Science Communication

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Definition

Science communication is a dynamic field of practice and research that deals with the communication of scientific knowledge to audiences that are typically outside academic institutions. Science communication is widely recognized as a broad term that encompasses a wide variety of actors and formats, and includes a spectrum of activities that range from informal to strategic in nature (Bucchi and Trench 2021). As such, science communication does not constitute a clearly defined discipline, but can be conceptualized – in the words of Bucchi and Trench – as "an inherently, even joyously, interdisciplinary field" (2021, 2).

Historically speaking, *science* is derived from the Latin word *scientia* for knowledge, understanding, and learning (Onions 1966, 797). Today, the term refers to a practice of systematic production and organization of specialized knowledge by means of specific methods and strict quality standards; it is simultaneously a system for stabilizing said knowledge (Bauchspies et al. 2006, 5–6; Mittelstraß 2010). This chapter employs the term science in a broad sense that is not limited to the natural sciences such as physics or geology, but "has a much broader meaning and includes all the academic specialties, including the humanities" (Hansson 2021). Communication refers to the "practice of producing and negotiating meanings" (Schirato and Yell 1997, x).

In order to do justice to the dynamics and diversity of this multi-faceted field of practice and research, science communication is understood as a broad concept that includes "all forms of communication focused on scientific knowledge or scientific work, both within and outside institutionalized science, including its production, content, use, and effects" (Schäfer et al. 2015, our translation). In this way, knowledge is not simply transferred from one person or community to the other, but it is rather negotiated, mediated, and transformed in a mutual exchange of ideas, opinions, and values. In this chapter, a distinction is made between science communication *teaching* and science communication *training*. For this purpose, *science communication training* is defined as practical courses that are typically offered over one or more days to researchers who are interested to advance their science communication skills. In contrast, *science communication teaching* is defined as academic courses offered by universities and other higher education institutions. Many of these courses are presented as dedicated postgraduate diplomas, Master's courses or PhD programs, but some universities offer modules in science communication as part of degree courses at undergraduate and postgraduate levels.

Although science communication constitutes an essential part of the processes of knowledge production (Horst et al. 2017; Secord 2004) and exchange (Jensen and Gerber 2020), and plays an essential role in transdisciplinary processes, the complex relationship between transdisciplinarity and science communication is yet to be studied from a comprehensive and systematic perspective (Wang 2019). Individual studies, however, offer some promising insights and lay the groundwork for further inquiry. For instance, Mercer-Mapstone and Kuchel (2017) conceptualize the entirety of science communication as a transdisciplinary field due to the inclusion of different actors and the traversing of disciplinary and professional boundaries. Others emphasize that science communication provides the communication skills that are essential for shaping transdisciplinary research processes (Kalmár and Stenfert 2020; Misra and Lotrecchiano 2018; Wang et al. 2019). In addition, Burns et al. (2003, 193) suggest that the act of communication itself has a transdisciplinary dimension, as "the need to explain complex issues in lay terms can lead to new perspectives on a topic and a deeper understanding of the field by the professional".

Background

The multifaceted nature of science communication stems from the complex socio-economic background that has determined the evolution of the field within distinct national and cultural settings. Scholars of different branches of knowledge have been sharing their knowledge in different contexts and languages for millennia (Gordin 2015, 35–40; Secord 2004). Many traditional approaches to science communication included elements of entertainment – such as music and art – as well as listening and dialogue. The diverse histories, cultural roots, and trajectories of science communication are reflected in Gascoigne et al. (2020). Despite the existing national idiosyncrasies, it is possible to trace a common historical trajectory (Gascoigne et al. 2020) along a number of major historical landmarks, such as the growth of the print market; the professionalization, specialization, and institutionalization of academic research; the emergence and proliferation of mass media and, more recently, social media (Bucchi 2008; Dawson and Topham 2020; Kiprijanov 2021). For a comprehensive overview of the history of science communication from the 18th to the 20th century, see Knight (2006), as well as Gascoigne et al. (2020) and the contributions in volume 16, number 3 (2017) of the *Journal of Science Communication*.

In the wake of the institutionalization of academic research, professionalization, and internal and external differentiation of academic disciplines at the beginning of the twentieth century (Mittelstraß 2010), researchers came to believe that science was too complicated for the general public to understand. This idea corresponds to the *deficit model* (also called *deficit-diffusion model*) of science communication, which was the predominant model until the 2000s. This model describes science communication as a linear transmission of specialized knowledge from a small number of experts to an allegedly ignorant mass audience. The transmission occurs from areas of high concentration among experts to areas of low concentration among audiences. Controversies and misunderstandings are attributed to a lack of scientific literacy among the public. Comparable to Shannon and Weaver's (1949) mathematical model, the deficit model distinguishes between active communicators (senders) and passive recipients who lack any agency.

