Chapter 1

Setting the Scene

Anne M. Dijkstra, Liesbeth de Bakker, Frans van Dam, and Eric A. Jensen

1.1 Introduction

Science communication is at the heart of many of the 21st century's most consequential issues. From climate change to artificial intelligence and biomedicine, science and technology are playing an important role in people's lives to an ever-greater extent. Science and technology are also considered important drivers for enhancing innovation. Moreover, citizens' role in engaging in democratic decisions about science and technology is vital, as such developments affect all people. This important role of science and technology leads to questions such as the following: How do people make sense of scientific and technological developments? How can societal needs and concerns be included when developing science and technology? How should communication about science and technology be conducted? Science communication practice and research is on the front line, helping both scientists and citizens grapple with such questions.

Communicating about science and technology comes in many different forms. Telling people about science is one important task. In addition, it is widely accepted that people should be able to engage with science and technology topics at a democratic level because science and technology affects all our lives. Communications on science and technology have been ongoing for a long time and have gained importance in recent years. Yet, science communication as a profession and a field of study is still relatively young. Historical events, societal changes, and other fields of practice and research have influenced the development of science communication. This book aims to provide readers with an accessible starting point to get an overview and to understand better what is known about science communication in practice and in research.

This book evolved out of a Dutch introductory text to science communication for Dutch practitioners and students. In recognition that science communication has become a worldwide practice and research field, this book has aimed to increase its international scope and relevance. An international review panel with well-respected colleagues from South Africa, China, and Mexico were asked for their guidance and input to extend the book's perspective. The book, hence, attempts to provide insights not only from a Western perspective. Instead, it includes a broader set of findings, principles, difficulties, and approaches that can flexibly be used to understand science communication in different cultural contexts and situations. This chapter sets the scene for engaging with science communication as a topic. It provides important concepts, ideas, and developments in science communication, which are presented within the context of a changing world, to aid in understanding the chapters that follow.

1.2 Science Communication: An Evolving Profession and Field of Study

Over the past few decades, especially since the 1980s, in many countries around the world, science communication has grown into an increasingly recognized profession and a field of study (see also Bucchi & Trench, 2016; Guenther & Joubert, 2017). Science communication always involves connections between science, technology, and society about (an application of) this science and technology. A great diversity of participants may be involved in this process, including scientists, policy-makers, activists, ordinary citizens, and other groups. The science communication process is dynamic, constantly changing, and driven by a variety of interpretations, views of science, and communication goals.

Science communication is a term that is widely used and interpreted in various ways. For this book, the editors have prepared a working definition of science communication, based, among others, on the discussion about public engagement from the website of the UK National Coordinating Centre for Public Engagement (2019):

> Science communication describes the many ways in which the process, outcomes, and implications of the sciences — broadly defined — can be shared or discussed with audiences. Science communication involves interaction, with the goal of interpreting scientific or technical developments or discussing issues with a scientific or technical dimension.

Approaches to science communication can range from an informative program on television in which information is transmitted to an audience (a so-called transmission-oriented activity) to dialogue sessions gathering public input about their views which will be strongly based on interaction between two involved parties (a so-called transaction-oriented activity). In transmission-oriented activities, one-way communication is mainly involved, while in transaction-oriented activities two-way communication is key. Goals for science communication may vary and overlap. They range from raising awareness and increasing appreciation for science and technology; sharing findings and excitement and, thus, aiming for enjoyment for science and technology; increasing non-scientists' knowledge and understanding; and influencing science-related opinions, views, and behavior or even people's policy preferences to engaging with others in order to include their perspectives in decisions about science and technology. The need for such a 'listening' approach in the last goal is particularly recognized with controversial science and technology topics (see also the report of the National Academy of Sciences, NAS, 2017).

In all science communication efforts and activities, science communicators take different roles, related to their aims (Jensen & Holliman, 2016). These roles can play out in transmission-based as well as in transaction-based approaches, or in anything in between. A journalist who writes a critical piece in the newspaper may aim to influence opinions, a museum staff member who develops activities for high school students may want to increase scientific understanding, while a scientist who presents an enthusiastic story for a science café public may be aiming for increasing knowledge and awareness. These are all examples of people who communicate about science and technology. And they all take up different roles in the communication process, as an intermediary, educator, facilitator, or expert. They are all practicing science communication. In addition to the roles these science communication professionals play, there is also a role for science communication researchers, that is, those who conduct research on science communication. These researchers or scholars often aim to better understand science communication processes as well as the effects of science communication.

