history of science communication (Chapters 25–27) and with current and future trends (28–31).

Section IV is dedicated to the historical perspective of science communication. Thomas Gloning gives an overview on historical developments of internal scientific communication in Chapter 25. The contribution of Monika Hanauska (Chapter 27) focuses on developments in external science communication, as far as they can be separated from internal ones. Michael Prinz (Chapter 26) elaborates on three prominent scholarly communication activities in history: lecture, disputation, and dissertation.

In section V we are completing the picture with four views on current trends and the future of science communication. Martina Franzen (Chapter 28) considers science communication as a subject for the sociological study of societal change and discusses in depth how new media usage will revolutionize scientific publication. Mareike König's contribution (Chapter 29) is linked to the argumentation in Chapter 28 and discusses in detail how new media usages have the power to merge internal and external ways of communication. Peter Reuter and Andreas Brandtner (Chapter 30) show how libraries are changing from a knowledge reservoir to a knowledge facilitator in the digital age (Chapter 30). Annette Leßmöllmann wraps up the volume in Chapter 31 by discussing current trends and future visions for both research on science communication and science communication practice presented in this volume and elsewhere.

## Other reading perspectives

Apart from the sections and its topic structure, the volume offers possibilities to pursue different interests and thus cherry-pick across sections. We mention some of these reading perspectives here, cautioning the reader that this is by no means a complete list:

- For philosophical advice for practitioners in science communication, we recommend Chapter 1.
- Vocational fields are the main topics of Chapters 20, 21, and 22. Chapters 25 and 27 touch this topic from a historical perspective, Chapter 31 from the perspective of future developments.
- Empirical findings are focused on in Chapter 4 with the communication science perspective, Chapter 5 with the psychological and pedagogical angle, Chapter 8 on terminological research, and Chapter 13 on spoken language.
- New frameworks for future research are advocated in Chapter 5 (network theory), Chapter 11 (visualization), Chapter 28 (science communication and social change),

Chapter 18 (grant proposal writing), Chapter 23 (advocacy and advice), Chapter 24 (new formats and their reception), and Chapter 31 (future trends in general).
- Many chapters touch the question of new media usage, but some of them focus on it: Chapters 28, 30 and 31, and in part Chapters 14 and 15.
- Chapters 16 and 17 concentrate on the aspect of formalization.
- Chapters 6, 7, 14, 15, and 20 touch historical aspects of their topics, respectively. They complement the three historical Chapters of section IV.
- Those interested in a linguistic perspective will not only benefit from Chapters 7, 8, and 9, but also from 10, 12, 13, and 19, and with a perspective of pragmatics and action theory, especially from Chapters 14 and 15.

# 4 Conclusion

The aim of the multidisciplinary and multi-faceted strategy for this handbook is to open up the view on a field with multiple perspectives on scientific communication. This handbook should be seen as a navigational device through these multi-perspectives. With many cross references, we tried to assist the reader to find possible touch points and pointers to future work. The common theme of this book is thus not to set basic notions, theories and methods into stone, but to thoroughly pin down approaches and the state of the art in order to open up future developments and perspectives on science communication as a research field with a lot of basic and applied research done – and still to be done.