The deficit model served as the ideological foundation and justification of the *Public Understanding of Science* movement that gained momentum in the United Kingdom during the 1980s and 1990s with the aim of promoting public interest in, and awareness of, the natural sciences (Bucchi 2008). While the dissemination of information about new advances in science is a legitimate and useful activity, the critical flaw of the deficit model is the logical fallacy and incorrect assumption that providing more information and better explanations will lead to more public support for and increased public trust in science.

Reflections on the motivations behind efforts to improve the so-called public understanding of science, as well as concerns about the efficacy of these campaigns, prompted the beginning of systematic science communication research. Criticism from social scientists led to revision of the assumptions and goals of the deficit model. Today, a variety of competing or complementary science communication models exist, as described by Trench (2008), and Schmid-Petri and Bürger (2020), and it is clear that these approaches (or models) are interdependent and often overlap in science communication practice (Brossard and Lewenstein 2010).

According to Horst et al. (2017, 883), the existing models can be placed on a continuum that ranges from *deficit* (one-way, elitist, and fact-oriented) to *dialogue* (two-way or interactive, participatory, and reflective). Dialogue and participation models acknowledge the communication needs and preferences of specific audiences and prioritize meaningful and "mutually supportive relationships between research and society … through high levels and varied forms of interaction between the two" (Burchell et al. 2017, 200). These forms are also used in transdisciplinary processes, such as participatory research and citizen science. These models reflect current societal demands for more transparency (Weingart et al.

2021) and a "general participatory/collaborative opening of the science system" (Schrögel and Humm 2020, 488).

As science communication became more professionalized and institutionalized, the demand for professionals in the field began to grow, and science communication became a flourishing industry (Davies and Horst 2016). Universities responded by offering a growing number and range of degree programs, as has been documented by a number of scholars (e.g. Massarani et al. 2016; Trench 2012; Turney 1994). For example, Schiele and Gascoigne (2020) document how university-based courses in science communication started to emerge in the 1980s (with one precursor program in the United States in 1960), spreading to countries around the world since then.

Debate and criticism

Proponents of science communication teaching programs use a number of motivations to justify the need for this type of offering in higher education. Motivations include professional capacity building, development of evidence-based policy around public participation in science, provision of authentic educational experiences involving academics and communication professionals, as well as the contributions of this type of program to the employability of students (Longnecker 2014; Longnecker and Gondwe 2014; McKinnon and Bryant 2017; Ramani and Pitrelli 2007).

Already in 1994, Turney pointed out that science communication courses on offer in the United Kingdom in the early 1990s varied from those focusing purely on skills to those with a more theoretical (or big-picture) approach. He argued for the inclusion of theory into science communication education in order to deliver more effective communicators who benefit from lasting intellectual resources, as well as to guard against courses that merely teach students to promote science. Since then, scholars and educators have debated the recurring question about to what extent students need to know the theoretical underpinnings of the science communication skills they learn and how much practical experience should be included in science communication teaching (e.g. Baram-Tsabari and Lewenstein 2017; Mercer-Mapstone and Kuchel 2017).

Overall, there is agreement that the content of science communication programs needs to address both theory and practice, striving for a balance and a productive interface between these components (Baram-Tsabari and Lewenstein 2017; Longnecker 2014; Mercer-Mapstone and Kuchel 2017; Mellor 2013). In general, these authors argue that a theoretical foundation is essential for students to be able to understand and apply the knowledge base, and to identify relevant evidence that can inform and enhance their practice. Practical work, on the other hand, is essential to consolidate what they have learnt and to prepare them for the world of work. Practical expertise can be brought into these courses via guest lectures by industry experts, as well as by work placements and internships. For instance, Bray et al. (2012) emphasize the need for students to develop self-awareness around their own scientific values and science communication objectives, as well as the contexts in which they operate, necessitating a broad understanding of the societal implications of science, rather than a focus on technical media skills.

Academic programs in science communication cannot afford to be static. In order to prepare students to cope with the increasing complexities of science communication and fast-changing media ecosystems, courses must be flexible and respond to changing circumstances and the evolving needs and expectations of students and future employers (Fähnrich 2020, 3; Ramani 2009, 2). Science communication students must be prepared for the complexities of communication around increasingly contested topics that are rooted in science but have social, moral, or ethical dimensions and are often heavily politicized, such as climate change, biotechnology, stem cell research, and artificial intelligence. In addition, societal challenges such as science skepticism and dwindling trust in democratic institutions call for a critical reflection on the relationship between science and society, as well as a new and more inclusive approach to knowledge production (Schrögel and Humm 2020). Students must therefore be equipped with competencies that will be required to navigate the controversies, uncertainties, and polarized debates around science and its applications in society.

