UNITED STATES OF AMERICA

Science communication in the USA: It's complicated

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1. Introduction

Science communication in the United States, as a field, has a complicated history and contested definitions. In part this is due to the decentralised nature of the country's scientific research agencies and professional societies. Unlike many countries, there is no single governmental scientific research agency or policy group that oversees the endeavour of science communication. But this is not the only reason for the field's lack of clear definitions and parameters. A look into the past reveals a broad array of historical forces and stakeholders that have intervened, over the years, to produce divergent purposes, strategies and outcomes in science communication here in the United States. In this chapter we apply a critical lens to understanding how these forces have forestalled the development of a coherent field of practice, while at the same time producing a vibrant (if jostling) set of opportunities to engage the public with science.

In the US, science communication can be conceptualised as consisting of multiple constituent parts or dimensions. It involves communication skills, the ability to connect with people or to tailor messages that resonate with various non-scientific audiences for specific objectives. It involves communication tools, such as news articles, podcasts, films and live productions (e.g. science cafés). It involves a variety of science communication actors, including scientists, science outreach communicators, journalists, informal science educators and others. Science communication is provided by a range of institutions such as universities, science museums, professional societies, media outlets and small non-profits as well as the public relations and communications

arms of industry and academia. It takes place in many settings, from café to auditorium, classroom to smart phone screen, congressional office to town hall. As a field of inquiry it has generated several subfields, such as the science of science communication (with its attendant research journals, conferences and collateral), science communication training programs (including institutes, courses and even graduate degree programs) and science communication professional organisations and networks (Gascoigne et al., 2010). Researchers in science communication span a range of disciplines, including sociology, psychology, neuroscience, learning sciences, political science, science and technology studies (STS), communication and more. There are a range of funding organisations and scientific societies that have a stake in advancing the field. These disparate efforts are largely uncoordinated, even within given regional communities, leading to what some have described as a largely fragmented science engagement ecosystem across the US (Lewenstein, 2001).

But the multiple dimensions of science communication are only part of the complexity. Its goals and objectives also vastly differ (Sugimoto and Weingart, 2015). A recent study by the National Academies of Sciences, Engineering, and Medicine (2016) synthesised the literature to name five distinct goals for communicators of science: to make the public aware of science, to build their appreciation of it, to develop their understanding of it, to inform their actions with it and, in turn, to have science itself become more informed by the public. This report did not directly call out other purposes we can see in the field, such as increasing the diversity of the STEM workforce, securing public support and funding for science as an enterprise, informing the production of science itself or developing scientific reasoning for citizenship in a democracy. One study revealed that scientists' motivations for online engagement include (in ranked order) to defend science, inform the public, excite the public, build trust between the public and science, and tailor messages for particular publics (Dudo and Besley, 2016).

Compounding this diversity of motivations and purposes, science itself can be conceptualised in multiple ways: as a body of knowledge, a process of inquiry, a professional practice and an avocation. Audiences could be differentiated by age (e.g. kids, adults, a mixture), degree of specialisation or purpose (e.g. total novices, policymakers, experts from other fields), type of interest (e.g. uninterested, community welfare, personal hobby, professional) and an infinite variety of other categorisations. They attend science communication events with a range of preparation and prior knowledge. Sometimes they may be motivated by a specific need-to-know, other times by more general curiosity. Some may identify closely with science and others may not. Some may be active participants who seek out science, some may stumble upon

science presentations in public settings such as music festivals, and others (such as students on field trips) may experience engaging with science/scientists as a form of coercion.

The decentralised nature of science communication in the US means that different organisations and actors define, pursue and describe science communication along some but not all of the above purposes and dimensions. In this somewhat cacophonous context, the field of practice is challenged to align its purposes, actors, skills, tools and settings with the goals and motivations of its audiences. Moreover, this range of overlapping approaches and foci leads to many instances of professionals in the field using the same words to describe their practices of science communication (e.g. communication, public engagement, science outreach) but sometimes meaning different things. Often, one-directional communication (e.g. science briefs shared with policymakers or science journalism) leads to engagement (e.g. scientists and policymakers collaborating in meetings or scientists engaging in the public discourse), further blurring the lines of what is communication or engagement (Smith et al., 2013). Consequently, people talk past or misunderstand one another, which limits knowledge-building in the field, whether research- or practice-based (Lavery, 2018).

