Global spread of science communication: institutions and practices across continents

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Introduction

When the first large-scale international conferences of science communication practitioners, educators and researchers took place in the early 1990s, the panorama was very largely restricted to western Europe and north America. But the PCST (Public Communication of Science and Technology) series of conferences now attracts more than 600 participants from over 60 countries in all continents; proposals of contributions to the 2012 conference came from over 50 countries. The World Congress of Science Journalists (700-plus participants from 73 countries in 2013) and the professional conferences of science museums and centres attract similar numbers and distributions of participants.

As an inherently international system, modern science has diffused institutional structures and practices across the continents from its earliest days. In an increasingly globalised world, these processes have accelerated and intensified and, with cross-continental collaborations and movement of personnel, ideas and attitudes have also spread. This includes ideas and attitudes on the place of science in society and on scientists' social roles. Partly based on this shared culture of scientists, but also driven by other globalisation factors in politics and economics, science communication has over a relatively short period become a world-wide phenomenon.

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This global spread of science communication, its shapes and its meanings, has become a theme in science communication research in recent years. The proliferation of science communication activities and institutions across the globe, but also the differences and similarities between countries and regions in the organisation of these activities and institutions have become an object of specific interest in the worldwide science communication communities. A collection of country profiles and essays, *Science Communication in the World* (Schiele et al 2012), that grew out of the PCST conferences featured 31 contributors from six continents, presenting national overviews side-by-side. An edited volume on national and international surveys of public attitudes to science and technology (Bauer et al 2011) sketched a global view of patterns of scientific culture.

In considering science communication comparatively across countries, we are helped by a large-scale assessment of science-in-society practices in Europe, the MASIS project which surveyed 37 countries.[2] The project's final report categorised national science communication cultures according to six parameters, as "consolidated", "developing" or "fragile". The parameters "collectively form a framework for analysing science communication culture" (Mejlgaard et al 2012: 67), which appears valid beyond Europe. These are restated here with slight modification: the degree of institutionalisation of the science communication infrastructure; the level of attention paid by the political system; the number and diversity of actors involved in science communication; the academic tradition for dissemination of research results; public attitudes towards science; the number and qualifications of science journalists.

When we examine the global spread of science communication we are looking in the first instance at its institutionalisation through the policies and programmes of national governments, national academies and research funders, professional networks, inter-

[2] The project web site, including all reports, is at www.masis.eu

governmental organisations, higher education and research institutions, international charities, and commercial companies. In different contexts, the strength of the roles that these actors play and the relations between them can vary significantly. But the state, in its various guises, tends to be the main driver of the institutionalisation of science communication. In looking for markers of the institutionalisation of science communication in individual countries across the globe one of the first, if not *the* first, to observe is the presence of government programmes to boost science awareness. Other markers include the presence of: communication training for scientists; initiatives to support media attention to science; university taught programmes in science communication; university research in science communication. In the following sections we examine each of these briefly, with particular reference to their appearance in countries and regions outside western Europe and north America.

Key indicators of global spread

Government programmes to boost science awareness: policy-making for the economy and for research and development have become ever more closely intertwined since the 1990s, as a central role has been ascribed to science and technology in economic development, whether in taking a country from a largely agrarian or from a traditional-industrial base to another phase of development. Across the developing countries, as in the industrially and technically more advanced regions, the knowledge economy and/or sustainable development have become central themes of public policy. Under either or both headings, government programmes and policies, with varying degrees of emphasis and explicitness, refer to the public's views of science and technology as a potential constraint on, or support for, economic and social development.

In the world's two most populous countries, China and India, the state's commitment to popularise science has been written into fundamental legislation for several decades. A more recent policy statement, Japan's *Science and Technology Basic Plan* (2011-15) links knowledge creation and innovation with working towards "a sound infrastructure of science and technology information and raise awareness and understanding of science and technology-related issues in Japan".[3] The Japan Science and Technology Agency's divisions include a Centre for Science Communication, which, "in addition to communication conveying the knowledge and enjoyment of previous achievements in science and technology, also seeks to promote constructive communication by sharing the tentative nature, uncertainty, and latent risks possessed by science and technology with the nation's citizens, its government, its research institutions, and researchers, for a better society and lifestyle".[4] This represents a more comprehensive view of public communication of science and of its contexts than may be found in many other similar documents.

Perhaps the most frequently shared feature of such policies is a concern – explicit or implicit – about children's and young people's competence in scientific and technical subjects and their attitudes to developments in science and technology. The context of this concern is also competitive: the high ranking of some south-east Asian countries in international surveys of school students' abilities in mathematics and science (e.g. PISA - Programme for International Student Assessment of the OECD) is noted with some alarm in western European countries. Government policies in these regions are targeted, respectively, at closing the gap or maintaining the lead. In a largely linear conception of the relations between education and economy, the preparation of young people in 'STEM' (science, technology, engineering and mathematics) subjects is seen as assisting skills supply to the economy.