As a field of study, science communication is heavily influenced by other disciplines, as shown in Box 1.1, which means that science communication practitioners as well as researchers bring in a rich variety of knowledge, related to their own backgrounds. The variety of communication approaches and roles for communicators, as well as their different backgrounds, make the field of science communication complex, challenging, and interesting.

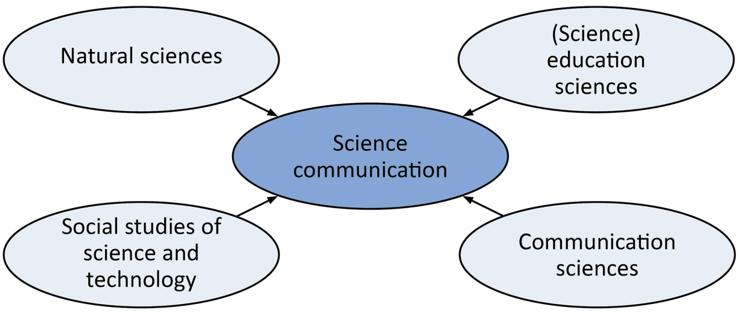
Box 1.1: Research disciplines and the field of science communication.

The field of science communication has been affected by several long-standing academic domains, most importantly by communication sciences, social studies of science and technology, (science) education sciences, and the natural sciences (Mulder, Longnecker & Davis, 2008). Important insights out of the academic domains of sociology and psychology feed three of these four key domains, and for the sake of overview, the domain of journalism and media studies is seen as a part of communication sciences.

Existing science communication courses taught at universities across the world often combine knowledge from several academic disciplines within their own curriculum along with the perspectives of practitioners (see Figure 1.1). According to Mulder, Longnecker & Davis (2008), knowledge from the natural sciences and the life sciences plays an important role in the 'translation' of information. Communication theories and communication skills provide a link between theory and practice. Knowledge about learning and teaching is also important in successful communication. This is especially the case in the area of informal learning. And the field of science and technology studies contributes to science communication through research into the interaction between science and society, its advice to policy-makers, and the reflective questions it raises about the nature and role of science and technology. Mulder, Longnecker & Davis (2008) also recognized other key knowledge domains such as sociology and psychology, and journalism and media studies.

Box 1.1: (*Continued*)

Science communicators can carry out their jobs informed by some of the different knowledge domains. For example, a museum staff member may use knowledge from the educational domain. A communication consultant at a hospital may use scientific knowledge about diseases and knowledge from communication studies when designing communication processes. Science domains that nourish science communication are themselves also influenced by developments in the science communication field. For example, natural scientists are becoming increasingly aware that scientific and technological developments are closely tied to social developments, and, therefore, in many countries, communication skills are now part of the expected competences for scientists (Gibbons, 1999). Over the past few decades, it has become increasingly accepted that multiple groups are involved in the complex relationship between science, technology, and society and the development of science and technology.



Source: Based on Mulder, Longnecker & Davis (2008).

Figure 1.1: Research disciplines influencing science communication.

1.3 Changing Views on Science Communication

Starting in the early 19th century, in 1825, the physicist Michael Faraday, a member of the scientific society called the Royal Institution of Great Britain, initiated the annual Christmas lectures in which scientists presented scientific subjects to a general audience. These lectures continue to the present day and reach a large, mainly young audience. The Christmas lectures have often focused on the beneficial side of science and technology. However, critique of science and technology has grown, and nowadays, in many countries all over the world, subjects such as climate change, biotechnology, and vaccination are debated in the public domain. Informed and empowered citizens often criticize or at least doubt whether the outcomes of science and technology are set in stone.

A few events can be identified as game-changers along the pathway to increased democratic engagement with science. For one, Rachel Carson published her book *Silent Spring* in 1962, in which she criticizes the use of pesticides. In 1968, concerned scientists worried about the future of the world and founded the Club of Rome. They published the book *Limits to Growth* a few years later. Environmental awareness awakened in certain parts of the world. About a decade later, in 1979, nuclear energy was discredited by a leaking nuclear power plant at Three Mile Island in the United States.

