Edited by Bernard Schiele, Joëlle Le Marec and Patrick Baranger

Science Communication Today - 2015

Current strategies and means of action

PUN – ÉDITIONS UNIVERSITAIRES DE LORRAINE

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ISBN : 978-28143-0236-5

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54014 Nancy Cedex

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Foreword by Pierre Mutzenhardt

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Foreword

Pierre Mutzenhardt

President of the University of Lorraine

Building citizenship for the 21st century: this is the ambition of the Université de Lorraine, which has imagined and designed a novel project on an international scale—Science & You.

The swift advance of science, the explosion in technology and the accelerated pace of the changes our world is undergoing unsettle citizens and lead them to question their environment and their future. Consequently, forging closer links between science and citizens appears as a major challenge if each of us is to be informed on the challenges facing society and become an actor. The construction of a scientific culture for citizens obviously involves meeting researchers, but also requires a stance of reflective practice.

In 2015, the 5th edition of the *Journées Hubert Curien* took place within the framework of Science & You, and hosted international specialists in science communication. Current issues in the field, many of which were presented in January 2014 during the Science & You Launch Day, were under debate: current models and trends, and the transnational, multidisciplinary and sociocultural contexts of science–society relationships. Fifteen prominent speakers from Africa, America, Asia and Europe contributed their critical viewpoints and reflections on different policies and strategies operating in scientific and technological culture throughout the world. Their contributions to the *Journées Hubert Curien* are brought together in this publication.

The Université de Lorraine, which has been involved in science communication for many years now, wishes to make Science & You a regular event; this publication is intended to be a signal start to a new collection of quality scientific publications with the accent on questions and issues in the scientific and technological culture of tomorrow. Here I would like to emphasize the commitment of the whole community and the variety of approaches, as demonstrated in this book. I hope you enjoy reading it!

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Introduction

Patrick Baranger, Joëlle Le Marec and Bernard Schiele

This book reports on the work of the fifth *Journées Hubert Curien*, which took place in Nancy, France, from 3 to 5 June 2015, during the *Science & You* event. The theme of the conference was ‘Current strategies and means of action’. In addition to the talks given by the researchers gathered for the occasion, the conference heard 15 keynote speakers share their views with all those interested in science communication.

With each edition, and particularly since 2012, the *Journées Hubert Curien* have proved to be a place for meeting and sharing for the international community of researchers working on science in society and science communication, institutions and associations involved in reflection and cultural action revolving round science, and all the actors who take on new issues and experiment with new practices in science–society relations.

To achieve this, in addition to the workshops where the researchers communicated and discussed their research, this conference introduced reflective practice workshops for science communicators. We need to nourish a high-quality approach to reflective practice with the contributions of those researching the underlying theory in order to steer away from evocative description and follow the path of reflexivity.

At a more general level, this fifth edition of the *Journées Hubert Curien* was an integral part of Science & You—an event on a much larger scale that included an international training course in science communication for PhD students, a practitioners’ forum, conferences, shows, performances, exhibitors’ stands, the finals of the Budding Researchers’ film competition, the French national finals of the Three Minute Thesis competition for PhD students, and so on. Many of those events were for the general public. In short, this science conference was also a conference immersed *in society*.

This book brings together the 11 main conference presentations, taking an internationally comparative approach in order to reach a broader audience, widen the scope of the discussion and thus enrich the debate. The knowledge, policies and practices of different nations deepen our global comprehension through reflection, just as a mirror gives us an accurate view of ourselves.

The papers that make up this book are in the chronological order of their oral presentation during the conference. Even so, if you read all the contributions, you will find a logic running through all of them—a logic that fans out in four directions.

(Re)mobilization

Almost all over the world, political actors are showing renewed interest in the public communication of science and paying more attention to it. They make vigorous declarations that are then taken up by the media. We have seen such an investment in many different countries in the past, but why is it happening again today? Is that interest just an artefact in political communication? Is it linked to research policies? To cultural and educational policies? Is it in reaction to a mobilization on the level of civil society or society in general? What is at stake for those who advocate, or perhaps orchestrate, such a remobilization?

Today's scientific culture, far more than in the past, is linked to the economic sphere, and particularly to the notion of innovation (scientific, technological, industrial and commercial). In this context, how does scientific culture connect to concerns about citizenship, environmental protection or management, or social progress? Of course, this remobilization enables science communicators, whether professionals or not, to develop their actions and to be more valued and better recognized, but it does not mean that they forgo questioning this renewed interest to better ground their practice in reason and ethics. Is it because some science communicators adopt a reflective and critical stance that some decision-makers opt for a policy radically opposed to this mobilization of science communication? How can calls for the widest possible communication of science cohabit with moves towards censorship as soon as that communication becomes politically incorrect in the eyes of those promoting it?

> Almost all the papers in this volume speak of the renewed interest in science communication. Those by **Massimiano Bucchi** (Italy) and **Brian Trench** (Ireland); **Jean-Yves Le Déaut** (France); and **Bernard Schiele** (Canada), **Joëlle Le Marec** (France) and **Patrick Baranger** (France) contribute to a better understanding of it.

Contexts and the effects of contexts

While very many countries show a renewed interest in science communication, our communications practice nevertheless takes many different shapes and follows many different rationales. Historical traditions in some countries, specific economic, social and cultural situations in certain regions, issues particular to certain actors or groups of actors—all call for, and produce, different objectives and modes of intervention. How are we to consider the gaps between local interests and supranational actions? What are the tensions between international standards and respect for locally rooted cultural views? What are the effects of these local, national, transnational contexts on conceptions of science, which is, on the face of it, universalizing? Are there contexts (and effects of context) of different sorts, perhaps linked to gender, to age, to habitat, to ways of living? How do the subjects, strategies, practices and discourses of science communication develop in relation to those different contexts?

When forms of communication (the media and the large science museums come to mind) are tending to become standardized, in what way can particular contexts generate transferable innovations in science communication? How do science communicators take part in the debate on models of society? How can we conceive of these contextual differences, not by building on an overdetermined generalist discourse, but by adopting a stance of openness to understanding the 'other'?

The contributions by **Elizabeth Rasekoala** (South Africa), **Cheng Donghong** (China), **Pablo Kreimer** (Argentina), **Sook-kyoung Cho** (South Korea) and by **Aziz Bensalah** (Morocco) enable us to get a better grasp of these contextual variables.

From audiences to actors

We often speak of audiences' motivation or lack of motivation for science, but what do we mean by 'audiences'? What are the identities present in the debates about science and science culture: populations, users, inhabitants, amateurs, professionals, women, men? What sorts of interest in science are there?

The category of 'audience' has broken up into a great many different subgroups: populations, users of science (particularly users of medical science), individuals, and groups affected by or involved in socioscientific debates (such as farmers versus citydwellers). Consequently, those targeted by science communicators are no longer considered only as audiences who *consume* scientific information; they are also *actors* in our science and technology culture. Sometimes, their mobilization is in response to their criticism of science and its techno-industrial uses. We have seen the citizen-science movement become highly organized, but what are we to understand by that compound adjective, and how is 'citizen science' linked with the construction of science citizenship in each one of us? In what way and how far have social and environmental crises played a role in the changes wrought in science audiences who are deeply involved on every level in those crises (simultaneously in the sources, processes and critical assessments of the crises, and in proposed models of socio-economic organization)?

The papers by **Alan Irwin** (Denmark), **Marc Lipinski** (France) and **Pierre-Benoît Joly** (France) analyse people's demand to be actors and full citizens.

Moving towards new relationships to knowledge

Today, we are living in a world in which attitudes to knowledge are changing rapidly. The authority and legitimacy of academic knowledge and of those who embody it are questioned more and more often. What forms of relationship to knowledge, to academics and to the authorities are summoned up and brought into play in science communication actions? We can tick some of them off (mis/trust in science, mis/trust of the authorities and the media, hopes, disappointments, mis/understandings, perceptions of 'legitimacy'), but does the abundance of cooperating or opposing alliances (of researchers, users, residents, politicians, businesspeople, bureaucrats) modify modes of legitimization and relationships to authority? What is the possible impact on science communication today of some actors' claims for the legitimacy of non-scientific knowledge, in the name of the legitimacy of their interests and aspirations? The very notion of truth is often challenged not only through obscurantism, but also through pragmatism, or through self-centred attitudes born of immediate and private interests (and those who adopt them usually take responsibility for them nowadays). How can (or must) science communicators take such psychosocial variables into account? Behind all these attitudes is the question of the relationship between knowledge and power.

That relationship—although sometimes implicit—underlies all the communications in this book. It is evoked more explicitly in the contributions by **Elizabeth Rasekoala** (South Africa); **Marc Lipinski** (France); **Pierre-Benoît Joly** (France); and **Bernard Schiele** (Canada), **Joëlle Le Marec** (France) and **Patrick Baranger** (France).

Part 1: Opening remarks

1 Between professional construction and field-work deconstruction

Joëlle Le Marec

Chair of the Scientific Committee

The fine contributions in this book offer a well-formed approach on contemporary issues in science communication. They are very diverse, but share four main elements:

- They showcase synthetical analysis, based on both the research corpus and major papers in the field, using arguments based on essential concepts and terms belonging to science communication as a whole.
- They take a pragmatic turn, grounding demonstrations on specific cultural milieus (including intercultural environments), as well as on significant political and cultural projects or initiatives, such as the creation of science museums.
- The authors' original, intertwining approaches allow them to create solid bridges between citizenship, policies and science development.
- Last, but not least, these papers clear the way for investigating imaginary figures as well as a set of previously unthought-of aspects of the relationship between science and society.

It is noteworthy that the authors themselves 'represent' a large geographical and professional (or scientific) diversity. Thus, their contributions (taken together) give a detailed picture of ongoing debates moving forward the many initiatives concerning science and society. Thanks to this composition, after a cautious reading we might say that nowadays science communication is perhaps re-enacting the very same sorts of concerns that shaped the actions taken in the name of 'science and society' during the 1970s. A militant optimism, the promotion of the scientific mind by means of popular sciences, the promotion of a value set embedded in the idea of progress, or even a certain understanding of science education targeting the 'layperson' sail alongside a vivid criticism of the sciences, a scathing rebuttal of researchers' subjugation by political or economic forces, and repeated outcries for a more reflexive or accountable science. Evidently, some things have changed in the sciences and in our societies since the seventies,[1] the profound transformations in the social sciences as well as in the humanities being among them.