[3] See http://www.jst.go.jp/EN/about/index.html#NOTE2
[4] See http://www.jst.go.jp/EN/operations/operation2_c.html

Informal education initiatives of the kind typically endorsed in programmes for science awareness are assigned a complementary role in this national effort.

However, government encouragement for public engagement with science in some western European countries has acquired a much wider scope during the past two decades; the public or publics in question specifically include those with an interest and ability to participate in exchange of ideas and in policy formation. The “turn to dialogue” signalled in national programmes across the developed world reflects the diversity of publics these programmes encompass. In countries where science communication has been institutionalised more recently, the emphasis tends to be more strongly – or, in some cases, exclusively – on children and young people.

This emphasis, represented also in a conception of science communication as informal education, contributes to a common trait of government programmes and policies on science awareness: the commitment to build or support science centres, generally of the kind that has grown up since the late 1960s and the establishment of Exploratorium in San Francisco (see Schiele in this volume). At the turn of the present century, a group of such centres was opened in Britain as a millennium project, with support from the government through the national lottery. Smaller European countries have built their landmark national science centres in the past two decades, generally in or near the capital city, as a representation of the country’s openness to science and technology. In more populous Asian countries, e.g. India and South Korea, science centres are counted in their tens or twenties and the networks have continued to expand through the 2000s and 2010s with support from regional authorities or state governments. But the most ambitious programme by far is that of China, where the number of science and technology centres almost doubled, from 185 to 380 between 2004 and 2008 (Shi and Zhang 2012).

The Chinese network of science centres is firmly integrated into a government programme of public education, as – in an apparently quite different political context – is Taiwan's National Science and Technology Museum which has the mission "to enrich citizens' knowledge of science and technology; to inspire citizens' interest in doing scientific and technological researches, and to value the development of science and technology; to record and present our national achievement in the development of science and technology, thereby building up our people's confidence; to promote public education of science and technology in southern Taiwan".[5]

But elsewhere in Asia different models can be found, illustrating that the development of science communication globally is uneven: the ArtScience Museum in Singapore, with its striking architecture, is part of a commercial leisure and entertainment complex; Miraikan, the National Museum of Emerging Science and Innovation, in Japan states, as a founding principle, that "science and technology are part of our culture. We provide an open forum for all to ponder and discuss the future roles of science and technology"[6]; Petrosains in Malaysia (see below in this chapter) "is a Science Discovery Centre that uses a fun and interactive approach to tell the story of the science and technology of the petroleum industry", housed in the world's tallest buildings, built for the energy company, Petronas.[7]

Government programmes for raising awareness about scientific developments also incorporate other common manifestations that are less visible than science museums and science centres. These include, for example, direct or indirect support for national 'weeks of science' or similar concentrated efforts in public science; for innovations in science education; and for Internet-based services for news from research, such as are found in Denmark, Netherlands, Norway and Spain. (Other such Internet-based services have also

[5] See http://aspacnet.org/ns/membership/list/national-science-and-technology-museum-taiwan
[6] See https://www.miraikan.jst.go.jp/en/aboutus/
[7] See www.petrosains.com.my

been established independently of government, e.g. AfricaSTI.com, operated by a network of African science journalists.)

Comparing government science awareness programmes, Bultitude and colleagues (2012) found that Brazil's and China's were more oriented to development and addressing social inequalities than those of Australia and Britain; emphasis on education was stronger for China and Britain, and emphasis on culture was strongest for Brazil. An earlier study noted that evaluations of the Australian awareness programme of the 1990s did not establish if it "caused Australians to become more or less aware of science and technology or of the part science plays in stimulating social and economic development" (Gascoigne and Metcalfe 2001); the authors recommended that evaluation needed to be built into such programmes from the start.

Training and other supports for scientists in public communication: short courses in media and presentation skills are increasingly available to scientists and other academics from research funders, universities, professional societies and – increasingly – private providers. Across western Europe, the number of such courses is growing continuously; the common requirement of national research agencies and of the European Commission that results of projects funded from these sources are 'disseminated' publicly is a strong driver of demand for such training. In the present decade, initiatives to provide courses have been taken in several European countries where none existed previously as, for example, in some Italian universities.

Courses are also provided on an international basis, as in the case of a 2011 communication course for scientists in developing countries; this was promoted on the basis that "communication skills are particularly important for scientists in developing countries, where the infrastructure for science is weak and where science education needs more support at all educational levels”.[8] The course hosts, the International Centre for Theoretical Physics and Third World Academy of Sciences in Trieste, Italy, noted that “by improving their communication skills, scientists can play an important role in the development of science in their countries”.