These — and similar — events, first of all, opened the eyes of many science journalists. After the Second World War, science journalists often acted as *cheerleaders*; they were positive and enthusiastic interpreters of scientific and technological developments. In the 1960s, some gradually took up a more critical role, that of *watchdog*. In this role, some science journalists critically commented on developments (Rensberger, 2009). Informed by the media, publics started expressing their doubts about some technological developments. For example, citizens protested against nuclear energy in many countries from the beginning of the 1980s.

Such a critical stance toward science and technology, however, is not completely new. People have, for example, worried about the changes that trains would bring along in the beginning of the 19^{th} century. And, as early as in 1663, the first cases were reported where workers destroyed textile machines out of fear of the technology and its implications for their lives.

The increasing resistance toward subjects such as GM foods made governments aware of the possible adverse economic consequences of rejecting new technologies. Therefore, government and policy-makers increasingly emphasized the importance of knowledge about science and technology. More knowledge and education, it was assumed, should make citizens adequately knowledgeable about science, *scientifically literate*, and would lead to more appreciation of science and technology and its products

(Bauer, Allum & Miller, 2007). It is this premise that defines the so-called *deficit model* of science communication. In this model, the communication process is defined as a one-way transmission (Nisbet & Scheufele, 2009), where greater knowledge leads to greater support for science, technology, and the institutional view of science.

The assumption that providing scientific information will lead to a positive appreciation of scientific and technological applications has turned out to be inaccurate for some topics and categories of people. In certain cases, studies have shown that people became more critical after receiving additional information. For example, this was found in public responses to genetically modified crops during a period of high-profile public debate on the topic in the UK (Marris *et al*., 2001).

Informing people better, and thus increasing the public's scientific understanding is not viewed as a sufficient aim by many in the contemporary science communication field. Science communication is, or needs to be, more nuanced than simply telling the facts or telling the facts better (Bauer *et al*., 2007). Moreover, science and technology will always be understood within their broader social context and, therefore, non-scientific factors play a role in science communication. Scientific information can often be interpreted in various ways (NAS, 2017), as is exemplified with knowledge about climate change. Furthermore, communicating about science is often mediated by others than scientists themselves, while people will judge information based on other factors such as their trust in the source, their existing knowledge, and their beliefs and values (NAS, 2017). Moreover, experts and citizens often perceive risks and benefits of science and technology differently.

In the early 1990s, social scientists argued for more openness and dialogue in the relationship between science, technology, and society with increased success in gaining interest in this perspective from policy-makers and scientific institutions in Europe. Dialogue and participation were considered a new approach aimed at restoring trust in science and technology (Bauer, Allum & Miller, 2007; Sturgis & Allum, 2004; Wilsdon & Willis, 2004). Public debates, organized in various European countries, tried to bring into practice such an open dialogue. For example, in the Netherlands, in the 1990s and the beginning of the 2000s at least five public debates about topics such as cloning (Dolly, the sheep), genetically modified food, and biotechnology were organized. The interactions between science and society, however, were not always implemented as intended by the social scientists who advocated this approach. Some of these dialogues were rather premeditated discussions where experts decided what to talk about and with whom. In turn, citizens did not always accept these public dialogue exercises and the desired high numbers of active participation in these debates were often not achieved (Dijkstra, 2008).

Since this initial burst of enthusiasm for public dialogue with science in Europe, initiatives that explicitly take public perspectives and values into account have continued to develop and gained ground in institutional and government policies in many countries. Accordingly, language within policy documents and funding schemes in many countries and at the European level moved from *public awareness of science* to *citizen engagement* and from *science and society* to *science in society* (Irwin *et al.*, 2018), or even *society with and for science* (European Commission, 2019). Aided by new technology, such as smartphones, citizens can now become data and knowledge producers as well, and scale-up the existing science communication initiatives such as citizen science, in which large groups of laypeople are involved in the process of doing research, or in helping set research agendas.