The professionalization of communication is another. When considering this professional aspect, one cannot avoid noticing that the professionalization of a field usually increases its technical organization. Coextensively, the political dimension of activity normally starts to decrease. However, as science communication became more professionalized, the political involvement of numerous other actors did not change. What this collective work shows is the persistence of schemes in which mobilizations in the sciences, which always intertwine science communication with

[1] See Quet (2013) and Babou & Le Marec (2013).

actual scientific and social challenges, still nurture a lively *political* activity despite ever more professionalization. Notably, this has happened at a time when communication, as a profession, has focused its intellectual force precisely on technical issues.

So, surprisingly enough—but surely for the better—the first and essential message from this book is the discovery of a certain persistence of the political turn in professional science communication.

In order to accurately assess the field's constant interest in reflexivity as well its health, we have decided not to scale or size the relations between propositions with a synthetic overview in these opening remarks. Rather, we would like to give the reader the freedom to find and explore them, while bearing in mind the complex nature of any given topic or approach, and the value of questions. As this journey begins, we could say 'Abandon all hope of finding uprooted information, ye who enter here!', for the heuristic deal we hope to make with our public is to promise great findings if one positions one's own concerns and personal preoccupations so as to find the singularity represented by each contribution.

This bottom-up, grounded and transversal approach is now generally used in the study of sciences. It has become unavoidable for anyone seeking to make sense of the various ways that we produce or receive knowledge. It has also become essential for anyone who wants to show how some phenomena can genuinely 'emerge' from a flow of events. Finally, it has become central for anyone who wishes to understand how and where our manifold individual involvements in science communication actually take place, for our relation to knowledge is material, culturally shaped, and always connected to and intertwined with a plurality of embedded and heterogeneous interests. As for our individual involvements, there is perhaps no better way to start than to focus on how we pay attention, or how we proactively participate in sciences. Where should we look, if not among our formal engagements or our authentic cognitive and political 'passions'—the very ones giving motion to this social life that we ought to share with others.

Hence, science communication, as well as discourses about science communication, can no longer ignore this sparkling and swarming 'life of knowledge'—a life that can be grasped from the field, and as it is happening.

As a brief introduction to this collective work, allow me to report from my daily routine as a professor and as a researcher—a routine that is reflexive by necessity. The viewpoint will be hereafter the one of a witness, for we are also witnesses to our own students, as they initiate their involvement in the field of science communication.

Every year, candidates to the Journalism, Culture and Communication of Sciences masters course at Paris Diderot have to introduce themselves and explain their motivations in front of a jury. Our students come from many scientific fields: the natural sciences and mathematics are fairly well represented but, surprisingly or not, growing numbers from the humanities and social sciences start the course, too. The latter group seems very keen to investigate their own private interest in the sciences.

These first contacts and subsequent ones have helped us to identify at least two trends:

- Some candidates are approaching us because they want to learn a 'real' job. This shows how much science communication, science journalism and science popularization *per se* are already identified, in France, as a career prospect and a professional reality.
- Some others, already engaged in a professional activity, whether as engineers or PhD holders, are preoccupied with issues involving an intense reflexivity about science and its dissemination. They are confronted, in some cases within their own research institutions, with scientific realities capable of creating cultural environments as well as lively debates. Eventually, this part of their job pressures them to a point at which they consider deviating from the path that their engineering, masters or PhD degrees would normally take them down. By coming to us, they commit themselves to thinking, writing, filming, questioning or even investigating issues related to science in society further and more deeply.

These two trends coexist, and these face-to-face conversations reveal, every academic term, the ongoing tensions structuring science communication as a whole, providing an interesting picture of its configuration in space and time.

These tensions perhaps indicate a conjunction of four contradictory internal trends structuring the field:

- *The autonomy of communication as a professional activity is progressive and growing*. After decades of media development and diversification, science communication has gone beyond being an extension of the science. Science communicators have created self-sufficient and fully functional services and dedicated businesses. Until the 1980s, science popularization was considered to be merely the direct transcription of what was happening in research. The professionalization of science communication since then has been widely reviewed and even celebrated in many reports and statements, which credit this blossoming for widening the job market and creating new economic opportunities. The transformation of science communication led to many specific contributions to the wider field of communication sciences, and eventually helped to unpack a persistent cliche—that media are neutral devices for transmitting scientific discoveries. Another stereotype—assigning communication services to the (fairly naive) role of valorizing research activities—was also deconstructed thanks to such studies. Overall, one cannot avoid noticing the prolific activity that focused on media discourses about science. The same prolific production is observable in analyses of the market for 'mediation' or, more generally, the market for the whole area of communications on every front.
- *More complex communications situations have blossomed*. Science communication now involves a greater diversity of actors in debates on what can be called 'socioscientific' topics. I am speaking here of the involvement of both associative networks and civil society within the framework. The reasons for such an involvement are not to be found in a so-called universal interest in science as a culture, embedded in a mission assigned to dedicated institutions. Rather, this singularly new framework has its origins in determined groups with very pragmatic concerns: associations of people with chronic diseases or those treating them;

groups created by citizens in areas facing potential technological risks (such as near bases, nuclear sites or landfill sites), or activists protecting ecological values, promoting deviant economic models or raising concerns about communities forgotten in national and institutional historiographies. All these movements have similarities to the one called 'citizen science',[2] which has been interesting science communication professionals for quite some time now. Thanks to much theoretical work over many years, citizen science has become fully part of the official history of science communication models. But, as they stand, citizen scientists have no need for an academic or expert background in a particular field; nor do they need more 'empowerment'. Having emerged from a multiplicity of participatory forms, they rely on different narrative forms, policies and cultural backgrounds to act in many fields, in the sciences and elsewhere.

- *Social communications about science are now recognized as important phenomena*. Each year, this recognition leads students *and* researchers (concerned about the overwhelmingly technical aspects of their own practices) to science journalism or science communication. It also shows the strength and vitality of the reflexive practice that was previously a feature mostly of the humanities and social sciences. Our candidates' choices therefore signal an appetite for reflexivity, rather than some blurry expectation of technical training. It was precisely these powerful concerns, crossing every social and professional barrier, that led researchers from different scientific fields at Strasbourg University to involve themselves in GERSULP—one of the very first laboratories to specialize in science practices and their meanings.[3] Science journalists and science communicators note that, for researchers and engineers, professional comfort appears to be much less desirable than the challenge and the risk of an uncomfortable and reflexive criticism focusing on how the sciences operate and work in our daily lives.
- *The strong cultural footprint of sciences and technologies is revealed* in multiple media in the production in broadcasts, literature, movies and theatrical or musical performances. One would intuitively think of science fiction as being the totemic genre, but many novels focusing on different and distant topics as cognitive passions, conflicts or contemporary epics are actually staging objects and questions of science: investigational habits, institutional organizations, professional involvements, and so on. Maylis de Kerangal's *Réparer les vivants* (2014), as well as Vassili Grossman's *Life and fate* (1980 for the first translation) are of that type. They stage forms of reasoning, behaviours and interests involving scientists and other characters, without necessarily being novels about science or being science fiction. Aleksandr Solzhenitsyn's *The first circle* (1968) and Ian McEwan's *Solar* (2010) both stage, in a dramatic or burlesque manner, researchers dealing with the authorities or the way media play them. Yves Jeanneret, a well-known comparative literature expert, focused on science publication literacy, without

[2] See http://sciencescitoyennes.org/; see also Charvolin et al. (2007).

[3] The GERSULP (Groupe d'Etude et de Recherche sur la Science de l'Université Louis Pasteur), Strasbourg) was created in 1973, and run by Baudouin Jurdant. See http://science-societe.fr/gersulp-groupe-detude-et-de-recherche-sur-la-science-de-luniversite-louis-pasteur-strasbourg/.

necessarily embracing the cause of the community of science communication professionals (Jeanneret 1994).

All these points lead to a first statement: science communication, if we look at it as being a well-formed and autonomous challenge, is not what brings together this plurality of political, professional, intellectual and cultural involvements. On the contrary, it is the many challenges *in which* the sciences are themselves involved that suddenly make those commonalities visible, allowing us to end with a 'science-centred' approach.

Even more symptomatic: by transforming itself onto a productive force obedient to market rules, the realm of research started to break its own scientific core and undergo a partial (though essential) loss of autonomy. Many researchers and professors still occupy the field of research, but managers, engineers, technicians and staff dedicated to managing research outcomes or to securing income from it are now increasingly entering the field. In Europe, since the 1999 kick-off of the Bologna Process, universities have embedded new sets of goals: they replace their traditional, self-provided goals with ones decided externally and determined by policies and economic constraints. Since then, the 'mission' has clearly become the contribution to economic growth and wealth, packaged into the idea of sustainable development. At the same time, governments made imperious recommendations that universities should carefully tune their teaching to trends in the job market. There has also been considerable emphasis on 'innovation' and 'excellence' as important markers. These factors changed the face of universities as they started to manage, within their walls and in their relations with society, a population now described as 'taxpayers' or 'shareholders'.

Nowadays, in many ways, science *as an institution* can find refreshing opportunities to participate in cognitive and political experiments only *externally*, after finding them internally for so many centuries. As an example of external opportunities, 'nursing studies' emerged from a composite of knowledge and practices derived from a great diversity of professionals, researchers and even patients. The science publishing sector has seen a comparable trend, bringing together early-stage and more experienced researchers and new economic actors who operate from a ground of cooperative values with solidarity as a structuring principle for their actions. It is noteworthy that these trends are also happening *outside* the secular realm of science publishing, and are focused and dependent on economic interests. They continue even though the scientific work produced is not reviewed or acknowledged, along with the academic measures usually evaluated by science and education agencies. The agencies remained blind to this phenomenon because of the irresistible political pressures on them to endorse only normalized research.

Another important aspect, unpacked by ongoing work in our field, is the consideration of science again from *outside* its expected and historical *topos* (such as universities or research institutions). Indeed, those familiar spaces for science are now slowly but surely invaded by challenging networks, redundant administrative structures and new agents, all expected to aim at the same target: the professionalized production of 'innovations'. Studies about science exposed very accurately the existence and nature of those multiple viewpoints that proliferate quietly in local actions or initiatives. They have shown a poorly recognized but very ordinary aspect of knowledge production, sparkling at the edges of academic life.