A decade ago, an EU benchmark study of activities in “the promotion of research, technology and development culture” noted that few countries were doing very much to train their scientific research community to communicate with their fellow citizens or to engage with their concerns (Miller et al 2002). More recently, a cross-country survey reported a significant correlation between communication training and confidence among researchers in communicating with the public (Peters et al 2008). But in many countries where there are similar expectations of researchers that they engage in various ways with the general public, there is little or no provision of relevant training. Although elements of communication training are increasingly found in doctoral and post-doctoral programmes, these are more likely to be directed to communicating with peers in related disciplines or with prospective business users of technologies arising from research, than to communicating with broad publics or with policy-makers.

As observed in the MASIS reports for several countries in southern and eastern Europe[9], support for (mainly younger) researchers wishing to become involved in public communication has come from the British Council and UNESCO as much as from local sources. In October 2013 UNESCO organised the First Regional Science Promotion conference in Serbia, bringing together science promotion professionals, practitioners and enthusiasts from south-eastern Europe to “share experience, network and formulate the next steps towards strengthening the link between science and society”. Among the topics

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[8] See http://twas.ictp.it/common/files/files-announce/ict-twas-workshop-on-science-communication

[9] See http://www.masis.eu/english/storage/publications/nationalreports/

considered was how to "improve science communication and language of scientists and researchers allowing them to present their work in a comprehensive manner".

MASIS reports for several central and eastern European countries cited the UK cultural relations agency, British Council, as a primary player in science communication, principally through the Famelab competitions. Famelab has spread to over 20 countries, mainly among the newer member-states of the European Union but also including Egypt, Hong Kong and Israel, and the British Council has provided the associated training, preparing mainly early-career researchers to present a chosen scientific topic in three minutes before non-specialist audiences.

The British Council has also helped organised science cafés in many countries and this format has also been applied elsewhere to familiarise scientists and others with communicating about science in informal public settings (see Einsiedel in this volume). In Vietnam, Café Khoa Huc was established by Oxford University's Clinical Research Unit and the Hospital for Tropical Diseases aiming to create "a friendly atmosphere in which everyone feels free to question and offer their ideas".

Also originating in Britain, the Science Media Centre (SMC) has come to be seen as a model capable of being applied in other countries; as of late 2013, similar centres had been established in Australia, Canada, Denmark, Japan and New Zealand, with "more on the way in China, Italy and Norway".[10] The British SMC has operated since 2002 with support from professional societies and private companies. It gives various kinds of support to scientists engaging with mass media, including short workshops under the title, Introduction to the News Media, where scientists with media experience and media professionals present "the

[10] See http://www.sciencemediacentre.net/

realities of the news media".[11] The Science Media Centre stresses that this does not represent practical media training, but rather offers "a flavour of the news media".

A key issue for the design and delivery of such training is the strength of emphasis on technical and formal aspects of communication. A media skills course may, for example, be largely or exclusively focused on the key elements of writing a news release or of doing a radio or television interview. A course on skills for communicating with lay audiences may, in the same way, be largely or exclusively focused on techniques of story-telling. The final report of the EC-funded Messenger project noted that opinions differed among those consulted for the project on the type of training that scientists need, from media skills that are relatively straightforward to impart to developing "an awareness of social as well as epistemological considerations" (SIRC and ASCOR 2006). As discussed elsewhere (Trench and Miller 2012), an approach to public communication oriented to dialogue requires preparing scientists to consider carefully the needs of their audiences and to listen well to their concerns. Encouraging scientists to take part in informal conversation, as at science cafés, may require specific forms of support.

Among the other supports offered to scientists, sometimes alongside training, sometimes in its absence, are prizes and other awards for outstanding achievements in communicating science. However, the increasingly common requirement of scientists that they engage in public activities is not generally matched by changes in the way scientists are assessed on their performance overall. Despite the increasing attention to the "third mission" (beyond teaching and research) of higher education institutions and to public access to research centres, there are few formal incentives for scientists to be publicly active. In a letter to *Nature*, correspondents from leading research institutions and the national science centre in Japan noted that the government "has urged the researchers it funds to improve

[11] See http://www.sciencemediacentre.org/working-with-us/for-scientists/intro/

communication with eh tax-paying public" but "time and effort spent on science communication will not help scientists to secure funding, promotion or employment" (Koizumi, Morita and Kawamoto 2013).

Communication training is often focused on early-career researchers or PhD students, as, for example, in the science and communication workshops held in recent years in India, with funding support from The Wellcome Trust and India's Department of Biotechnology. Meanwhile, training for wider groups involved in science communication is spreading, and increasingly internationalised: in September 2013 the first Euro-Mediterranean and Middle East Summer School of Science Communication took place in southern Spain, supporting science communication professionals in their efforts "to drive development of new science communication endeavours". The participants included staff of existing science centres and museums as well as newcomers to the field from related organisations such as universities, local authorities and associations.