In short, science communication in the United States (ironically) suffers from a communication—and coordination—problem. This lack of coordination and centralisation means that telling its story is not easy. In this chapter, we zoom out to examine the history of science communication in the context of the history of the US writ large. In so doing, we posit that different institutional stakeholders in the US—e.g. scientists, industrialists, policymakers, educators—have historically sought to use science as a means of exerting social control at times of social disruption and change (e.g. urbanisation, immigration, militarisation or social atomisation in the age of the internet). These different historical moments, in turn, have led to the emergence of disparate, sometimes misaligned, purposes and approaches to science communication, which today we experience as a cacophony. This cacophony can be positive, in that it promotes new thinking, innovation and creativity in the field and practice. But it can also lead to inefficiencies, misalignment and conflicting messages that can alienate or anger some audiences. In this chapter, we provide an overview of these historical forces before discussing both tensions and possibilities for the work moving forward.

2. The history of science communication in US history

We use a critical lens to describe how science communication as a field has developed in the US. Specifically, we examine the ways that science communication has been used to exert and to challenge existing power structures and to advance particular agendas.

Historians and sociologists of science have long applied a critical lens to science as an enterprise (see, for example, Haraway, 1988; Harding, 1998; Latour and Woolgar, 1986). Some studies in science communication, particularly on the subject of climate change, have also used this lens (e.g. Russill, 2018); however, to date, critical perspectives have not permeated the mainstream practices and journals of science communication in the US (Rauchfleisch and Schäfer, 2018).

There are ways to tell the history of science communication in the US without respect to larger historical currents or contested power relations. However, we believe that looking at the intersections of social change and science communication affords particular insights about the production, experience and evolution of science communication that can help the field today as it seeks to reconcile competing visions of what science communication is and can be. We recount this history via perspectives from science communication and policymaking, science journalism, the learning sciences and informal science education. We aim to be representative, not exhaustive, in our historical account.

For the purposes of this chapter, we define science communication broadly as a diversity of activities, with a variety of purposes, that strengthen the connections between the scientific research enterprise (its history, processes, people and products) and public audiences. We understand moments of science communication to be moments of cultural production, where different social and personal histories, interests and motivations converge to shape experience and meaning-making (Nasir et al., 2014). In these moments the discourse adopted by science communicators—the language, images, and representations they use—is always ideologically saturated (Bakhtin, 1981), as is the meaning made by their audiences. By ideologically saturated we mean that words, images, stories and representations used in science communication do not exist independent of history, culture, disciplinary epistemologies and social stances; as such they constitute particular Discourses of science (Gee,

2004).¹ That is, they are imbued with and invoke, explicitly or implicitly, specific positionalities and ideological commitments as to what science is and why we the public should care about it. Surfacing the ways in which science communication advances powerful interests is critical to any examination of its history. However, it's also important to note that despite its historical alliances with economic and social power structures, science communication as a practice is never monolithic or ultimately hegemonic but instead creates sites of exchange where power, and powerful ideologies, can be both exerted and challenged (see Foucault, 1990).

2.1. Acculturation and citizenship in the context of rapidly changing demographics

As in many nations, in the US science communication as a field began in the 19th century with the second industrial revolution (Lewenstein, 2016). Large-scale industrialisation, urbanisation and immigration dramatically transformed social organisation in communities across the country. A primary goal among the educated and upper middle classes was to acculturate new urban populations to 19th-century progressive American ideologies related to the role of science and economic prosperity. At the heart of this ideology were Enlightenment views on science as a source for rationality and democratic citizenship (Dewey, 1916). In this context, science communication involved creating new public spaces—such as the American Museum of Natural History in New York, the Franklin Museum in Philadelphia and the Museum of Science and Industry in Chicago—that opened up private collections to the public. Public lectures proliferated, as did guided tours of exhibitions, and short classes.

The creation of scientific societies—targeting science professionals and dedicated amateurs, modelled on the British Royal Society—extended this ideology of science as a tool of Enlightenment rationality and social progress to more privileged social sectors. Societies included the American Association for the Advancement of Science (founded in 1848), the National Geographic Society (1888) and the American Chemical Society (1876). As in Britain, these societies were private, and intended for both practising professionals and dedicated amateurs of particular social classes (Kohlstedt, Sokal and Lewenstein, 1999; Rhees, 1987).

¹ Gee contrasts 'little d' discourse and 'big D' Discourse. Whereas discourse with a lower case d refers to the ways in which individuals discuss or represent ideas, Discourse with a capital D refers to the much broader social, cultural and historical conceptualisation, significance and representation (e.g. science as culturally neutral, science as a means for global prosperity) that may shape how little d discourse develops.