As a conclusive recommendation, I advise you not to approach the contributions in this volume as if they are the sequential parts of a bigger narrative canvas. Instead, my colleagues and I would propose a different, more modest and yet more accurate and heuristic: consider each contribution, as well as the book as a whole, as a genuine attempt by the writers to define and explain a viewpoint on their science or science communication in a way that is beneficial to people working in other areas. We believe that by doing this we will be able to widen the space for critical thinking on science and for political actions about science.

Acknowledgement

I thank Ludovic Garattini for translating this address.

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Part 2: Keynote addresses

2 Science communication research over 50 years: patterns and trends

Brian Trench and Massimiano Bucchi

Over recent years, there has been much discussion of the status of science communication as a discipline, as a field of empirical research and theoretical reflection. In our own contributions to that discussion, we have tended to raise questions about the possibilities of this 'emerging discipline' (Trench & Bucchi 2010). We have sometimes drawn attention to the marks of immaturity—notably, the relatively underdeveloped state of theory in the field.

But when a major international academic publisher commissions an anthology of 'major works' in our field, we can surely say that science communication studies have come of age. From a scattering of personal stories, manuals and essays there has emerged a growing stream of publications that now constitute a 'literature' in public communication of science. Analytical and critical work in science communication has consolidated in the past two decades, and the rate of publication has accelerated greatly.

Greater maturity and stability in this field do not necessarily correspond to greater visibility, as seen from outside, even by near-neighbours. Science communication is still struggling for recognition as a field of study, and is probably less visible than the professional practice of science communication, as, for example, in science museums and centres. A contribution from an STS (science, technology and society) scholar to a recent edition of the *Canadian Journal of Communication* opened confidently: 'The dominant approach to science communication assumes that science constitutes secure measurable knowledge that an unknowledgeable public lacks and needs' (Bronson 2014). This statement might be less 'unknowledgeable' if it were qualified to suggest that this is the dominant approach within science, but it still seems to betray ignorance of the very considerable literature in science communication. Perhaps the publication of an anthology will help raise the field's visibility.

2.1 Evolution of science communication research

In this paper, we present an outline view of the evolution of science communication research, based on our work as co-editors of a new collection of writings that will be available from late 2015, in a series titled *Critical concepts in sociology* (Bucchi & Trench, forthcoming).[1] Here, we identify some significant strands of science communication research from the late decades of the 20th century (with some earlier pioneers and ancestors) to the present, and summarize its achievements. But we also

[1] This paper is based on part of our introduction to the anthology.

draw attention to some weaknesses and remaining challenges in the rapidly growing body of literature.

To edit an anthology, particularly a collection of so-called 'major works', is to invite disagreement with one's selections. We did not intend to produce a collection that is representative of the whole field over the past three decades or more. However, we would like to believe that it represents good, even best, practice. But there will undoubtedly be many suggestions of works that should have been included, and of others that should not.

We worked within the requirement for this series to provide a selection totalling approximately 1,600 pages in several parts. We started with some fairly roughly drawn criteria, and then refined and revised them as we proceeded. We also balanced them against each other. Thus, if the criterion of frequent use of a given work weighed in its favour, the criterion of explicit attention to communication might rule it out. In summary, we hope to have assembled a collection of texts treating science communication in various ways that:

- have explicitly addressed processes and contexts of communicating science
- have proven their worth in the field through frequent citation
- have been cross-referenced in other texts within the collection
- have been valuable to the editors of this collection in their own work
- have endured as foundational texts in the field
- have set new directions for work in the field
- have the potential, in the editors' view, to influence future work in the field
- represent significant elements of the diversity of the field

    and/or

- address big moments or big issues in the evolution of science communication.

In our initial scoping of the corpus from which we might select, we listed works that we ourselves have cited frequently, looked at the bibliographies in those works, and looked at the bibliographies of papers and chapters such as literature reviews that surveyed the field, all the time adding items to our list. Not surprisingly, certain authors' names came up repeatedly, so we decided in the interests of wider distribution to limit our selection to two works by any one author. (This also applied to co-authorship.)

We had the opportunity at an international conference to ask several of those authors who were certain to be represented to choose the two of their works that they would most like to have included. They found this a difficult, but also interesting, exercise. We made it clear that we were not bound by their selections of their own 'best work'.

Our long list ran to over 200 items but was reduced to one-third of that through continuing refinement and review. In applying standards of value and quality to our selection, we excluded works that, although frequently cited and influential at least for a certain period, represented in our view 'blind alleys'. Thus, there are no examples here of what was once a very common type of science communication analysis, and remains in use to a lesser degree: the study of popular, mainly mass-media, texts in terms of their (in)accuracy in scientific terms. We also tended not to include empirical studies—whether based on accuracy concepts or others—unless they offered substantive contributions to the conceptual understanding of the field.

Related to the exclusion of accuracy studies, the once-dominant ‘deficit’ model of science communication, itself also still in use, is present in our selection mainly as an object of critical study. Apart from the highly influential 1985 report of the Royal Society on public understanding of science (Royal Society 1985), there are here no mere statements or proposals of the deficit approach to science communication, and there are several works included precisely because they were early in identifying the limits of that approach.

As readers of several languages, we found it particularly onerous to be limited to texts in English. We were in a position to commission only one translation, and we are especially happy to include here in its first English-language publication an essay by Jean-Marc Lévy-Leblond, ‘The case for science criticism’—in the original form, ‘Pour la critique de science’—from the very valuable volume of essays, *La pierre de touche: La science à l’épreuve* [*The touchstone: Science put to the test*] (Lévy-Leblond 1996).

We are all too aware that there are other works in French, but also in German, Spanish, Italian and other languages, that merit consideration and possible inclusion in this anthology.

The bias towards authors writing in English as their native language is mitigated somewhat by the fact that English is the *lingua franca* in the field, including for writers with other first languages. Thus, we have authors here whose mother tongues are Finnish, German, Japanese, Portuguese and other languages. Of course, the dominant position of the English language in international academic publishing produces its own distorting effects that are especially significant when we are writing about writing and talking, but that is a matter for a much wider discussion.

We adopted a somewhat arbitrary threshold of 1995 to mark shifts. It was in the early and mid-1990s that education, research, publishing and conferencing in science communication took a leap forward. In that period, postgraduate programmes were established in several countries and PhD projects in the field reached critical mass. The two still-dominant academic journals, *Public Understanding of Science* and *Science Communication*, were, respectively, launched and relaunched in that period, too.

2.2 Patterns and trends

While we are keenly aware of the limitations noted above, we observe in our collection the following patterns and trends.

2.2.1 Productivity trend

The distribution of items over two periods—37 in sixty years before 1995, 42 in twenty years after—can be taken as reflecting increased publishing activity in the later period. However, the rising curve through the 1990s and 2000s, during which two decades nearly two-thirds of the total collection was published, may also show a recency bias on our part. The works of the 1990s (28 of the total 79) have had time to prove their worth,[2] but our assessment of the significance of some more recent items may well prove ill-founded. However, several of those items are by authors well established in the earlier period, as we note below.

2.2.2 Internationalization trend

The United States and Britain together account for three-fifths of total authors, including co-authors, when the author is assigned to a country by their institution. There is almost equal representation between these two dominant countries. But their domination weakens over time, from over 70% of authors in the earlier period to just over 50% in the later period. The diversity of authors' nationalities increases significantly: a total of six countries are represented among authors and co-authors of items published before 1995, and 12 countries for items published later. France is the most represented country outside the UK–US axis, Canada, Germany and Austria follow behind, and there is a scattering of countries represented by a single author, including Denmark, Portugal, Italy and Ireland.

2.2.3 Institutionalization trend

Reflecting and contributing to the diversification trend outlined above, there has been an increase in joint authorship, multi-authorship and cross-country studies. All but four of the items published before 1995 are single-author pieces, which reminds us that science communication studies were taken up very largely by individual champions and advocates for the topic. For the later period, 11 of the 42 items have more than a single author. The notable increase in multi-authorship can be taken at least in part to show the increasing institutionalization of science communication; collaborations between scholars often arise from connections between institutions in shared projects, including cross-country studies.

[2] This distribution in time echoes that of the 50 most cited papers in *Public Understanding of Science*—see Smallman (2014), discussed below. Of those 50 papers, 33 (two-thirds) were published between 1992 and 2001, and one-third in the 2002–2010 period.

2.2.4 Communication trend

The balance of disciplines represented by our authors has shifted. Up to 1995, social scientists were clearly dominant: there were twice as many social scientist authors as there were communication scholars. However, for the works from the past 20 years, the numbers of each are equal. Alongside this trend, contributions from natural scientists have declined dramatically, from seven authors before 1995 to three since then. We can reasonably interpret these two linked developments as demonstrating the establishment of science communication as a field of study within communication generally.

2.2.5 Making-explicit trend

Just over one-quarter of the texts in this collection refer explicitly to ‘science communication’, and all but four of those were published from 2001 onwards. Near-equivalent terms, such as ‘science popularization’ and ‘public understanding of science’ prevailed in the earlier decades, although Dornan, a pioneer in several ways with his 1990 critique of the paternalistic conceptualization of relations between science and media, already used the phrase ‘science communication’ then. The term is well established a decade later: 17 of the 28 texts (60%) that were published after 2001 refer to ‘science communication’.

2.2.6 Gender trend

Gender diversity improves between our two selected periods: women account for one in five authors up to 1995, and nearly one in three for the period since then. We refer below to the central role of two female authors in particular (Rae Goodell and Dorothy Nelkin), but we should also note that the female authors include notable pioneers in the field, such as Marcel LaFollette, Sharon Dunwoody, Susanna Hornig Priest and Helena Nowotny. However, the representation of women in this collection is out of proportion to their strong representation in science communication practices and among science communication students. Whether this reflects an actual under-representation of women in the publishing of science communication research more generally is for others to assess.

2.2.7 Ageing trend

The age profile of the authors is rising. For works published before 1995, four-fifths of the authors were in their thirties or forties. For works published in the past

20 years, that proportion falls to a half, and a larger proportion are in their fifties or sixties. This ageing profile confirms the continuing strong presence in the later years of authors who emerged in the earlier period and are now in late career (such as Dunwoody, Einsiedel and Schiele). However, we note also in the more recent period the presence of relatively early-career researchers (such as Brossard, Fahy, Nisbet, Schäfer and Scheufele). We know from other work that the numbers working on PhDs in this field have grown dramatically; in this very active arena, we expect more younger researchers to make their marks.