Initiatives to support media attention to science: national and international bodies have become involved in efforts to encourage media interest in science, and to support journalists giving special attention to this 'beat'. We can observe a spreading trend of governments encouraging publicly funded broadcasters to increase and maintain levels of science coverage, in some cases providing support through national awareness programmes, or less directly, through state agencies and institutes in the science and technology sectors. High-technology companies also feature as sponsors of science programming on television. Inter-governmental organisations, such as UNESCO, also seek to promote media attention to science and to support media professionals working in this field. Alongside the south-east European regional meeting of science communication professionals that UNESCO hosted in October 2013, it also organised a school of journalists "oriented towards improving the quality and quantity of ethical science reporting by the SEE [south-eastern European] media and will contribute to increasing public awareness on the importance of scientific knowledge and towards developing a critical science journalism culture in SEE”.[12] On a broader European scale, the European Commission published in 2007 a guide to science journalism training, updated in 2010 (European Commission 2010), and hosted a forum in Barcelona to discuss issues in the media coverage of science and in the associated training.

In Africa, global and continental inter-governmental organisations supported a 2012 workshop in Addis Abeba that gathered science and technology journalists from various African countries, heads of key media institutions and scientists to “discuss how best to communicate scientific issues to the public”. In Asia, the Pakistan Biotechnology Information Center organises media workshops and training courses aimed at enhancing “the capacity of electronic and print media to objectively cover biotechnology-related issues”.

Among non-governmental organisations supporting the worldwide development of science coverage in mass media, scidev.net and the World Federation of Science Journalists (WFSJ) deserve specific mention. Scidev.net provides an Internet platform for reporting and discussion of scientific developments particularly in – or from the perspective of – less-developed countries. The service has the support of the journals, *Nature* and *Science*, and of development aid agencies and charities with a particular interest in supporting science and technology in developing countries. It has developed a network of correspondents across the world’s regions, encourages emerging talent and publishes practical guides on various aspects of reporting science. Similarly, the WFSJ provides experienced mentors for journalists in less-developed countries wishing to specialise in science, and offers an online course in science reporting. The federation’s biennial conferences have become a focus for discussion of the effects on science coverage of the crisis affecting media industries, particularly in the more developed countries.

[12] See http://www.unesco.org/new/en/venice/about-this-office/single-view/news/call_for_participation_south_east_european_science_journalism_school_deadline_8_september_2013/#.UnI-RXAmWSo

University taught programmes in science communication: over the past 25 years, programmes leading to awards specifically in science communication have come to be recognised as one of the features of a developed science communication infrastructure. From the earliest examples of Masters and Postgraduate Diplomas in science communication established in Australia, Britain, France, Italy and Spain, such programmes are now found in many western European and Latin American countries and India. Among the more recently established Masters programmes in science communication are those in Budapest, Hungary, in Lisbon, Portugal, and online by Universitat Pompeu Fabra, in Barcelona, Spain. In New Zealand, Otago University in 2013 recruited a second professor of science communication for its programmes; over half of its students in this field come from abroad. India's and Korea's several postgraduate diploma and degree programmes in science communication or science journalism have been driven largely by guidance and funding from national or state government. In Brazil, a Masters in Scientific and Cultural Communication was added to the existing offering in science journalism at the University of Campinas (Vogt et al. 2009). At the National Autonomous University of Mexico, the programme in science popularisation, started in 1996 through a close association with a science museum, has been linked to longer-established studies in the philosophy of science (Haynes 2009). Laurentian University, Ontario, Canada, set up a Graduate Diploma in Science Communication as a joint initiative with the Science North science centre, declaring it "North America's first and only comprehensive Science Communication program", though there are specialisation strands in communication masters at Drexel University, Philadelphia and at the University of Florida, and preparatory work on a new single-subject masters in science communication began in 2013 at another Canadian university.

These programmes show some common characteristics across quite different cultural and educational settings, though the relative emphasis on social studies of science, communication theory and professional skills can vary considerably (Mulder et al 2008; Trench 2012). North America is under-represented in this sector, reflecting a preference there for more strictly professional programmes in science writing and science journalism. In this respect and in others, the global spread of science communication is not a uniform diffusion of a universal model. Nor is the trend in one direction only: there are also examples of programmes that have been reduced, suspended or cut as part of their host institutions' rationalisation (Trench 2012).

University research in science communication: individual projects and institutional programmes in science communication research have grown up alongside postgraduate taught programmes. A first wave of doctoral research projects in science communication featured trained scientists who were converting to science communication. More recently, the taught programmes in science communication have been a source of doctoral researchers. The countries that were earliest to establish postgraduate taught programmes have tended also to be the most strongly represented in formal academic research. In many cases in these countries, those who teach on the degree and diploma programmes have completed such programmes themselves and proceed to PhD degrees. In China, however, research in science communication has developed in the absence of postgraduate teaching in this subject area; the China Research Institute of Science Popularisation (CRISP) has facilitated many doctoral research projects, often also including periods of study abroad, and thus contributing to the exchange of experience across countries and continents. Science communication research outputs in China are at a comparatively high level, and increasing: a report on the development of science popularisation studies found 1,795 papers published between 2002 and 2007 (Ren, Yin and Li 2012).