Figure 40.1: Science demonstrations have been a mainstay of science communication. Here a wary audience closely observes a cow's eye dissection.

Source: © Exploratorium (used with permission).

As such, the goal of science communication at this time of social change was education and *enlightened citizenship*, towards building a democratic society (Terzian, 2013). Science was presented as a mode of inquiry, a collection of artefacts, and a tool for—and promise of—rational, democratic progress. This Discourse links to a strand of science communication in the US today commonly associated with informal science education. This sector involves many large and established institutions—primarily museums, but also media outlets such as public television and radio—and receives significant funding from entities concerned with science education. In turn, this strand of science communication conducts research and assessment focused on learning outcomes, where learning is conceptualised broadly to include the development of audiences' science interests, identities, skills, concepts, epistemologies and practices (National Research Council, 2009).

2.2. Instrumentalism in the context of rapid economic growth

In the first half of the 20th century, science communication efforts broadened (i.e. were not replaced but expanded) to include more instrumental views of science. Specifically, the rapid growth of manufacturing and agricultural industries led to a perceived need to ensure that new scientific knowledge and technologies were put into practice. In 1914, the Smith Lever Act established

a partnership between the US Department of Agriculture and a number of land-grant universities charged with applying research to agricultural practices. Extension agents were arguably some of the earliest science communicators in the US, connecting farmers and researchers to allow them to benefit from each other's knowledge and craft. In this context, science communication was motivated by a desire to achieve efficiencies (of all types) to advance economic prosperity.

This Discourse of science was accompanied by efforts to win the hearts and minds of the public, to encourage them to support investment in the scientific enterprise. Along these lines, the birth of the field of science journalism occurred. Science journalists sought to persuade the public to accept science as a force for ongoing social improvement (Lewenstein, 1992). From Pluto to penicillin, scientific discoveries covered in the news elicited awe and promise during this time. By 1934 there were enough science journalists to launch the National Association of Science Writers (NASW), dedicated to improving their craft.

Aided by the proliferation of radio and later television, public science evangelists began to appear. These figures mediated between professional scientists (employed in the burgeoning scientific industry) and the public. Figures such as Mr Wisard, who had a television show that ran from the early 1950s into the mid-1960s, engaged children and families in the science of everyday objects and phenomena (LaFollette, 2012). These shows both advocated for science as an important enterprise and emphasised the applicability and usability of science. Such views were taken up by Warren Weaver, an influential figure who served on the board of the American Association for the Advancement of Science (AAAS) in the 1950s and took a strong interest in the public understanding of science. The launch of Sputnik, and the doubling down of federal investments in science education (Rudolph, 2002) propelled science communication efforts aligned with a Discourse of science focused on the practical, utilitarian and instrumental uses of science in an increasingly technological society.

Such views were not unconnected to broader social and historical forces, particularly the role of science in prosecuting World War II and later the Cold War arms and space races between the US and the Soviet Union. In this instrumentalist Discourse, uses of science were entwined with rhetorical positioning of the US as a bastion of political liberty, which was closely connected with the expansion of the military industrial complex, putatively to defend those liberties. As such, science communication was focused on advocating for further state investment in science and scientists in the interest of nationalism.

Today, such Discourses exist in efforts to have science communication excite people about the potential future and current utility of science, partly because State funding depends on that support. From 1969 photos of Neil Armstrong walking on the moon to the Twitter account of today's Mars Rover, NASA's science communication exemplifies science communication as public relations. DuPont's 'Better Living Through Chemistry' campaign is an industry-driven example.

It is notable that instrumental approaches—because they tout science as authoritative and essential to economic prosperity—lend themselves to deficit framing. There is a literature spanning decades that demonstrates the weaknesses of deficit-based models relative to asset-based approaches in which the interests, experiences and cultural patterns of interaction are positioned as the means for productive engagement with, for instance, science; this is especially true for efforts to engage individuals from racially or socioeconomically marginalised communities (Bartolomé, 1994; Gonzalez, Moll and Amanti, 2005; Simis et al., 2016). Yet, a recent consensus study found that in the US the use of deficit models is most common in efforts to engage the public with what are considered to be controversial social issues—those same issues that may be most urgent in terms of decisions, direction and behaviour changes, such as vaccination, climate change and food safety (National Academies of Science, Engineering and Medicine, 2017).