2.2.8 'Biologization' trend

Where these works refer to the content of scientific work, they most frequently refer to science in general. However, many also illustrate their arguments through reference to specific areas of science or focus their analyses on case studies in specific areas. Not surprisingly, the life sciences—including various branches of biology, but also medical research, biotechnology, neuroscience and natural history—are the most frequently chosen. That is markedly more evident in the later period: examples from the life sciences were one-third of those from science-in-general before 1995; the two domains were almost equally represented in the years since then.

The attention to physical sciences, including space sciences, was much less in both periods and changed little between them. This is consistent with studies looking at the intensity of media coverage of different scientific areas, which report an increasing emphasis on biomedicine and life sciences since the 1980s (Bauer 1998, Bucchi & Mazzolini 2003).

However, it should be noted that the authors in this collection have also paid significant attention to areas of science that are internally controversial or contested from without, whether in life sciences or physical sciences. Thus, we find cold fusion, genetic engineering, food and environmental risks, and climate science used as sources of illustration or as the focus of analysis.

2.3 Theoretical concerns and interests

When we considered the primary theoretical concerns or substantive interests of our 79 texts, we found that they fell into four sections with roughly equal numbers in each:

- *Theories and Models* contains works that have contributed to defining the field of practice and theory through naming and defining critical concepts, exploring key relationships, and elaborating the means to comprehend underlying assumptions. This volume opens with works in the category of 'classic'; that is, the work has been mined again and again and proven its worth over many years, or, as the Italian author Italo Calvino once wrote, has 'never finished saying what it has

to say'.
- *Processes and Practices* presents works that analyse routines, strategies and relationships in science communication and science reporting for media, that advocate policies, or that present the experiences, reflections and advice of science popularizers of various kinds.
- *Publics for Science* presents analyses of the changing conditions of science communication as they are affected by public attitudes to and understanding of science, treatments of the publics' and scientists' participation in consultation, and debate on science-based issues.
- *Media Representations of Science* includes analyses of storytelling and representations of science in public affairs media. These are not only content studies of one kind or another, but also examinations of the production of content and, in a few cases, its reception or public impact.

2.4 Questions from the past

But what is our collection for? How might it be used? One path of entry into the collection is through reappraisals of the enduring value of several 'foundational' texts. Despite relevant changes in media technologies, organizational logics and professional practices, and transformations of the public as well as attitudes to communication by scientists, some of the key theoretical and strategic questions today are strikingly similar to those raised by very different authors, such as Ludwik Fleck in the 1930s, J. B. S. Haldane in the 1940s, C. P. Snow in the 1950s and Robert K. Merton and Peter Medawar in the 1960s.

Among the questions they addressed were:
- What is the relationship between science communication addressed to non-specialists and the core, specialized practices of scientific communication?
- What are the dynamics of visibility and recognition of scientists both within the scientific community and in society at large?
- What are the particular attributes of the culture of scientists ('scientific culture' in the anthropological sense) that affect how they perform and how they are perceived in public?
- How do communication contexts shape expository (communication) practices in science? How and why might scientists tell their stories to lay publics?
- How does exposure to media coverage influence public perception and attitudes to emerging science issues—and, more generally, to science?

One tendency in our field has been to reinvent the wheel of science communication, almost as if these important analyses and reflections of 30 and 40 years ago had never been published. By recalling what some of the pioneers in our field had to say that is still pertinent, we hope to help reduce such redundancy. We are pleased also to have 'rediscovered' some texts that may have been somewhat obscured by all that has been produced more recently. For example, the 1981 paper by Helena Nowotny that we include was published in a rather primitive form, and has been followed by a very large output from the same author on a wide range of science-in-society topics. Yet this early paper sets out valuably the changing public roles of scientists as experts and has continuing validity.

Going back a further 40 years to 1941, the radical British scientist J. B. S. Haldane offered advice to his colleagues on writing for a lay audience that is also still largely valid (Haldane 1941/2009). Haldane insisted that scientists could themselves learn from writing popular science, and he also demonstrated further reflexivity in his sceptical stance towards the norms of his own professional community and in this comment: ‘Popular science can be of real value by emphasizing the unity of human knowledge and endeavour, at their best. This fact is hardly stressed at all in the ordinary teaching of science.’

Against a certain tendency to forget or to overlook, we can discern another tendency, more selectively applied, to recall again and again. Two authors and two works, in particular, have remained strongly in view over the decades. The late Dorothy Nelkin and her 1987 book, *Selling science* (revised edition, 1995), are centre stage. Almost a quarter of the texts in this collection cite Nelkin’s seminal study, which is all the more remarkable given its description in one of these texts (Bauer et al. 2006) as ‘somewhat anecdotal, but poignant’. Several other of her works, including a second paper included in this collection, are also frequently cited. Rae Goodell developed her 1977 book, *Visible scientists*, from a PhD thesis and it continues to hold value, not least because of the attention now being given to the most visible of scientists: ‘celebrity’ scientists.[3]

From the collection of works that we assembled, a picture emerges of an international community of scholars and professionals who share many interests, concerns and activities. They are strongly interconnected, referring to, and respecting, each other and also collaborating frequently. There have been some arguments over the years within the community, such as about the relative merits of quantitative and qualitative approaches to understanding the publics for science, but it is notable that there are no strongly drawn lines of intellectual division. We can consider it a moot point whether that is a sign of strength or weakness—explicit divisions could be taken as an indication that theoretical positions are clearly articulated and considered worth fighting over.

2.5 Five themes for further work

Our collection represents a historical collective portrait that illuminates, and is illuminated by, current activity in the field. We have proposed elsewhere in more detail[4] five themes of science communication research that deserve particular attention. The works we have collected have much to say to explorers of these themes:

[3] See Fahy (2015); like Goodell’s work over 30 years earlier, this was also developed from a PhD thesis.

[4] See Bucchi & Trench (2014).

- *Increasing fragmentation of actors, publics and media.* Science institutions and actors are diversifying their attitudes and practices, including in the communication domain, making it decreasingly valid to continue using traditional expressions such as 'scientific community' that imply internal homogeneity and a shared commitment to specific norms and values. Equally importantly, the plural 'publics' of science communication continue to multiply and fragment, not least through the fracturing of media and the emergence of new platforms.
- *New mediations.* Digital media allow, among other things, research institutions and actors to supply directly to target audiences an unprecedented amount and variety of materials, such as videos from labs, interviews with scientists, and even datasets (as in 'open science'). The once indispensable intermediaries are increasingly displaced or marginalized. In the same way, traditional media platforms for science communication, such as newspapers, magazines, television and radio programmes, and science museums and centres, are losing their role as filters and guarantors of the quality of information.
- *Collapsing communication contexts.* The traditional sequence of the communicative process from specialist discussion and didactic explanation to public communication or 'popularization' has been fundamentally disrupted. More and more, the analysis of public communication is required to consider how and by whom the substance and the mode of such communication are determined in exchanges within and between sciences.
- *Science in society and science in culture.* Situating science in society and culture implies much more than improved functionality. We can consider science communication research to be about 'how society talks about science', and this implies research into the cultural contexts of such talk—scientific, artistic, everyday, and other. The increasingly blurred boundaries of communication contexts should also encourage researchers to explore with more courage conceptual affinities and potential inspiration in the humanities, arts and culture. This resonates with longstanding invitations to 'put science into culture' (consider Lévy-Leblond 1996 on 'la mise-en-culture'). In this way, science communication—both practice and research—can contribute to increased reflexivity within society and within science.
- *Global trends and challenges.* Public communication of science has become a global enterprise with common denominators as well as distinctive regional characterizations. This certainly expands opportunities for sharing experiences and for comparative analysis. It also makes increasingly visible the strong contextual interaction of science communication patterns with broader cultural, policy and sociopolitical landscapes.

It may be around these topics that many of the next generation of 'major works' will be written, but other areas will doubtless emerge in the coming years as also demanding priority attention. However, when we consider discussion and publication in the field it is not easy to establish links with either the main strands of the major works we have collected, or with the priority research themes we propose.

2.6 Trends in conference contributions

One possible way to detect international trends in science communication reflection and practice is to look at presentations and discussion topics at global conferences. Since the early 1990s, Public Communication of Science and Technology (PCST) conferences have been the main international occasions for such discussion. The conferences have gradually expanded their content to public engagement and science in society more broadly. They also offer a unique combination of scholars' and practitioners' contributions and perspectives that many academic conferences miss.

As a contribution to a project funded by the European Union, Brian Trench and colleagues sought to discern trends in the interests and concerns of European science communication communities. In part, this was done through an analysis of the contributions of European presenters to Europe-based PCST conferences in 2004 (Barcelona), 2008 (Malmö/Copenhagen) and 2012 (Florence). That study was looking, in particular, at the strength of the supposed 'turn to dialogue' in science communication. Looking first at the kind of science communication activity these conference contributions focused on, it was found that the strongest attention was paid to *mass media* and *social context*, which accounted for over half of the abstracts analysed for each of three conferences. The more obviously 'dialogical' activities coded as *online media*, *social talk* and *public science* were the object of significantly less interest, though the 'classical' form of scientist's lecture (*expert talk*) was notable only for its complete absence.

There is certainly less evidence in these materials of attention to the use of online media in science communication than might be expected from the widespread and everyday discussion of media changes. However, there was interesting evidence of the widening diversity of activities: even with a list of 12 activity types, the category *other* was either the most or second most represented category in the analysis of conference content.

The conference materials were also analysed for their underlying model of communication (which could not always be discerned)—*dissemination*, *engagement* or *conversation*—where, from first to third category, the communication is decreasingly science-centred and the publics are increasingly active; communication is decreasingly hierarchical and formally organized, and increasingly inclusive and everyday; and scientific knowledge is represented as decreasingly certain and increasingly open to interpretation and critique.

Over the 2004–2012 period, the attention to *dissemination*, *engagement* and *conversation* shows shifts but not a marked one-directional trend. *Dissemination* and *engagement* together accounted for a very large majority of the coded abstracts, with *conversation* a weakly represented third. Despite all the talk of a turn to dialogue, there is consistent interest in, or affiliation to, a *dissemination* model, and that interest was seen to increase from the 2008 and 2012 conferences.