1.4 Science Communication in an Increasingly Changing and Global World

Science communication is always embedded in a wider social and cultural context. When changes occur, either at a local or global level, in the ways in which people communicate, learn and grow, and live together, then all these small changes are bound to impact science communication and shape it as a field of practice and scholarship. Hence, the call to understand science communication within the system it operates (NAS, 2017). This section provides an overview of important global developments for science communication which relate, first, to the content of science communication, thus science and technology information and knowledge; second, to the people involved in science communication; and, finally, to the communication means and approaches used.

1.4.1 *The Content*

Over the past few decades, huge changes have taken place in science and technology, including increased specialization and interdisciplinary working (Agar, 2012). In some fields, science has rapidly become a team effort. An extreme example concerns the publishing of research articles, with 1,000 or more contributions that are becoming more common in the field of particle physics (Mallapaty, 2018). In some countries, the focus in science and technology research gradually is shifting away from fundamental to more applied research. Economic exploitation of knowledge is promoted, and relevance of research for society is stressed. As a consequence, ethical and social aspects of new research fields become study objects as well. Partners other than researchers with their academic knowledge are asked to join projects in some contexts. Professionals and practitioners, for instance, nurses and farmers, can contribute with their professional knowledge. Members of the general public, sometimes called laypeople, can provide insights by sharing their local, experiential knowledge, for instance, their experiences as a patient or as an amateur geologist (Wynne, 1989). An increasing number of communication activities facilitate the participation of both scientists and layexperts as equal partners (Davies *et al*., 2009).

Science and technology research is increasingly seen as a way to find solutions to the huge and complex problems that societies worldwide face. A large, complex problem with potentially far- reaching consequences is climate change. It is related to issues like feeding the world, resource depletion, and biodiversity. Innovative and sustainable solutions are called for, requiring the input of many different actors: scientists, professionals, and laypeople. This presents a huge challenge for science communication: how to motivate everybody to do the right thing; how to inform everybody effectively; how best to teach them the required skills; and how to engage with them? This may call for more elaborate and more specified communication approaches.

An aspect related very closely to science and technology is risk. Risk has become a more visible issue in recent decades. It plays an important role in heated debates, for instance, about genetically modified food, Universal Mobile Telecommunications System (UMTS) radiation, and climate change. According to sociologist Beck (1992), scientific risks play a crucial role in how contemporary society operates. He argued that the world is in a *risk society* phase, defined by the hazards that people live with each day such as nuclear weapons and climate change that were created by technological developments. More than before, people and institutions are aware of the risks facing them and demand that governments and industry take action. The credibility and expertise of scientists and technologists are essential for evaluating and understanding these risks.

1.4.2 *The People*

A very important societal change with widespread effect is that the nature of global economic activity has shifted toward greater technological development, thus increasing the global need for education and technical skills. Rates of education have increased globally. In Western countries, more people are gaining an academic education than ever before, while in developing countries more people are receiving basic education than before (UNESCO Report on Education, 2017).

The 21st century economy in the most advanced economies is increasingly based on digital and other non-physical goods and services and to a lesser extent on traditional physical products. This has necessitated a more educated workforce, and the proportion of university graduates has mushroomed in recent years accordingly (International Institute for Applied Systems Analysis, IIASA, 2014). In this context, formally recognized knowledge is key to economic success. Lifelong learning to help the population keep its knowledge up once they leave school is also important. In addition, technology and the instant availability of information online make it increasingly feasible for people to develop their own understanding of topics that were formerly the preserve of experts. This includes self-diagnosis and home-based medical diagnosis and patients taking increased responsibility for self-managing their health care.

Furthermore, in the Western world the role of the democratic citizen has increasingly been recognized in the context of science and technology policy. Citizens have become involved and engaged into dialogue about new developments, often science and technology related, that are about to take place. In different ways around the world, there have been initiatives to align priorities in science and technology with needs and values in society. For example, in the European Union, there has been an emphasis on developing a responsible approach to research and innovation through social inclusion, appropriate ethical consideration, public participation, open access, and other good practices within science.[1]

1.4.3 *The Means*

The Internet has greatly influenced science communication in the recent decades. It has enormously increased the amount of information available. From scientific programs on YouTube to the ever-increasing emphasis on open-access journal publishing, science information is at the fingertips of computer and smartphone users. The Internet has also 'democratized' information about science and technology by making it much more widely available and accessible to everybody. Yet, as a consequence of this exponential growth of available information, the focus in accessing knowledge has shifted from searching (just seeking out information) to sifting (separating good from bad information). In addition, Internet users need to learn how to work with new technology and deal with the overload of information.