An attempted characterisation of topics, theories and methods in current PhD research in science communication showed wide variation (van der Sanden and Trench 2010). While the pattern may be complex and even contradictory, the trend in numerical terms appears clear from informal evidence gathered in convening a network meeting in 2012 of early-career researchers: there may have been more PhD projects in science communication under way in late 2013 than were completed in the two preceding decades. A study of science communication research in Australia noted the increase in PhD students from three in 1997 to twenty in 2012, and a doubling of the output of research papers written by Australian researchers from the 1990s to the 2000s (Metcalfe and Gascoigne 2012). In the 2000s, research on public attitudes to science, media and science and policy on science communication commanded roughly equal attention, at 19, 17 and 16 per cent, respectively, of the primary topics of these papers.

A further outgrowth of postgraduate teaching in science communication has been the publication of specialist academic journals in the field. *Public Understanding of Science*, whose title reflects its provenance in Britain in the years following the 1985 report of the Committee on the Public Understanding of Science, emerged in the early 1990s from the same impetus that led to the Masters in Science Communication in Imperial College London. The renaming of another journal, *Knowledge*, as *Science Communication* and the establishment of *JCOM – Journal of Science Communication*, an online, open-access publication from SISSA, Trieste, also reflected the growth of postgraduate teaching and research in the field. Catering to more local markets, *Quark* was published for over a decade by the Science Communication Observatory at Universitat Pompeu Fabra, Barcelona, and the *Japanese Journal of Science Communication* (Kyoto), *Indian Journal of Science Communication, Science Communicator* and *Journal of Scientific Temper,* originating in India, have emerged in more recent years. The pattern of publishing shows both globalisation and localisation trends. This extends to the keywords used in the description and discussion of science communication, some of which have distinctive or exclusive usage in particular countries or regions: “scientific temper” in India, “science popularisation” in China, “social appropriation of science” in Latin America, “scientific, technical and industrial culture” (generally denoted by the acronym, CSTI) in France.

Reports from five emerging centres of science comunication

To illustrate how the global spread of science communication is manifested in national contexts, we asked correspondents in five countries that have not typically received much attention in the research literature to outline the state-of-the-art in those countries. It will be noted that each of these reports refers to several of the elements outlined above.

Argentina: the global processes affecting scientific and technological practices have been evidenced in Argentina and other Latin American countries, particularly Brazil, Colombia and Mexico. There are many indicators of how science communication is becoming an expanding cultural industry. The environment of institutional science communication is shaped by Argentina's economic growth that during the last decade stimulated public policies and consolidated basic science and technology system capacities. The creation in 2007 of a ministry for science, technology and productive innovation was a signal of new times. Over recent years, R&D investment – following a regional tendency – grew faster than in Europe, USA and Canada, though behind Asia. Some areas of biotechnology, nanotechnology, information technology and food technology have expanded considerably (Ricyt 2011). The public policy discourse shifted towards a knowledge economy and reducing dependence on commodities production. Within this framework, the importance of social communication of science, including the reinforcement of traditional museums and new science centres, has been emphasised.

There are also signs of stronger relations between scientific institutions and the mass media system, as suggested in the mediatisation process (Weingart 1998; Väliverronen 2001; Peters et al 2008). S&T institutions have progressively incorporated media and public-opinion operating logics, including practices, values and institutional and technological modes that media use to operate, supported by formal and informal rules. Some indicators are: the creation or consolidation of groups and structures for public communication in universities and S&T institutions; the intensification of contacts between scientists and journalists; the increasing salience of a rhetoric of engagement, dialogue and public inclusion. Scientists have tended to gain salience in the public sphere and are participating in wider social debates. This is connected with new national political tendencies where intellectuals, scientists and public figures in general have recovered their public role (Polino 2013). On the other hand, the empirical evidence indicates science journalism is also becoming incrementally professionalised and institutionalised (Gallardo 2011; Vara 2007). During the past fifteen years, the media have appointed specialist journalists and increased coverage of S&T-related issues. Argentina's research and development has become more prominent in coverage in the main newspapers, public TV and some commercial radio programmes. Science journalists have organized themselves through a network and a professional association[13] and young professionals with new expectations are entering science journalism and science popularisation, as can be seen in data for Argentina from a worldwide survey (Bauer et al 2013). Many of these are coming through new university programmes (Murriello 2011), though the spread of science communication training programmes is still limited.