Overall, this study concluded that the evidence for the frequently declared 'dialogic turn' in science communication is uneven and contradictory, and that the influence of supposedly discarded models of communication can still be seen in activities and programmes presented as dialogue or engagement.

This is a rather different conclusion from that of a study of more formal research publication conducted to mark the 20th anniversary of the *Public Understanding of Science* journal (Smallman 2014). However, that analysis of the 50 most cited papers from that journal spanned a longer period, from 1992 to 2010.[5] Dividing that period in two, similarly to the way we have done with our collection, the analysis showed how, in the 1990s, a majority of the 50 papers described or adopted 'public understanding models'; that is, approaches roughly equivalent to *dissemination*, as discussed above. From the 2000s, however, a similar proportion of papers presented critiques of the public understanding model or discussions of public engagement practices. The analysis is said to show 'the field's convergence on a dialogue / science and society model', but also the development of 'a critical discourse around the practice and purpose of dialogue'. That critical discourse is reflected in more recent works in our collection, although it is not so evident in the contributions to science communication conferences, where the participants are as likely to be reporting their own practice as offering evaluation, analysis or theoretical propositions.

As a contribution to a recent report for the European Commission, Massimiano Bucchi and colleagues did an analysis of non-European contributions to PCST conferences in 2010 (New Delhi), 2012 (Florence) and 2014 (Salvador, Brazil). That analysis supported the view of science in society as having become a global concern but also pointed to significant national and regional variations. For example, it showed that science communicators and scholars from India tended to focus on communication and engagement with science in rural areas and on nutrition/health issues, whereas in China priority attention has been given to science museum activities and impact assessment (a relevant focus also for Australian contributions).

Overall, media coverage of science and science journalism was the most strongly represented topic, with five other topics closely grouped but significantly behind: new tools and actors in science communication; strategies and practices for science communication; evaluation of science communication; museums and visual communication; and climate change, environment and risk. Although the categories used in the two analyses were different, the primary interest in media showed similar emphasis among European and non-European conference contributors.

In the analysis of non-European materials, climate change emerged as a key topic in 2010, particularly for contributors from Australia, China, India and Korea. Latin America, and Brazil in particular, showed a specific interest in activities aimed at students and children, as well as in the theme of scientific citizenship and social inclusion through science engagement, while North America, and the United States in particular, saw a significant proportion of contributions on the role of scientists and their training in science communication.

Engagement and citizenship are a relevant focus also for South Africa, which is also one of the areas explicitly thematizing 'developing countries' as a context of science communication. Risk-related communication emerged as a key focus of contributions from Japan, mainly related to the 2011 Fukushima disaster.

[5] The papers are not listed in the presentation of this analysis, but it is fair to assume that they included several of the 15 (19% of total) works in our collection that were originally published in *Public Understanding of Science*.

2.7 Global and future trends

In general terms, global trends show an increasing focus on government policies and on the role of scientists in communicating research to the public, including training researchers for communication, which is also referred to below. Compared to Europe, less attention seems to be given to issues such as democratization, citizenship and communication in relation to scientific debates and controversies. The key difference lies in the fact that contributions from Europe reflect an agenda of science in society and science communication that is professionally autonomous (to the point of being, to some extent, self-referential) and relatively independent of government. On the other hand, non-European contributions tend to be more influenced—and in some cases directly managed—by policy agendas through funding mechanisms or the direct provision of organizational resources.

The number and variety of national, regional and international conferences of science communication practitioners, educators and researchers are increasing, adding to the evidence of the global spread of science communication (see Trench et al. 2014). A recent special issue of *Public Understanding of Science* was dedicated to 'Voices from other lands', with contributions from Taiwan, Ghana, Mexico, Thailand and Russia.[6] This global spread is likely to ensure the continuing diversification of the topics and sources of future major works in the field, already seen in the period covered by our selection. The editors who are asked to replicate our exercise in 10 or 20 years will undoubtedly present different maps and different trends.

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3 Citizen science and scientific citizenship: same words, different meanings?

Alan Irwin

This paper sets out to explore the relationship between the still developing phenomenon of citizen science and what I will refer to as 'scientific citizenship'. Are they essentially synonyms or do they point in different directions? Since both terms are very broad in scope, it may be that no definitive answer is possible (unless that answer is 'it all depends'). Nevertheless, I believe the question is important, not least in throwing some critical light both on the citizen science movement(s) and on the possibilities for the democratic governance of science and technology.

3.1 The different meanings of citizen science

We can start by simply observing the remarkable growth of citizen science. The February 2015 inaugural conference of the Citizen Science Association, held in San Jose, California, brought together more than 600 people. There is also a recently launched European Citizen Science Association supported by organizations from more than 10 countries, and, since 2014, the Citizen Science Network Australia. As the European Citizen Science Association website proclaims: 'Citizens create knowledge—Knowledge creates citizens.' Meanwhile, the Zooniverse website lists a range of projects in space, climate, humanities, nature, biology and physics: 'We make citizen science websites so that everyone can be part of real research online.'

The European Environment Agency has been active in developing citizen science for biodiversity monitoring, and many other international and national organizations have incorporated citizen science (or *les sciences citoyennes*) alongside their more traditional activities. The upsurge of interest seems clear (see also Haklay 2015).

But what is actually going on amidst all this enthusiastic activity? The opening and closing keynote talks at the 2015 Citizen Science Association meeting demonstrated rather nicely the span of meanings being attributed to citizen science. In the opening session, Dr Chris Filardi, Director of Pacific Programs in the Center for Biodiversity and Conservation at the American Museum of Natural History, addressed 'A place in the world—science, society, and reframing the questions we ask'. In his talk, he emphasized the interplay between science and broader society, the social and cultural context within which research projects are conducted, and the ways that science embodies the relationship between people and the world around them. The vision here was of a participatory mode of research in which science is a necessary but not necessarily dominant partner, and in which researchers are open to other ways of knowing and other ways of asking questions. Science from this perspective is a profoundly social activity, and citizen science is a way of expanding the possibilities for constructive science–society relations (Irwin 1995). As Dr Filardi put it in discussion, it may be that some kinds of science can be carried out in a back room, but any complex sociotechnical field (for example, environmental management) needs what can also be termed ‘participatory action research’ if it is to have any chance of success.

The closing keynote by Amy Robinson, Executive Director for the crowd-sourcing[1] project EyeWire, also embraced citizen science, but in rather different terms. EyeWire is a game played by more than 160,000 people that involves the mapping of synaptic connections between neurons in the human brain. The emphasis now was on how to build an online citizen science community in order to support scientific efforts within neuroscience. The basic idea is that collective human intelligence can make a huge contribution to the discovery of 3D cellular structures. Tapping into the energy and excitement created by computer-based games, citizen science from this perspective is about drawing in new audiences to science, keeping them motivated, and getting willing volunteers to support research in a very practical fashion. Beautiful imagery, clear design and campaign ‘blitzes’ all play a part here. While citizen science for Chris Filardi was about the mutual construction of legitimate questions and an openness to different ways of ‘knowing’ specific environments, for Amy Robinson the issue was one of how to build an online community, how to capture and maintain interest, and how to crowdsource science in a stimulating but also worthwhile fashion.

Already we get the basic point: citizen science is open to many definitions, and it contains more than one strand. It can be presented as a public extension to existing scientific projects. It can also be considered as one step towards greater public participation with—and democratic accountability over—the direction and creation of scientific research. Running through both the Filardi and the Robinson presentations was a sense of wider engagement, of the power of participation and of the societal significance of scientific research. However, the form those took in the two presentations differed greatly. On the one hand, the wider publics were presented with the possibility of participation in each stage of the research process, including the framing of the original questions and the co-construction of research design. On the other, there was an online ‘gamification’ that could be of value to the research community (and to the individual gamer) but in which ‘participation’ essentially followed a prescribed and carefully designed form.

In this multistranded situation, a number of attempts have been made to capture analytically the varieties of citizen science. Thus, one ‘green paper’ on citizen science (Socientize 2014) presents citizen science in terms of different categories and levels. Categories range from ‘collaborative science’ and ‘crowd-crafting’ through ‘participatory experiments’ and ‘collective intelligence’ to ‘volunteer computing’ and ‘human sensing’. Levels, perhaps more predictably, extend from the ‘local’ and ‘regional’ to the ‘European’, ‘global’ and ‘virtual’.

[1] ‘Crowdsourcing’ in this context refers to the use of non-scientists to collect data. This is in line with the *Oxford English dictionary* (2014) definition of citizen science as ‘scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions’.

In another attempt at categorization, Muki Haklay has presented citizen science according to a series of levels, shown in Figure 3.1.

Fig. 3.1. Levels of participation in citizen science

Level 4 'Extreme'	• Collaborative science: problem definition, data collection and analysis
Level 3 'Participatory science'	• Participation in problem definition and data collection
Level 2 'Distributed intelligence'	• Citizens as basic interpreters
Level 1 'Crowdsourcing'	• Citizens as sensors

Source: Adapted from Haklay (2013).

In terms of Haklay's model, Chris Filardi's presentation was somewhere between levels 3 and 4—between 'participatory science' and 'extreme' citizen science. Amy Robinson's presentation meanwhile operated around levels 1 and 2—a mix of basic 'crowdsourcing' and the employment of gamers as 'distributed intelligence'.

In principle, other categorization schemes are possible. They could be based on the organizational context and location of participants: from state-led and centrally organized efforts through to voluntary organizations and 'self-help' or 'DIY' groups. A categorization could also be built around the status of the knowledge claims being made by citizen science—from the extension of current scientific methods and epistemologies to more radical innovations, challenges and departures. Extending science is one thing; generating whole new knowledge structures and cognitive frameworks is quite another.

One pivotal notion running throughout these attempts at categorization concerns the connection being identified between the organizational structure (or *context*) of citizen science and its contribution to knowledge (or *epistemology*). One could say that the defining characteristic of citizen science is its location at the point where public participation and knowledge production—or societal context and epistemology—meet, even if that intersection can take very different forms. This is important when the recurrent tendency among political and scientific institutions has been for 'public communication/participation' and 'scientific production' to be kept firmly apart. Even the most modest efforts in citizen science involve the recognition that those without formal scientific qualifications can contribute to the generation of legitimate knowledge and understanding—a key point for our discussion of the relationship between citizen science and scientific citizenship.