2.3. Empowerment and actualisation in an increasingly mechanising society

As the Cold War continued, and wars in Korea and Vietnam were waged, the dominant Discourse of science in the US became more divergent, with the space race providing a sort of fulcrum for competing views. On the one hand, with NASA's massive investment in science communication and public relations and efforts by a range of other industrial players (from pharmaceuticals and General Electric to the military), there was an ongoing advocacy for the instrumental role of science in advancing social, technological and economic prosperity. After all, this was the era that led to the polio vaccine and a man on the moon. At the same time, the publication of Rachel Carson's *Silent Spring* in 1968, soon followed by Apollo 17's first images of Earth taken from space (the 'blue marble'), sparked environmental movements that joined with other liberation movements of the time (civil rights, feminism, etc.) to challenge existing power structures, including that of science. Some public science evangelists began to shift their lens from the instrumental dimensions of science for advancing economic prosperity to the relationship of science to topics of social concern. In 1969, at the

height of the Vietnam War, the Union of Concerned Scientists was founded in response to the scientific community's concerns about the ways in which science was being used to inform military, environmental and social policies.

These trends towards challenging existing power structures triggered reflection in the science journalism community about their role. Was it the responsibility of science journalists to cover the remarkable science that led to pesticides, or was it their responsibility to cover the health concerns over the use of pesticides? Was the goal of these communication efforts to excite people about the potential of science, or was it to connect content to social issues and decisions (Nelkin, 1987)? Science journalists increasingly tried to address adverse results of science, as well as demonstrate how and where science was being used to address adverse social and environmental conditions. In 1974, the second episode of the renowned American television show NOVA focused on the devastating effects of land and water mismanagement on the health of the Colorado River. Five of the first 11 NOVA episodes adopted critical perspectives on how human progress and tools of science had put the planet and its inhabitants in various types of danger.

Figure 40.2: The Exploratorium, an early interactive science museum founded in 1969, greatly expanded the field by making its exhibit designs and teaching materials widely available and free of cost.

Source: © Exploratorium (used with permission).

Along with calls for ‘power to the people’ emerged a novel form of public science museum that operated with a motto akin to ‘science for the people’: the interactive science centre. In the US, this movement was launched in the late 1960s with the founding of the Exploratorium and the Lawrence Hall of Science, both in the San Francisco Bay Area (which had just concluded the ‘Summer of Love’). The goal of these new institutions was to empower rather than strictly enlighten (as in the 19th century) the public to observe, question and engage with the natural world (Cole, 2009). Visitors were invited to participate in designed experiences (mostly interactive exhibits) where they could observe and develop their own questions about scientific phenomena—e.g. resonance, shadows, waves, linguistics. In this sense, a major goal of these early science centres was not to propagate knowledge but to stimulate questions about the natural and social world. Exploratorium founder, Frank Oppenheimer—who often touted a perhaps apocryphal story of a visitor to the museum writing him a note to tell him of her feelings of immense empowerment when after her visit to the museum she had gone home and re-wired a lamp on her own—said of that institution ‘the whole point ... is for people to feel they have the capacity to understand things’ (Cole, 2009).

This emerging Discourse of science as empowerment—adding to continuing propagation of the Discourses of science as enlightened citizenship and as instrumental to a nationalist and economic agenda—aimed to support the populace to pay attention, to ask questions, to see science as something that we all can do, and to use science to challenge authority. The interactive science centre movement has not always or solely advanced this Discourse, oftentimes resorting to more instrumentalist or enlightenment models. But this empowerment Discourse has continued in pockets—including new community-driven models of science centres such as the Science Gallery in Dublin—as well as in the development of community-based science programs such as the COASST (Coastal Observation and Seabird Survey Team) project or the Learning in Places project in Washington State.

COASST works collaboratively with Aleutian fishing communities to collect data on fish, mammal and seabird populations as a means of tracking the effects of sea temperature rise as a tool for political action. Science communication activities include workshops about climate change and trainings for data collection, in order to empower local individuals and communities to advocate for mitigation efforts to preserve their indigenous practices and villages. Learning in Places is a collaboration among local schools, a community-based garden program and a university to engage students with socioecological justice issues (e.g. food sustainability and water usage) through investigations involving ecological reasoning and decision-making. Many programs that

provide informal science education programs in prisons, such as Nalini Nadkarni's Oregon program, position science engagement as a tool for personal empowerment, where prisoners develop skills and understanding, but moreover personal meaning, through conducting pond studies or cultivating mosses for local industries. Community-based programs such as Guerrilla Science design interactions between the public and scientists so that their audiences can engage with science in ways that empower them to take action, whether to apply dream science to their dreams or neurosciences to their love lives. Science as empowerment is commonly measured through constructs such as activist uses of science, and pursuit of science in everyday and informal contexts indicating a personal commitment and sense of self-efficacy in science.