[13] See http://www.radpc.org/

Increased public demand is reflected in the publication by the main publishing houses of popular science books, some locally produced and some translated materials from Europe and United States. The market for popular science magazines is also growing. The recent creation of competitions and awards for science journalism and popular science that stimulate novel contributions are another effect of the cultural industries' increased interest in science-related matters. These developments can be seen to relate to audience interests and cultural habits as demonstrated by nationally representative surveys on public understanding of science (Mincyt 2012; Secyt 2004, 2007; Polino 2012).

However, the science communication environment in Argentina also has certain constraints which are shared with other Latin American countries. As pointed out elsewhere (Polino 2013), institutional communication shows some structural weaknesses: despite university and federal institutions acknowledging the importance of press offices, funding is scarce: most of these groups have no guaranteed budgets or permanent positions to produce science communication materials, so many of their practices are voluntary. Although things can be seen to change slowly, scientists are not clearly incentivised to engage in public communication. Often, these activities are considered to be 'decorative' from the perspective of a scientific career. The consequence of this is evident: the system tends to integrate only those who are already convinced and to reject new talent.

Another problem is the conception of communication and the perception of the public that underlie many institutional initiatives in science communication and science popularisation. Even with strong evidence showing why the deficit model does not work and how it produces a distorted image of S&T (e.g. contributions in Bucchi and Trench 2008; Dierkes and von Grote 2000) many university efforts in science communication are still inspired by or oriented to that model.

Many scientists often deal with journalists in pedagogical terms: they assume that journalists need to be educated (by the scientists). This produces an obvious tension, which is recreated many times in public lectures, talks and media interventions.

Dialogue and social participation are values not clearly translated into institutional practices: there are almost no sponsored mechanisms for citizen participation. We can also observe that media tend to favour descriptive rather than analytical perspectives; science news is often reduced to scientific discoveries, leaving out perspectives on risks, conflicts of interests or the connections between science and economy. Coverage is dominated by a small number of information sources and, consequently, the media offer limited comparative content.

Estonia: the upheavals of the political, economic and social transition of the 1990s left little intact of the ideology-driven and scientist-centred Soviet science popularisation system. The few survivors like the popular science magazine *Horisont* (Horizon) were run by devoted enthusiasts but the field was marginal and had poor resources and support. By the turn of the millennium Estonia had started to establish itself as an innovative country strongly oriented to information technologies. Along with that came the realisation that future successes in that area will be seriously undermined by the lack of scientists and engineers and the low public profile of sciences. Since then, the economic benefits of a high number of scientists and engineers in a society and the need to attract young people to science and engineering has been the dominant discourse in Estonian science communication activities, especially those run by public sector.

Through the Estonian Research Council and other schemes the government funds various initiatives to engage young people with science-related activities. These focus on hands-on activities like robotics workshops in schools or interactive study programmes in science centres and on promoting science as a career choice.

Many of them stand out as youth-to-youth projects; one of the most notable has been the Science Bus project by the National Physics Society, delivering science theatre shows to schools. To further increase the public visibility of these activities, September 2011-September 2012 was declared the Year of Science in Estonia.

The biggest government scheme to support science communication has been the partly EU-funded TeaMe programme (2009-15). Its main outcome for the public has been two prime-time TV programmes: a series of portraits of prominent scientists and a students' game-show. The programme has also funded training of scientists and journalists and development of various study materials for schools.

In recent years science centres and museums have become prominent actors in the field of science communication, acquiring new buildings and new exhibits. The opening of the new science centre AHHAA in Tartu and the new exhibition of the Maritime Museum in the Seaplane Harbour in Tallinn have been major events and these have attracted record numbers of visitors. AHHAA also co-ordinates the annual Researchers' Night, that has grown into a week-long festival and culminates with a live TV-show on the national broadcaster's main channel. Besides the festival, the number of events for adults is still small and they are mostly one-off.

In the mass media, the only specialised science journalist is employed by the national broadcaster for a weekly radio show, though most of the major newspapers have regular contributors specialising in science. There are several online sites dedicated to science and technology news, one of the most prominent ones (www.novaator.ee) hosted by the University of Tartu. The nature of science coverage is mostly informational and promotional with little critical analysis. As issues of public trust in science are not among the main drivers for science communication there is little discussion about the nature of science or about the need for critical journalism.

Public information from research institutions tends to focus on institutional affairs rather than presenting scientific results, however, there are a few individual scientists who skilfully engage with media directly. The Estonian Research Council annually awards national science popularisation prizes.

The rapid changes of the past decade in Estonian science communication field have been brought about by a combination of internal and outside factors. For example, the national contest for young scientists was launched after Estonia was approached by the European Commission to send entries to the European contest. Many major projects (museums, TV programmes) have received one-off EU grants. However, this followed decisions made in Estonia to dedicate funds to science communication-related projects. Still, regular funding remains the most pressing question for many activities; the government mostly supports activities via yearly open calls.