Also, the onset of social media and its proliferation, Facebook, YouTube, Twitter, WhatsApp, Instagram, and other applications, urge people to prepare for a new communication era, that of online communication. This not only brings new opportunities for democratic engagement with science but also new challenges such as *filter bubbles*, where users are systematically fed information that aligns with their existing views (Jensen, 2011). New skills have to be learned, such as distinguishing real news from *fake news*. Such analytical skills are necessary to survive online. Some may even want to develop skills to become online information providers.

1.5 This Book

The complex changing relationship between science, technology, and society has caused science communication to develop as a field, from predominantly

[1] For example, www.rri-tools.eu/about-rri.

transmission-based activities to a mix of different approaches, which also include more transaction-based activities, such as a public dialogue about nanotechnology. In addition, the science communication field is affected by broad global developments such as science and technology becoming more specialized and tackling more complex problems, the drive toward higher education levels and democratization of societies, and the advent of the Internet and new communication tools such as social media. No standard approach exists for organizing science communication activities. Science communicators must design an approach that best fits the situation, the message, and the people involved. More in-depth insight into science communication processes and products will help both researchers as well as practitioners to undertake science communication activities more effectively.

As the science–society relationship is so complex, the chapters in this book address a variety of topics in an effort to enhance insights in science communication practice, research, and theory. The first four chapters introduce the field of science communication, while Chapters 5–9 provide insights into subdisciplines of science communication. These subdisciplines are by no means exhaustive but represent important fields of practice in science communication: informal science education, science journalism, risk communication, health communication, and environmental communication. The final chapter introduces research in science communication.

After this introductory chapter, which sets the scene, Chapter 2 sheds light on the core content of science communication: science itself. It presents different views of science which provide a basis for reflection on how science is constructed; its dependency on social, cultural, and economic contexts; and how such contexts influence the image of science portrayed by science communicators. The authors end the chapter with provocative questions that serve as a guide for this analysis.

Chapters 3 and 4 show how the field of science communication has become more complex in order to cover a wide range of motives to communicate about science with non-experts, with an increasing number of issues that must be addressed, the need for different models and strategies, new social responsibilities for science communicators, and new ways of relating with different sectors of society. The chapters address the actors or stakeholders in science communication. The discussions in these chapters offer a starting point for considering how to approach science communication.

Chapter 5 gives the reader an introduction to the field of informal science education, a field that is closely aligned with, and often overlaps with, science communication. People have the need to incorporate information, knowledge, and skills which are closely connected to science and technology. This has increased the demand for programs, activities, and settings for informal education as part of society's offer of lifelong learning opportunities.

Chapter 6 deals with the rapidly changing field of science journalism, its challenges, and its implications for science communication. This subdiscipline is most intensely influenced by the onset of Internet and the development of online communication and social media. In particular, these developments are relevant for the role of journalists and the framing of scientific information.

Chapters 7, 8, and 9 present three different contemporary subdisciplines of science communication: risk, health, and environmental communication, respectively. Even though the chapters deal with different content, they share a general approach in that much of the communication efforts in these domains are targeted toward attitudinal or behavioral change, be it focused on health, benefits and risks, or environmental sustainability. The communication strategies proposed in these three chapters — which are often related — are most useful in the analysis of how science communication can provide people with the necessary knowledge and tools to empower them. Authors in all three chapters address these topics, often emphasizing the individual level of communication.

Finally, Chapter 10 focuses on research and evaluation in science communication and includes a case on communicating about pseudoscience. As science communication becomes more and more professionalized, research evidence is becoming increasingly important to underpin the best practices in the field, while effective evaluation must be considered as a fundamental ingredient of the creative process of science communication initiatives. The chapter presents how research insights can help both researchers and practitioners.

This book is meant for professionals, students, and all those who look for an introduction into the quickly developing practice and discipline of science communication. By presenting a general overview of the science communication field with more in-depth insights into several subdomains, this book aims to provide an informative and enjoyable tour through the rich and varied field of science communication.

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