3. Staying relevant in an age of social atomisation and science communication solidification as a field

At the turn of the 21st century, in the context of the ubiquitous smartphone and an increasingly on-demand society, science communication in the US has grown more atomised. On the one hand, empowerment approaches have been embraced by advocates for topics ranging from HIV/AIDS research and popular epidemiology (Brown, 1992) to GET City in Lansing Michigan, where teenagers use the tools of science to investigate issues of community importance, such as the effects of urban heat islands on community health (Calabrese and Tan, 2010). Science as enlightenment continues in a broad array of informal science efforts, and science as instrumental is also advanced in many public engagement events, such as TED talks, public lectures and films.

On the other hand, science communication is being forced to play out against a backdrop of misinformation, a competitive media environment, identity politics and modern-day political communication (which some might call post-truth). In an age when science communicators are facing waning attention and growing scepticism the field continues to explore the dialogic, cultural and value-laden nature of the exchange and meaning-making of ideas (Kahan et al., 2013; National Academies of Science, Engineering and Medicine, 2017). This builds on the public understanding of science field's reflections of its evolution from science literacy from public understanding to an era more focused on the relationship between science and society (Bauer et al., 2007). The subfield of informal science education first began to engage with such issues in the wake of the formal education system's attention to

multiculturalism in the 1990s and the development of a large body of work focused on the cultural (and therefore value-laden) dimensions of how people engage with science and mathematics in everyday settings, such as playing dominoes, scoring basketball or shopping in supermarkets (National Research Council, 2009). In science communication, this ‘cultural turn’ has led to more targeted and niche approaches to communicating science, including conceptualising the two-way nature and mutual learning and benefit that can come through science engagement. Though even this new term has multiple meanings (Lewenstein, 2016), and we might increasingly question the role of science communicators in social contexts where values outweigh facts and data (Kahan et al., 2013).

Figure 40.3: Guerrilla Science stages live interactions with scientists, mathematicians and artists. Here science communicators discuss probabilities at the National Mathematics Festival.

Source: © Guerrilla Science International (used with permission).

More science communication efforts today adopt two-way and asset-based approaches to engaging public audiences with science. For example, more of this work takes place beyond university lecture halls and museum floors, where cultural scripts that imbue knowledge with the scientist predominate. From Nerd Nites at nightclubs to Guerrilla Science’s work in music festivals, community events and county fairs, most of these events seek to connect cutting-edge science to specific interests of the target audiences (e.g. what neurosciences can tell us about sexual attraction at speed-dating events). Science Discourse in these contexts is related to social transformation relevant to the questions and needs of the public audiences as individuals and as sub-

communities. Where is science already a part of your life, your values, your priorities? How do you or could you use it to advance your goals? Much of this Discourse places the public audience member—not science itself—at the centre of the interaction.

Social transformation is also present in how the role of scientists is conceived today. As science communication and journalism have increasingly moved to more niche and participatory outlets—such as blogs and social media—who is doing the science journalism has changed too. Scientists have found themselves in new positions as the number of paid science journalists has declined. In this context, the international media outlet *The Conversation* has emerged as a leading place for scientists (and other academics and experts) to share their work beyond traditional journal articles, reports and books. This shift in role and responsibility has occurred just as awareness of shared communal issues, such as climate change—along with concomitant political resistance in the US to taking action on it—have raised a sense of urgency of the need to enlist the public as allies to advocate for political change.

In her AAAS Presidential Address, Dr Jane Lubchenco challenged the scientific community to enter into a ‘social contract with science’ (Lubchenco, 1998). Lubchenco called on scientists to not only prioritise research questions that inform the most pressing questions of our time, but to communicate their knowledge, insights and findings with the public. Indeed, studies have found that scientists are highly interested and active in communicating directly with the public (Besley, Dudo and Yuan, 2018). Scientists describe a variety of objectives for meeting their science communication goal: most scientists cite their top objectives as defending science from misinformation and informing the public about science, but others communicate and engage in order to strengthen the public’s trust in science and shape policymaking (Dudo and Besley, 2016).