Malaysia: the importance attached to science and technology has been reflected in several Malaysian government key policies such as Vision 2020, the 10th Malaysia Plan, the National Science and Technology Policy, the National Biotechnology Policy and the National Agricultural Policy. Related efforts to embed science and innovation in Malaysian society include the declaration of 2010 as Malaysia Innovation Year, 2011 as the Year for the Promotion of Science and Mathematics and 2012 as the National Science and Innovation Movement Year.

The National Science Centre (PSN) and Petrosains science centre are at the heart of science promotion in Malaysia. The first is run by the government under the auspices of the Ministry of Science, Technology and Innovation (MOSTI), and the second is the corporate contribution of Petronas, the leading oil and gas company.

PSN has various outreach programmes which give opportunities for people outside the area around the federal territory, Kuala Lumpur, to visit the centre, and science camp programmes which give a chance for school students in rural areas to experience the learning of science and technology through interactive hands-on activities. The centre also conducts a special programme for teachers and organises competitions and carnivals to instill interest in science and technology. Petrosains is an interactive science centre that presents the science and technology of the petroleum industry, as well as general science using a hands-on approach. The National Planetarium is also active in educational and outreach programmes on space education (Zainuddin, 2008).

Various organisations in Malaysia have shown a strong commitment to science events. The Academy of Science Malaysia has initiated programmes such as back-to-school lectures by the fellows, quizzes and competitions, science camps, Science and Mathematics Expo, National S&T Month and exhibitions and publications to enhance public awareness. Universities and schools throughout the country conduct science camps during the school holidays, either on their own or collaboratively. The various government ministries have also played their part through programmes and campaigns related to their particular responsibilities, either on their own, or in collaboration with universities, corporate bodies or NGOs.

One effort by MOSTI has been the creation of the MyBiotech@School programme which has exposed nearly 40,000 students throughout the country to biotechnology through hands-on experiments, multimedia shows, demonstrations and talks by scientists and industry experts (Mivil 2013; BIO-BORNEO 2013; Firdaus-Raih et al 2005). The Ministry of Natural Resources and Environment and the Department of the Environment have conducted various environmental awareness programmes (Pudin et al 2005).

The Ministry of Health has organized health-related campaigns (MOH 2010; Malaysian Digest 2013; CAP 2011). Non-governmental organisations have also played a prominent role in science awareness in Malaysia with various projects and websites.[14]

The mainstream newspapers play a significant role in the dissemination of science-related information to the public. In January-March 2009, about 300 science-related pieces of news were published (Arujunan 2011), with about two-thirds of these articles focusing on medical- and health-related issues. The remaining one-third dealt with disciplines such as biotechnology, space, biodiversity, the environment, agriculture, and others. The coverage of scientific issues tends to follow current interest or controversy at national or international levels, including the focus of government policy at any particular time.

Nigeria: The future of the Nigerian economy is considered to be predicated on the rapid diffusion of science and technology as the government has adopted this approach as the best way forward for accelerated growth. The successes of the technology-driven mobile telephony industry in generating employment and increasing wealth no doubt contributed to this policy direction and to the hope that this success can be replicated in other sectors. The increase in GSM mobile lines from less than a million in 2001 to over 100 million in 2010 showed the highly significant impact of policy changes on economic growth; in 2001 the state monopoly in telecommunications was ended. A summit meeting in 2010 aimed to stimulate the interest of the public in science, technology and innovation, to encourage indigenous researchers, inventors and innovators and to promote the domestication of modern technologies. Those attending included federal agencies, small and medium enterprises, chambers of commerce and industry, and international organisations.

[14] See www.mac.org.my; www.cancer.org.my; http://ensearch.org/global-gateway/environmental-ngos-in-malaysia

A new science, technology and innovation (STI) policy was subsequently launched in 2011, the first such policy statement having been produced in 1986, and reviewed in 1997 and 2003. The new policy emphasises innovation and technology transfer and sets out specific objectives for the promotion of STI communication and inculcation of science culture.

The Nigeria Academy of Science provides advisory services for the federal government on STI, of which one was an audit of research and development agencies; one recommendation was for more synergy among the agencies and the institution of an annual national science and technology forum. The 19 science agencies under the Federal Ministry of Science and Technology were at that time running independently, each holding its own public exhibitions and managing its own library and science museum. Without upscaled science awareness activities at federal and state levels, including regular exhibitions of the numerous outputs of the state's research and development agencies, these will remain largely hidden from the wider public and potential users of the technologies.

The Academy of Science is also actively involved in popularising science. In 2012, it held a workshop on effective communication of science research aimed at bridging the gap between scientists and the public and bringing together young scientists and journalists. The Academy also works in partnership with Schlumberger, a private firm, the Nigeria Young Academy and science, engineering and mathematics teachers and volunteer employees on the Schlumberger Excellence in Education Development (SEED) programme.[15] SEED gives students and teachers the opportunity to work together on a research project. The programme aims to ignite a passion for science and develop the student's technical potential by building critical thinking, creativity and innovation skills.