What these categorizations of citizen science choose to highlight is certainly significant. In different ways, they reinforce the point that citizen science is a broad and heterogeneous activity, bringing together crowdsourcing with efforts towards more fundamental participation in the form and direction of science (Haklay's 'extreme' citizen science). Citizen science is both a matter of individual 'power players' focused on their computers and of indigenous peoples (in Filardi's terms) 'picking me up and putting me inside their questioning community'. However, it is crucial to note that such categorizations can at best only be snapshots based on one analytical perspective at one particular time. Hypothetically, at least, one can imagine different movements and shifts across categories as engaged citizens reflect upon the underlying issues and the goals of the organizers evolve.

What if EyeWire had the unintended consequence of encouraging a debate over the close relationship between Silicon Valley and university laboratories? What if it led to an open critique of the 'commodification of bioinformation' (Rose & Rose 2012)? Of course, this movement could go in other directions, too. In the case of Filardi's presentation, it could be just a short step to the attempted recruitment of the same indigenous peoples as no more than 'citizen sensors'. But one could also consider the potential for engaged citizens in one context, in this case Papua New Guinea, to connect with other groups in order to share ideas and possibilities, creating transglobal alliances and new sociotechnical outcomes.

What I am suggesting is that simply because a citizen science activity starts out in one place (or category) does not mean that it will necessarily stay there. Anticipating the discussion of scientific citizenship once more, the potential of citizen science projects to generate further questions, projects and actions seems crucial. One could think of this in terms of the capacity of specific citizen science projects to generate 'citizenship learning' or critical reflection. However, this is not just a matter for citizens but equally for *scientific and institutional* learning as the experience of citizen science projects leads to deeper organizational and scientific reflection upon what I will simply call 'contemporary knowledge relations', including routes to citizen engagement. In this sense also, the form in which a citizen science project starts may be less important than where it ends up or the individual journeys of scientists, citizen scientists and others.

I would certainly estimate that there are many more 'Zooniverse'-type projects initiated at Haklay's levels 1 and 2 than there are projects designed to create fully participatory forms of citizen science. That was also my impression at the 2015 Citizen Science Association meeting. But is it possible that even a relatively modest citizen science project could lead to an enhanced sense of citizenship?

3.2 Exploring scientific citizenship

'The need to clarify our understanding of the complex interfaces and intersections between science and citizenship is now more pertinent than ever' (Leach et al. 2005: 3).

Let me say from the start that I do not see 'scientific citizenship' as a fixed or agreed concept. Instead, it brings together ideas from a set of long-running discussions about how science and citizenship both are and should be (co-)produced. Certainly, it is a term with a very rich intellectual and political pedigree—especially within the fields of science and technology studies, political science, history, philosophy and anthropology. It is also a field that many natural scientists have entered, albeit usually motivated by concern about what they see as the encroachment of politics upon scientific freedom.

From my viewpoint, at the heart of scientific citizenship is an inquiry into the relationship between members of society, especially in their capacity as 'citizens', and matters of science, technology and innovation—or what we can more broadly term 'sociotechnical futures'. As Melissa Leach and Ian Scoones (2005) have noted, there are a number of possible perspectives on this relationship. They include liberal approaches within which the view of the state as neutral fits well with the notion of science as rational knowledge. Citing Cornwall and Gaventa (2001), Leach and Scoones suggest that much 'participatory' development (including public engagement with science) falls within this framing, 'with participation seen in terms of individuals choosing among an array of options and services, but not playing a major role in setting agendas of policy or technology development' (2005: 23). A similar point could of course be made about 'Level 1' forms of citizen science.

Leach and Scoones develop other perspectives on the relationship between science and citizenship, including communitarian approaches, which centre on the notion of the socially embedded citizen, and civic republican approaches, in which individuals are presented as one part of collectivities that make claims on the political sphere. Crucially, they pay attention to issues of citizenship and identity, putting particular emphasis on matters of difference and exclusion—including questions of race and gender. One implication of this perspective is that people do not have equal access to material resources and political power, but that there is a 'political economy of knowledge that legitimizes and privileges certain kinds of expertise over others' (Leach & Scoones 2005: 27).

Very importantly for this paper, Leach and Scoones also discuss what they term 'citizenship practice and subjectivities'. Drawing broadly on a poststructuralist approach, that perspective challenges essentialist (or static) notions of collective identity and instead identifies the ways that subject positions multiply in contemporary social and political life. On the one hand, emergent forms of solidarity are likely to be shifting and malleable. On the other, they may gain energy precisely through their performative and flexible nature as new issues arise, as people react to fresh situations and contexts, and as connections are made between aspects of everyday life that had previously been separate. This does not mean that the old markers of citizenship (including social class, gender and ethnicity, in particular) have disappeared. Rather, the old markers do not always tell the whole story in this 'late-modern' world (Beck 1992).

On that basis, Leach and Scoones present citizenship as a form of 'practised engagement' and make the link to a form of participatory democracy that emphasizes the potential of citizens to deal actively with questions that are relevant to their lives. This could also be a learning process as initial engagement with one set of issues enhances wider citizenship capabilities and potentialities. Once again, we return to what I discussed earlier as 'scientific, institutional and citizenship learning'. Put differently, and as Leach and Scoones express it, 'engagement … may now be a key context where citizenship practices are played out in new, important ways in an era when other issues have been depoliticized or given over to the play of liberal market forces' (2005: 31).

I want to introduce just one more concept to this discussion of science and citizenship. Visvanathan (2005) has employed the notion of 'cognitive justice'. Fricker (2007) discusses related issues under the equally provocative heading of 'epistemic injustice'.[2] For me, a focus on justice with regard to issues of knowledge relations and, in particular, connections between science and citizenship raises questions of citizens' rights, of accountability and of the responsibility to do what is best for the collectivity (including, in the case of environmental rights, collectivities as yet unborn). It also acknowledges that, while different forms of expert knowledge can certainly be important (this is not a matter of anti-science), there are also other ways of knowing the worlds in which we live. Those ways of knowing relate closely to different ways of living and acting. Rather than separating science and citizenship into separate domains, ideas of cognitive/epistemic (in)justice precisely interconnect and intermingle the two, suggesting also that modes of citizenship and forms of knowledge flow together through many areas of social life.

While 'justice' raises a fundamental issue for all models of citizenship, its juxtaposition with 'cognitive', 'epistemic' or both puts issues of science, technology, knowledge, innovation and technical decision-making at the centre of sociopolitical debate. Seen in that way, scientific citizenship is not simply about the responsibilities of scientists, on the one hand, and citizens, on the other. Instead, the area sits at the intersection between political discussion, social inequalities, innovation, research policy and scientific practice—all in a complex and globalizing world.

That is quite an agenda. It is also an extremely important one. But the question for now is where citizen science comes into such matters of scientific citizenship—including, as I have just suggested, considerations about cognitive or epistemic justice. Is citizen science only about producing more science in nonconventional ways? Or does it have a larger role in terms of these citizenship questions?

3.3 Putting the citizen (and the science) into citizen science

In this final section, I pose two key questions:

- To what extent *is* citizen science facilitating the wider development of scientific citizenship?
- How *could* citizen science facilitate the wider development of scientific citizenship?

Given the heterogeneity of both citizen science and scientific citizenship, the answer to the first question depends to a large degree on where one looks—and how one sees. But, put very crudely, can one identify a citizen science in which 'Filardi-like' perspectives are more prevalent than crowdsourcing? And when we identify 'higher level' citizen science approaches, do we see clear signs that scientific

[2] My thanks to Tom Wakeford for introducing me to this term and for co-organizing a breakout session on this topic at the 2015 Citizen Science Association conference.

institutions and groups of citizens are reflecting upon the implications and putting into practice the lessons learned?

As much as I hate to be predictable, it is very hard to answer such questions strongly in the affirmative. It is not at all difficult to make the case that citizen science today is more about remote sensing than 'collaborative science'. One could even suggest that the 'broad church' definition of citizen science, as covering both crowdsourcing and deeper knowledge partnerships, risks being misleading in this regard. It certainly appears that very different models of scientific citizenship underpin the two keynote presentations that I have discussed—and there are probably more within the citizen science movement as a whole. One could also observe that, despite the hard work, fertile imagination and infectious enthusiasm of the citizen scientists, scientific institutions are still reluctant to engage fully with level 3 and 4 activities.

But, and let me say this plainly, I do see more significance for scientific citizenship in the current direction of citizen science than is expressed by such a negative conclusion—even if at this point I put particular emphasis on the potential of citizen science as a gathering movement rather than on the accumulated evidence of institutional change, in particular. Several characteristics of citizen science seem especially significant here.

First of all, what demarcates citizen science activities (of whatever sort) from more conventional public understanding of science activities is that they build not only on the active participation of citizens but also, and explicitly, on their *expertise*. Whether identifying earthworms in one's garden or helping to create new maps of the brain, there is a move to take forms of expertise developed outside the confines of the university or laboratory seriously and in some way to grant them both recognition and value. Of course, there is a continuum here—from ticking items off a prepared list to deep knowledge acquired over many years—but the recognition of citizen expertise as a resource is significant in itself. One might reasonably argue that this 'finding' of distributed expertise should hardly come as a surprise (it has existed for centuries), and in that sense that the 'discovery' of citizen science says more about the limitations of the existing institutions of science than it does about citizen knowledges. Nevertheless, my basic point remains.

My second thought concerns the *heterogeneous mix* of citizen science. One of the activities at the 2015 Citizen Science Association meeting involved asking participants for statements in response to the question 'WhyICitSci' (*sic*). Jostling together among the responses, we find 'fun' and 'problem solving' but also 'advancing science and conservation' and 'engaging youth'. 'Democratization of science', 'bridging gaps' and 'harnessing local knowledge' featured, too—as well as 'more brains'.[3] We could easily interpret this as a lack of clarity and purpose: what hope for citizen science when those attending such an inaugural event do not even agree among themselves? In noting heterogeneity and difference, however, one could argue that this is not a weakness but a strength. If citizenship is not to be something that sits aside from everyday life, then it precisely needs to be invigorated by 'fun',

[3] Based on a post prepared by Pika Jo Varner (accessed 23 February 2015).