As more scientists are communicating and engaging directly, there is increasing focus to ensure that their communication is based on research about how best to communicate science. To this end, in 2012 the US National Academy of Sciences launched the Science of Science Communication Colloquium, which ultimately led to the development of a synthesis of the research called *Communicating science effectively: A research agenda*. As the study’s committee co-chairs state: ‘Fortunately, a growing body of scientific evidence can help inform the most effective ways of communicating with the public under different circumstances’ (National Academies of Sciences, Engineering and Medicine, 2017). However, many practitioners, like science communication trainers, do not access or use research to inform their practice (Besley and Dudo, 2017). With this, we might infer that many science communication

practitioners did not access or influence this report developed by researchers in the field. Indeed, a study by Bevan et al. (2019) found a disparity between researchers and practitioners in science communication—for example, researchers expressed far less engagement with issues of equity and inclusion than did practitioners, and researchers were less likely to indicate that they had strategies for staying up with new practices than practitioners reported for staying up with research. In contrast, there was much greater overlap among researchers and practitioners who identified with the subfield of informal science education.

Parallel to the rise of scientists engaging directly with the public has been an increase in the subfield of science communication trainers (Besley and Dudo, 2017), professionals who train and support scientists to be effective in their communication skills and messaging. Groups like the Alan Alda Center for Communicating Science, Seattle-based COMPASS and AAAS have pioneered approaches to supporting scientists' communication skill development, while hundreds of other courses and sessions are being developed (often by scientists themselves). The objectives and motivations of science communication trainers similarly run the gamut, ranging from wanting to ensure scientists inform policies to helping scientists engage in their local education systems. Frequently, trainers are unable to articulate specific goals for their programs (Besley and Dudo, 2017).

There can be a strong deficit orientation to some of this work. That is, scientists who see issues such as the role of vaccines and genetically modified organisms in meeting health and nutrition needs for an exploding world population are intent on public audiences embracing their analysis of the challenge and the solution. In this context, scientists are enlisted 'to set the record straight', particularly in the context of the internet-led spread of alternative, non-scientific views about (for example) the safety or efficacy of vaccines; and to advocate for particular, science-informed policies in a transforming world. This maps to Dudo and Besley's 2016 finding that 'defending science from misinformation' is a primary motivator for many scientists to engage the public.

To help scientists avoid falling back on deficit orientations, and in so doing vitiating the impact of their work, many new programs have been developed (led by scientists and science communicators) to re-imagine science communication as a means of promoting social justice and broadening participation in science. This extends the Discourse of science for social transformation to take on issues of social justice. For example, recent economic and natural disasters in Puerto Rico have resulted in Ciencia Puerto Rico's work to position science as a tool for economic development and social justice, including diversifying the scientific workforce. We Act, a

group located in New York, collaborates with low-income people of colour to build healthy communities. These approaches seek to measure change by understanding who is participating in, who is contributing to, and who is benefiting from science as an endeavour.

4. Discussion: Tensions and possibilities in science communication

This brief historical overview is necessarily superficial and does not provide space for other approaches (e.g. a rhetorical analysis) or to the many counterexamples that we might have discussed. For example, a 1950s kind of instrumentalism—preparing for the new economy—drives much of the current focus of 2019 informal science education related to coding, though much is also underpinned by a discourse of equity and inclusion for young people from communities historically excluded from science. TED Talks, referenced earlier, are contemporary means of communication that rely on traditional lecture-based, one-way transmission models of engagement delivered by individuals who, notoriously, are primarily white, male and highly educated. At the same time, TED Talks are also heralded as breaking down walls of the academy to democratise current science (and other issues).

Figure 40.4: Sensory speed dating. Neuroscientists are teamed with stand-up comedians as they guide public audiences at music festivals through inquiries into the science of attraction.

Source: © Guerrilla Science International (used with permission).

Despite the existence of these and plenty of other counterexamples, we hope that examining how larger social and historical forces may have shaped the development of different science communication goals and their attendant strategies can help science communicators adopt a more critical, and therefore inclusive, perspective on what science communication seeks to accomplish and how it goes about its work.

We can see how different Discourses of science—enlightened citizenship, instrumentalism, tool for personal and community empowerment, and for social transformation—have emerged at particular times and also persisted over time. As new Discourses of science have emerged in response to their historical moment, old ones have continued. Moving into the future, as the public is increasingly bombarded with information—ranging from 24/7 news cycles, 23andMe² and similar DIY genetics testing, and internet misinformation trolling—new Discourses will undoubtedly emerge that may for example position science as a resource in a teeming sea of information.