[15] See www.planetseed.com

The Nigerian press regularly feature science and technology articles and *The Guardian*, regarded as the flagship of the Nigeria press, has maintained regular science columns for several decades and media analysis (Falade 2014) has shown that the percentage of science in the news compares favourably with what obtains in the United Kingdom and the United States.

Turkey: with a population of over 75 million that is comparatively young, Turkey has acknowledged the value of science communication through investment of large amounts of money to enhance public engagement with science and technology, promote a scientific culture, and develop a dialogical science communication culture in the country. The Scientific and Technological Research Council of Turkey (TUBITAK), in cooperation with local authorities, has been establishing science centres around the country, aiming to complete a science centre in all 16 metropolitan areas by 2016, and in all 81 cities by 2023 (TUBITAK 2013). TUBITAK is also responsible for promoting, funding and carrying out cutting-edge scientific research, and making the findings available to the public. It publishes popular science books as well as popular science magazines for children and for the general public.

The Turkish Ministry of National Education has also been working with TUBITAK and the Turkish Radio and Television Corporation on developing effective ways of science communication. The involvement of the education ministry reflects recent changes in science education: creating engaged and scientifically literate citizens has become a focus of the new science curriculum.[16]

[16] See Turkish Ministry of National Education, *Science Curriculum*, at http://goo.gl/jSSG5w

The new media literacy curriculum[17] specifically endorses public participation in policy debates about science-related social issues; this is seen as essential to maintain a healthy democracy (Cakmakci and Yalaki 2012).

There are several challenges still to be addressed, among them the small number of researchers in science communication and very limited output of research on science communication. There is no science communication division in any Faculty of Communication or in other faculties. The Turkish press often covers science and technology-related issues, but few of the newspapers have a separate science section. Journalists writing about science have limited knowledge and expertise in science communication (Erdogan 2007). But the need and the means to improve the quality of science communication research, education and practice are overlooked in the policy reports. These activities and the establishment and sustainability of a community of practice in science communication are not seen as important as the material outputs such as science centres. Another challenge that Turkey faces with is the unsustainable short-term cycle of policies in science outreach. Over little more than a decade, the minister of education changed five times and each person in that role had different priorities, agendas and different kinds of science communication models (from deficit to dialogue and participation models). This has caused tensions among the public, policy-makers, science communication researchers and practitioners.

Concluding remarks

There are striking parallels in these short summaries of conditions for science communication in five countries that have few, if any, bilateral connections. These summaries can be taken as evidence of trends that are not merely born of international diffusion through contagion but represent a global phenomenon. The phrase "science communication" is far from universally

[17] See http://www.medyaokuryazarligi.org.tr

recognised, nor is it used uniformly used, where it does occur. But in disparate countries, with notably different cultural contexts, a similar kind of commitment is being made to promoting science and, with it, to promoting awareness and appreciation of science. Across these examples, there are similar references to science's role in technological and economic development and to the need to encourage interest in science particularly among children and young people.

It is fair to observe that the contributors of these reports are scholars who are aware of the international publications and discussions on models of science communication, also continued elsewhere in this volume. They are thus more likely than others to draw attention to the continuing force of supposedly 'old' models in these 'newer' regions. However, one conclusion is inescapable: the supposed turn from deficit approaches to dialogue – however valid or not it may be as an observation of regions with longer traditions of institutionalised science communication – does not apply in regions where the science communication culture is, in the terms of the European mapping mentioned above, "developing" or "fragile".

To make this observation is not to make a judgement, nor to apply an evolutionary perspective. It is a reminder that different social conditions shape institutions and practices of communication differently, that trends validly observed in one region of the world do not necessarily apply elsewhere, that discussions of 'old' and 'new', or 'better' and 'best', in science communication need to be modulated with reference to specific circumstances. We have seen plentiful evidence that didactically oriented programmes of science awareness can co-exist with open-forum, interactive and conversational forms of communication in science centres and science cafés. Indeed, the spread of science cafés across the continents is a strong example of a global format, now adapted to local circumstances very widely. The British movement curiously adopted the fully French term, café scientifique, and provides information and advice to the international movement.[18]

As we have seen, several other science communication formats have also spread globally, including science weeks, science festivals, science media centres, short-course communication training for scientists and postgraduate professional education for science communicators. While the international science communication communities have in many cases networked effectively to learn from each other, they may need to develop more sophisticated tools for thinking about and analysing science communication in a global context. Taking a global view draws attention to the patterns of difference as much as to the patterns of similarity.

Key questions

- What are the main policy and other drivers of the global spread of science communication?
- What are the social and cultural factors that shape science communication institutions and practices in particular contexts?
- What analytical criteria might we use to identify most effectively patterns of similarity and difference in science communication cultures of different countries?

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[18] See http://www.cafescientifique.org/

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