Teaching in this field must also keep up with fast-evolving science communication ecosystems and landscapes, characterized by a general move away from mainstream media where journalists were the traditional gatekeepers, towards online and social media where everyone can communicate and comment on science (Fähnrich 2020, 1). Digital science communication channels are characterized by fragmented audiences, online hostility and concerns around mis- and disinformation, and social media may disrupt scientific standards and challenge the authority of science. Jointly, these trends demand a continuous reassessment of the theoretical and practical content taught within academic science communication courses.

In the 1990s, higher education and research institutions around the globe embarked on a journey of transformation toward fostering positive societal impact beyond economic goals. This ongoing transformation, reflected by concepts such as *Third Mission* (Trencher et al. 2014) and *Quadruple Helix* (Carayannis and Campbell 2009), is accompanied by a shift toward a mode of knowledge production that surpasses the boundaries of established academic disciplines (Scholz 2020). Science communication is understood to be an essential and integral part of this process, as dialogue-focused and participation-oriented activities play a key role in knowledge and research exchange through engaging a wide range of stakeholders from outside the academic domain (Jensen and Gerber 2020; Leshner and Scheufele 2017). Scholars also point out that, following the idea of Responsible

Research and Innovation, participatory science communication – understood as joint knowledge production – can make a significant contribution to strengthening innovation processes, and to developing solutions to challenges that affect society as a whole (Loroño-Leturiondo and Davies 2018).

Current forms of implementation in higher education

Academic programs in science communication around the world share some common approaches and characteristics, but also significant variations in content, goals, learning outcomes, and delivery (Trench 2012; Trench and Bucchi 2021). This plurality originates from different national and institutional contexts, and the unique views of the individuals who champion these programs. However, despite the interdisciplinary nature and diversity of the field, it is argued that there are some core topics that should be covered in a science communication degree program (Longnecker and Gondwe 2014).

A number of handbooks related to science communication constitute evidence that the field is maturing and encompasses a range of core topics that should be considered by teachers in the field. These books provide a valuable starting point for curriculum developers and are useful guides for educators and students (Bucchi and Trench 2021; Jamieson et al. 2017; Leßmöllmann et al. 2020; Van Dam et al. 2020). In addition to the field delineation and guidance provided by these handbooks, several science communication scholars have generated ideas and topics for a core science communication curriculum (e.g. Baram-Tsabari and Lewenstein 2017; Bray et al. 2012; Mercer-Mapstone and Kuchel 2017). Further reports by scholars such as Costa et al. (2019), Fähnrich (2020), Gascoigne et al. (2020), Hong and Wehrmann (2010), Longnecker (2016), Longnecker and Gondwe (2014), and Massarani et al. (2016) have suggested several core topics to be considered when new science communication programs are designed. These include: (1) Social studies of science, including the history, sociology, and philosophy of science and science communication; (2) Media studies and communication science, theory, and strategies; (3) Behavioral studies, including persuasive communication; (4) Education studies and learning theories associated with informal learning; (5) Public participation in science and the co-creation of scientific knowledge, including citizen science; (6) Evaluation of science communication materials and projects; (7) Research methodologies relevant to science communication scholarship; and (8) Real-world experiences for students via industry placements or institutional internships.

Despite consensus on the value of agreeing on core concepts, experienced science communication teachers recognize that most science communication programs will not be able to include all these topics. They therefore advise curriculum designers of new programs to consider local needs and priorities carefully (Longnecker and Gondwe 2014). New degree programs in the field should be clear about their learning outcomes and strengths, and should use their uniqueness as a way to attract relevant students (Hong and Wehrman 2010).

Although science communication plays an essential role in transdisciplinary processes, there is little systematic research into the specific relationship between transdisciplinarity and science communication (Du Plessis 2012; Wang 2019), and only a few studies explore this question from the perspective of science education (Arber 1999; Mercer-Mapstone and Kuchel 2017). There is, however, a number of practical examples that illustrate the effective integration of transdisciplinary approaches into science communication courses. These include programs at the Karlsruhe Institute of Technology (KIT), the Universidad Nacional Autónoma de México (UNAM), and the University of Leeds. The latter offers joint honors degrees consisting of a STEM subject (e.g. biology or physics), instruction in history or philosophy of science, and an integrated research project in science communication (University of Leeds 2021).

Science communication has been an integral part of modern science for over 200 years and contributes significantly to the circulation and targeted exchange of knowledge between academia, politics, society, and business. Today, the presence of academic education in science communication is recognized as a key indicator of the maturing of the field and its associated infrastructure in different national and regional contexts. However, empirical research into the relationship between transdisciplinarity and science communication in the context of higher education is still lacking. Here, prospective studies might benefit from existing scholarship in neighboring areas, most notably in sustainability studies, and Research and Innovation.

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