Harkening back to our introduction about the different dimensions of science communication, it is clear that in the US science communication field different goals are being pursued by different institutional actors adopting different engagement strategies—citizen science, podcasts, science cafés, etc.—towards different ends. The resulting cacophony is one of the drivers for the current push for the development of a science of science communication and for an infrastructure to support science communication.

Developing ‘a science’ is a move made by many different fields seeking to establish political, academic and social legitimacy (e.g. learning sciences, network science and organisation science). Fundamentally, it refers to the development of a systematic body of knowledge and theory that can be used to guide and analyse practice. The fact that this field of study is beginning to form reflects both the growth and the disorder of the field: a ‘science’ suggests that order will be instilled. Some leading science communication researchers come from the larger communication field, which can include strategic communication, journalism, public relations persuasion and advocacy, perhaps leading with (but not exclusively so) an instrumentalist Discourse of science. Researchers in the informal science education field tend to lead with both enlightened citizenship views as well as individual empowerment, with some drawing from the broader education research, especially related to learning. Of course, there are many examples of researchers pursuing other Discourses of science. We do not mean to essentialise but to make sense of

2 23andMe is a privately held personal genomics and biotechnology company based in Sunnyvale, California.

the emphases in the literature that show that science communication research often stresses how science communication practices lead to changes in public beliefs, decision-making, and behaviour. Whereas informal science education research often stresses how the practices contribute to dimensions of learning, writ large (see Bevan et al., 2019).

Similarly, as the field—driven by funding agencies that invest in scientific research such as the Kavli Foundation, the Gordon and Betty Moore Foundation, the Rita Allen Foundation, the Simons Foundation and others—seek to develop a national infrastructure for science communication, competing Discourses of science may suggest different directions. For example, training programs are underpinned by ideologies of science that dictate how science communicators are prepared. To date, many have adopted instrumentalist Discourses—focused on helping scientists excite and engage audiences about the work that they do in order to build support for science, or to ‘defend science’ (Dudo and Besley, 2016), rather than to position science as a tool for social transformation (e.g. as efforts such as *Ciencia Puerto Rico* or *GET City* pursue). If preparation programs seek to adopt Discourses of science as empowerment, they would focus their trainings primarily on helping scientists to develop relationships with and understanding of the communities and individuals they seek to empower. Less attention would be focused on messaging and storytelling, and more on listening and collaborating. Again, we do not suggest that this is an either/or, but we do posit that there are unacknowledged emphases and ideologies at work in the field in the US.

Organisational theory suggests that new fields rapidly tend towards isomorphism: institutions and institutional actors and routines become like one another over time (DiMaggio and Powell, 1983). A case in point is the way in which the field of interactive science centres has developed. The number of such fully interactive museums has mushroomed around the globe since they were first founded 50 years ago. Although the first of these organisations tended to focus on science as empowerment, the radical (playful) way in which they engaged people with science—building on a laboratory for inquiry model familiar to scientists—was so novel, in a society that understood science learning to be about books and demonstrations, that it led to the creation of a new Discourse of the science centre as a playground, where science is ‘fun’. This is the Discourse and model that the science centre field largely consolidated around in the 1990s and 2000s, with notable outliers, many of which have older histories as early science and industry museums (e.g. Boston’s Museum of Science, Philadelphia’s Franklin Institute, Chicago’s Museum of Science and Industry), which tend to keep a close connection

with scientists and the scientific community. These outliers may more closely associate themselves with science education and science communication than entertainment.

We raise this issue because as the science communication field consolidates it is essential that it is careful about what is in and what is out. Early interactive science centres, while arguing for an approach echoing ‘science for the people’ did not adequately articulate which people. Efforts to engage publics from communities historically marginalised from science—by social forces such as racism, sexism, hetero-normativism, etc.—were not explicit in their histories, their mission statements or even their design choices. As a result, the field has drifted towards serving mostly young people, on school trips or with their parents, and mostly young people from educated middle-class sectors. Again, there are exceptions to this rule. The Science Gallery International model seeks to engage adults with contemporary science and society issues. Some of the earliest maker spaces were developed in community settings, such as the San Francisco Mission neighbourhood, or Watsonville California or Detroit Michigan, to support and engage local audiences with science in the context of addressing immediate interests or needs (e.g. fixing a bike, building a bird house, fabricating a tortilla maker).