'youth' and 'problem solving' (to take just three factors). In that sense, citizen science might be pointing out roads to citizenship and engagement that do not start in the conventional world of politics and citizenly responsibility but precisely in the unsorted mix of everyday life. Perhaps social scientists and even politicians could learn something from such settings about the meaning of contemporary citizenship?

A third, and related, point connects to Leach and Scoones' argument for '*practised engagement*'. If citizenship is not to be something we simply receive but instead needs performance and development, then citizen science projects seem to have the potential to catch the attention of different parties and draw them in in a relatively sustained fashion. There is something in the specificity and immediacy of citizen science projects that can create a starting point or potential catalyst for future projects—and also provide a partial identity in a world of shifting solidarities. Of course, this cannot be taken for granted and is by no means given—sometimes (just as Freud may have said about cigars) a project about earthworms is just a project about earthworms. It could also be that the citizenship dimensions of citizen science projects are more 'mundane' than more traditional forms of citizenship, democracy and social movements usually entail. However, the capacity of citizen science projects to provide a shared focus and a common sense of possibility in an immediate and practice-oriented manner should not be underestimated.

Now the questions start to get more difficult. Will citizen science be capable of addressing issues of *cognitive or epistemic justice*? Certainly, there was a reasonable level of interest in this topic at the 2015 Citizen Science Association conference, which included important discussions about diversity and inclusion. One needs to be careful not to overburden what are in many cases still fledgling initiatives, but there is a potential here (as has already been noted) to connect with groups that may feel excluded from more conventional forms of social and political action. For me, the issue of epistemic injustice taps into a double exclusion of certain social groups in particular, both in terms of conventional citizenship and in a marginalization of their ways of knowing and understanding the world. Citizen science cannot deal with all these questions alone, but it can provide both a meeting and a starting point for social and epistemological action.

Finally, one crucial factor for the future development of this area will be what I have termed '*scientific, institutional and citizenship learning*'. Perhaps the most challenging aspect of this will be the capacity of scientific institutions to view citizen science as not simply an extension to their activities but also at least partially as a reframing of those activities and a positive invitation to enter other 'questioning communities'. I must confess that this is the area of discussion where I feel most cautious—especially when the emergence of citizen science coincides with a heightening of global scientific competition and the strengthening of conventional measures of research evaluation (Felt et al. 2013).

Citizen science can provide a way of bringing working scientists into direct contact with problem situations and communities with sometimes revelatory consequences (not least in causing a reassessment of whether the right questions are being asked and the right relationships established between scientists and specific communities). But the institutional conditions must allow—and preferably even encourage—such reassessments and redefined relationships. Otherwise, citizen science can only exist on the margins.

My point is not that institutional learning in this area is impossible. One can certainly point to the close relationship with citizen groups that already exists in certain scientific fields (for example, parts of biology, geology and archaeology). However, wider learning and positive action will not occur without the conscious and sustained support of the scientific community. It follows also that responsibility for a positive relationship between scientific citizenship and citizen science should lie at least as much with the institutions of science as it does with citizens. There is more to scientific citizenship than can be delivered by scientific institutions. Nevertheless, positive change in that area may not be a bad place to start.

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4 Science communication in a post-2015 world: the nexus of transnational, multidisciplinary and sociocultural contexts

Elizabeth Rasekoala

Ongoing consultations and discussions on the UN-led post-2015 global development agenda have highlighted the challenges of 'mainstreaming' science in strategic development frameworks—implying that there is a danger of the marginalization of science, and hence science communication (Rasekoala 2014). The landscape of post-2015 global sustainable development is highly predicated on the stark challenges of the nexus of transnational, multidisciplinary and sociocultural contexts. The role of science and its communication in this complex arena is one for which a 'business as usual' modus operandi will not suffice. Science communication should help to overcome the world's myriad and intractable development challenges by highlighting and promoting the pivotal role of science, through developing innovations and solutions. Those challenges are profound, and nowhere more so than on the African continent.

The Ebola pandemic, which continues to devastate parts of West Africa and has global ramifications, is a case in point. It highlights the convolutions of this nexus of parameters and how they have come together in a perfect storm to challenge the orthodoxy of current science communication, science and society discourses and approaches, and the sociocultural dimensions of how people and communities conceptualize and understand the 'scientific' notions of risk and uncertainty. It further illustrates the very dismal levels of scientific literacy in African countries and the challenges that this poses for addressing public health pandemics and pathologies, such as Ebola, HIV/AIDS, high maternal and infant mortality rates, and the take-up of preventive childhood and other vaccination regimes, on the African continent.

There is a strategic rationale for the development of science communication capacity, expertise and innovative good practice in Africa, based on African-centred approaches. Despite major advances in the field of science communication in the global north, and in parts of the developing world such as Latin America, the Caribbean, India and some Asian countries, science communication and the popularization of science and technology on the African continent has woefully failed to take off and is very marginalized in the scientific landscape. That marginalization is due to certain factors, such as the lack of policy development and institutionalization of the science communication agenda by the African scientific community, governments, and science and technology institutions on the continent.

There is also a growing acknowledgement that multidisciplinary scientific endeavour is critical to enabling societies to overcome multiple development challenges. The imperative of multidisciplinarity should thus also apply in the ways that science is communicated—the what, the how, the where, the tools, the methodologies and so on. The craft of science communication thus needs a root-and-branch overhaul to deliver the transformative innovations required in this challenging new global development framework.

Furthermore, this transformed framework for science communication should be forged out of a normative agenda that seeks to resist a scientific status quo that has tended to make invisible the contributions of the global south to scientific endeavour while at the same time making the scientific solutions to global development challenges universal.

The main features of an overhauled post-2015 science communication landscape should be:

- *citizen-centred approaches* that prioritize gendered social and cultural paradigms to transform the Eurocentric and masculine-biased programmes that currently dominate
- the active *involvement of social scientists* to help address sociocultural contexts
- effective *joint leadership and control* by local actors (governments, civil society and community-based organizations) as well as international groups
- an *emphasis on the long-term sustainability of initiatives*, such as training a new generation of multidisciplinary science communicators and journalists to work for and with their fellow citizens to communicate the pivotal role of science in sustainable development and the betterment of societies, in an inclusive and empowering dynamic.

4.1 Take citizen-centred approaches

The transformation and advancement of science communication in Africa can only be achieved through the conceptualization and contextualization of methodologies and approaches that are grounded in African agency, giving voice, status and recognition to that profound paradigm shift from Eurocentric hegemony to transnational and sociocultural empowerment within the African landscape. This involves acknowledging the patriarchal and male-dominated mindsets, nuances and practices that, to date, have informed and driven the science communication framework as we know it. Unfortunately, the science communication arena features the same gender disparities and inequalities that bedevil the global scientific enterprise. There is no part of the world that is free of this hegemony, and in this regard the challenges on the African continent are as profound as they are elsewhere in the world.

Building the capacity of women scientists, science communicators and practitioners, and mainstreaming gender in science communication policy formulation and implementation, are vital to achieving the universal post-2015 sustainable development goals. Women need to be empowered through the sharing of best practices and the provision of enhanced opportunities and access, so that they can actively contribute to science communication programmes as designers, actors and delivery agents, rather than simply as passive observers, targets or consumers of those initiatives. There is a need to develop strategies for the formulation and implementation of policies geared towards elevating the status of women in science communication, science and society, and in the public communication of science and technology sector. There is also a rationale for the development of gender disaggregated data to advocate for women's participation in these sectors at individual and institutional levels. It is critical that gender perspectives be infused and integrated into the design, planning and conceptualization of these programmes and activities, including in the framing of audiences and stakeholders who will be the target for the initiatives. This implies that a gendered 'lens' should be applied to the notion of defining audiences, 'publics' and 'citizen-centred' participatory approaches for the framing of science and society discourses and activities.

Thus, gendered notions of good practice in science communication, which empower, include and recognize the unique contributions of women as effective agents of the scientific enterprise, need to be evolved, advanced and mainstreamed into formal systems.

Here, the notion of Afrocentricity as a paradigm of transformation is critical. Asante (2007) defines Afrocentricity as:

> a consciousness, quality of thought, mode of analysis and an actionable perspective where Africans seek, from agency, to assert subject place within the context of African history.

Afrocentricity operates within African ways of knowing and existence and results in the implementation of principles, methods, concepts and ideas that are derived from our own African cultural experience. Afrocentricity derives from and enhances African agency and exhorts Africans to be agents rather than spectators of their development. Afrocentricity postulates that the African experience must guide and inform all inquiry and that the knowledge generated must be liberating (Asante 2007).

The science communication transformation agenda can also be enhanced by opening up discourse and practice to be truly global, working with multiple sociogeographical perspectives and approaches, and incorporating communities of practice and epistemic frameworks from all parts of the world. In the African context, this would involve the mainstreaming of indigenous knowledge systems (IKSs) into ways of conceptualizing, delivering and practising science communication, so as to tap into local urban and rural communities and their traditional indigenous ways of knowing and understanding natural and scientific phenomena (Seleti 2013). The emphasis here is not on romanticizing or eulogizing IKSs, which, just as any other knowledge system, have their flaws and challenges; the aim is to use IKSs to build foundations on which local communities can embark an evolving, empowering and progressive journey to own and include scientific notions in their everyday experience, so that they are better able to make informed choices and decisions that will improve the quality of their lives.

4.2 Involve social scientists

The UN's post-2015 Sustainable Development Goals (SDGs) framework elucidates the complexity, range, breadth and depth of the global development challenges of the 21st century, much more so than the preceding Millennium Development Goals, which were limited in their scope and application. The SDG framework shows that the framing of science communication and science and society discourses, practices and mechanisms, which have been heavily predicated on the natural and physical sciences, has not served societies and communities well. There is increasing global recognition of the need to integrate scientific effort jointly and collaboratively between natural and social scientists. Science communication initiatives should then be co-designed in transdisciplinary, trans-science contexts to address multifaceted development challenges. Furthermore, if science communication is to be both salient and credible for a wide range of audiences and meet the needs of diverse publics, there is a need for new ways of approaching the craft and delivery mechanisms in order to maximize impact and enhance development gains (ISSC 2012).