Is cultural relevance and responsiveness at the centre of the discussion in science communication as it begins to develop and solidify as a field? What does this mean in an age of too much information with an undercurrent of misinformation? Until we see cultural relevance and inclusiveness addressed in a comprehensive or widespread way there is a risk that the field will be developed by and for existing science stakeholders (with histories of deficit model thinking). Organisational theory suggests that later efforts to map social inclusion and cultural relevance back into the structures, the research and the work will be an uphill climb.

5. Conclusion

Rather than eschewing the multiple and competing goals of science communication, we hope that this cursory historical view of how such goals emerged reflect how values underpin work in the field. In that light, rather than pushing scientists and science communicators towards one set of common goals, we suggest that a careful articulation of goals and the subsequent alignment of audience, strategy and evaluation techniques are essential for both strengthening practice and working towards coherence across the STEM engagement ecosystem.

We know diversity is a strength, from natural ecosystems to our social structures: the more diverse things are, the more effective and resilient they can be. A science of science communication can create the structures, the theory and the connectivity to allow for diverse approaches to thrive (see Trench and Bucchi, 2010). But science communication practitioners must recognise themselves, their questions and their challenges in the research that is developed. The communities we seek to engage must also see their concerns and questions addressed in both research and practice. The field will best serve those who construct it. As it begins to solidify, we need more members of the public, and especially those publics long excluded from science, to inform its formation. For some of us this may mean that we need to ‘lean out’ so that others—those representing and working with communities who have not been an active or visible part of the history of science communication—can ‘lean in’ and create a more inclusive, and therefore more impactful, field of practice. We hope that this history, as retold a decade from now, will be able to recount such a new chapter for the field.

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Timeline

Event	Name	Date	Comment
First interactive science centre established.	New York Museum of Science and Industry	February 1936	Many of the early museums had a blend of interactives and objects, and the earliest museums that we now think of as interactive (e.g. Exploratorium, Pacific Science Center) had more objects than interactives when they opened
First national (or large regional) science festival.	Possibly Flagstaff Festival of Science	1990	Suggested as the first one by Ben Wiehe, manager of the national Science Festival Alliances
An association of science writers or journalists or communicators established.	National Association of Science Writers	1934	
First university courses to train science communicators.	Possibly New York University	1960s	

Event	Name	Date	Comment
First master's students in science communication graduate.	Several master's degree programs started in the mid-1960s, although some students graduated with science communication specialties in the 1940s and 1950s		1946: MS in Journalism and Mass Communication, with Science & Technical Writing specialty, Iowa State University 1950: MS in Agricultural Journalism, University of Wisconsin-Madison 1966: MA in Journalism, with Science Writing specialty, University of Missouri 1966: MS in Science Communication, Boston University 1967: MA in Mass Communication, with specialty in Science Journalism, University of Minnesota
First PhD students in science communication graduate.	A cluster of PhD students graduated from Indiana University after studying science communication topics in the mid-1970s	1970s	The cluster included Sharon Dunwoody, Edna Einsiedel, Marcel LaFollette and Holly Stocking. Also Rae Goodell at Stanford
First national conference in science communication.	Possibly the conferences of the Association of Science Technology Centers (ASTC)	1970s	AAAS in the US held sessions around the early 1970s. ASTC was founded in 1973
National government program to support science communication established.	The National Science Foundation created a program on public understanding of science in 1958	1958	The National Aeronautics and Space Administration and the Atomic Energy Commission supported science communication activities before that
First significant initiative or report on science communication?	<i>When Doctors Meet Reporters</i> . Kreighbaum, Hillier. New York: New York University Press	1957	
National Science Week founded.		1985–99	A National Science Foundation initiative
A journal completely or substantially devoted to science communication established.	<i>Science Communication</i>	1979	The original title until 1994 was <i>Knowledge: Creation, Diffusion, Utilisation</i>

COMMUNICATING SCIENCE

Event	Name	Date	Comment
First significant radio programs on science.	Science Service's <i>Science News of the Week</i>	1920s	
First significant TV programs on science.	<i>Serving through Science</i>	1946	
First awards for scientists or journalists or others for science communication.	Westinghouse-AAAS Science Journalism Award	1946	
Other significant events.	Establishment of Science Service	1920s	Publisher of <i>Science News Letter</i> (now <i>Science News</i>), and ran the 'Things of Science' mail order system
	National survey	1957	First full survey about public knowledge of and attitudes toward science
	Incorporation of Council for the Advancement of Science Writing	1960	The first NGO committed to science communication
	Founding of the Center for the Advancement of Informal STEM Education	2009	

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