We need social science knowledge on how decisions are made in the face of uncertainty, what makes knowledge work, and where the limits of expert knowledge lie. Constructive collaboration between social and natural scientists would engender mutual and transformational learning. The co-design, co-execution and co-delivery of science communication practice would, in turn, embed the personal and collective values, beliefs, assumptions, interests, world views, hopes, needs, aspirations and desires that underlie peoples' experiences of and responses—or lack of responses—to natural and scientific phenomena (ISSC 2012).

In addition, integrating social science and co-framing and co-producing the science communication agenda will stimulate and support innovation and out-of-the-box thinking by natural scientists in the technological and social frames, and will enhance their understanding of the influence of diverse contexts and values. This is critical to understanding how risks, impacts, perceptions, experiences and responses differ across different regions and cultures, across social classes and gender, race or faith groupings, and across a range of personal and professional identities (ISSC 2012).

4.3 Provide for effective joint leadership and control

Joint leadership and control of science communication and science and society practices, programmes and frameworks are critical in addressing concerns about the processes of social engineering and the feasibility of participatory approaches to determining and achieving alternative, empowering and inclusive visions of a scientifically literate society. Building consensus on directions and mechanisms of progress and development in ways that include marginalized and non-scientific views and voices is a key challenge. Collaboration with multiple societal actors, including decision-makers, practitioners and civil society organizations, is pivotal.

In addition, there is also a need to alter the fundamental attributes of the current system, so that attitudes, practices and power relations are interrogated, contested and transformed, including through critical questioning of the systems and paradigms that have served science communication thus far. They provide a fundamental set of lenses for understanding processes of scientific engagement as social processes embedded in specific social systems, past and present.

Science communication and science and society strategies that are based on good-quality and appropriate community engagement are the key to achieving development goals. External agencies often underestimate the role that communities play in enhancing the impact of science communication in development innovation.

These new approaches could also include the development of new institutional arrangements and mechanisms for fostering multilevel and multidimensioned partnerships to make science communication and science and society initiatives relevant and to make a real difference in people's lives.

4.4 Emphasize long-term sustainability

During the 13th International Public Communication of Science & Technology (PCST) Conference in Salvador, Brazil, from 5 to 8 May 2014, it became clear to the few African delegates that there was a driving imperative to address the challenges of public communication of science and technology on the African continent, and to enhance capacity, visibility and collaborative partnerships among African practitioners through the formation of a pan-African continental network, similar to the Latin American and Caribbean network, known as RED-POP. They noted the poor legacy of the 2002 PCST conference held in Cape Town, South Africa, in delivering leadership and a post-event pan-African framework for policy development and capacity building and institutional frameworks for political engagement and social inclusion.

Our Latin American colleagues in RED-POP informed us of the pivotal role of UNESCO support in enabling, facilitating and sustaining the development and growth of their network.

Those developments have led to the establishment of *African Gong*: the Pan-African Network for the Popularization of Science & Technology, with the strategic support of UNESCO Africa Region.

Science journalism on the African continent is taking longer strides to move in step with international developments in the sector. This has been driven by the formation of subregional and regional networks on the continent, such as the West African and the East African Associations of Science Journalists. These networks have grown from the base of national science journalists' associations in many African countries.

However, there are no such networks for science communicators and practitioners on the African continent at the national, regional or subregional levels—hence the powerful rationale for African Gong. We envisage a network that is multidisciplinary, inclusive, interactive and multilevel in its membership, constituencies and partnerships, and that will allow exchanges of information and regional and continental cooperation, including among the African diaspora. Other critical aims include training, capacity building, resource management, the development and sharing of good practices in science communication and the public communication of science and technology on the African continent.

The key goal of African Gong is to encourage the creation, dissemination and use of science and technology to address pressing developmental needs in Africa in a sustainable manner. We see as pivotal the task of harnessing IKSs and the participatory capacity of Africa's scientists and communicators to enhance social inclusion and cultural and political engagement. The network will also create opportunities for international research collaborations, projects and networking in various international forums and conferences.

African Gong is a timely development. We hope that it will give Africans a strategic platform from which Africa can contribute to global structures and institutional capacities for the advancement of science communication, science and society studies and the public communication of science and technology. It will also contribute a uniquely relevant and inclusive African-centred paradigm and community of practice to the global development agenda and address the critical need for transformation in the science communication sector. African Gong will also facilitate and enable the strategic positioning of science and its applications at the heart of the global sustainable development framework.

4.5 Summary

The emerging global framework of the post-2015 Sustainable Development Goals creates a critical opportunity to reach consensus on a vision for development that is science-based and applicable everywhere. This creates an imperative for science communication, science communicators, science and society practitioners and others to think, act and transform their practices so that they critically and inclusively engage linkages between the diverse and multidisciplinary knowledges of multiple actors (local communities, social scientists, indigenous knowledge systems), multilevel capabilities and transnational dialogues.

A distinct hallmark of this transformed landscape in science communication should be the synthesis and delivery of scientific and other knowledge in dynamic and empowering multistakeholder partnerships, which reduce the knowledge gap at the individual, policy, institution and government levels and at socio-economic (race, gender, social class) levels and reduce the knowledge gap in legislation and implementation.

In this context, the development of African Gong—the Pan-African Network for the Popularization of Science and Technology—will be pivotal in bringing on board the agency, capabilities, voices, lenses and knowledge generation of African practitioners to contribute to and drive the delivery of the vision for the global science communication transformation agenda for sustainable global development.

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5 Developing a science museum system with Chinese characteristics: strategy, framework, mechanism and evaluation

Cheng Donghong

5.1 Introduction

In this paper, I examine the development of China's system of science museums, the social contexts that influence strategic science communication in China, and the government's official plan for deepening and widening citizens' science literacy.

The paper details the specifically Chinese characteristics of the system, summarises research into the effectiveness of the system and notes some problems and challenges ahead.

5.1.1 Literature review: selecting science communication strategies in a social context

As a research methodology, social context research has been enriched and applied in the theory and practice of the sociology of science (which I term *scienology*) and science communication in recent years. Wei Yidong once described social context analysis in scienology research as placing science in social history to comprehensively analyse the interaction and relationships between the science and the internal and external social factors, including the synchronic and diachronic aspects of those factors (Wei 2002). Huang Huaxin holds that the action of social context on science communication is affected by political, economic, cultural and historical factors. In addition, at different times and in different spaces, such social context factors have different effects on science communication (Huang & Yu 2004).

I divide the social context of science communication into external and internal contexts. Social factors (economy, culture, politics, history and so on) are the external context and the subjects within the science communication system; the ecological relationship of those subjects is the internal context. To some extent, the external context is the social context of science communication, while the internal context is its situational context (Cheng 2014a).

In addition to research on social context that affects science communication, research on the selection of modes and strategies for science communication in different social contexts has also attracted academic attention.

In empirical research on public attitudes to science in different social contexts in Europe, India and China, Martin Bauer (2011) has found that in 'industrial' and 'post-industrial' social contexts public understanding of science does not correlate with support for science, and proposes that that the characteristics and modes of science communication in different contexts, and selected strategies for communication, will differ. Bernard Schiele (2008) puts forward the idea that most science and technology communication performance relies on remoulding social roles and converting the knowledge relationship. In other words, science communication enables those in social roles to rethink how to understand science and particular knowledge in specific situations. Therefore, science communication practice is carried out in close social relationships and significant shared interactions, and the development of science communication strategy must also match the real social context.

Based on analyses of real social contexts in China, I have interpreted the influence of social context on the selection of science communication strategies in China in the light of practical cases of communication (Cheng 2014a). It is clear that it could be worthwhile to research science communication strategies from the angle of social context. As for policymaking, the selection and development of science communication strategies, whether at the macro, meso or micro level, matched with or adapted to the real social context, should be considered as a priority.

5.1.2 The current situation in Chinese science museum development

Science museums[1] are playing important roles as infrastructure for providing public science communication in China. The Chinese science museum system currently includes four main types: conventional science museums, mobile science museum, science wagons and digital science museums.

A 'four-in-one' museum system with Chinese characteristics

By 2014, the construction of public science communication infrastructure in China had built a 'four-in-one' science museum system with Chinese characteristics. The four elements are:

- conventional science museums in medium-sized to large cities
- mobile 'science wagons'
- mobile science museums servicing middle and small cities and rural areas
- online science communication resources.

[1] In this paper, I distinguish modern science museums, which are science centres equipped for participatory exhibition activities, from science museums *per se*, which give priority to collections.

Conventional science museums

Chinese science museums were first established after Deng Xiaoping introduced the policy of reform and opening up to the outside world. The first one opened in 1984. At the end of 2000, the China Association for Science and Technology (CAST) published standards for science museums, which indicated that science popularization, exhibitions and education were the main functions of the museums. From that time, developments were rapid.

At the beginning of 2006, the State Council issued the *Outline of the National Scheme for Scientific Literacy (2006–2010–2020)* which set out specific requirements for the development of science museums and boosted the development of museums throughout the country. In 2007, the Ministry of Construction and National Development and Reform Commission issued the *Construction standard for science museums*. From 2006 to 2012, 56 'reach-the-standard'[2] science museums were established nationwide, at an average of eight per year over that period. By the end of 2012, there were 99 such museums in China. Visits to the museums exceeded 34 million in 2011 (Table 5.1).

Table 5.1. Reach-the-standard science museums managed by the CAST system, 2000, 2005 and 2012

Year	Number of science museums	Total building area (m^2)	Total visitors (visits/year)
2000	11	174,412	About 1.8 million
2005	43	574,343	About 10 million
2012	99	1,457,535	About 34 million[a]

a Data for 2011(Qi et al. 2014).

Note: Including these museums, which meet the CAST standards and national construction standards, 364 science and technology venues had names that included the words 'science museum' in 2012 (Cheng 2014a).

The data in Table 5.1 indicates that the development of Chinese science museum has made tremendous progress since 2000, and has made important contribution to science and technology popularization and scientific literacy.

Science wagons

In 2000, CAST began to develop 'science wagons' and distribute them to local associations for science and technology. The wagons bring science museum style services to towns, villages and schools far away from large cities. A Type II science wagon can accommodate 25 vehicle-mounted exhibit boxes, DVD projection equipment and other facilities.

[2] In this paper, the adjectival construction 'reach-the-standard' indicates that a science museum meets the CAST standard and the national construction standard.

By the end of 2013, 733 science wagons were operated by 36 provincial organizations, 214 prefecture-level organizations and 132 county-level organizations. Their total mileage had reached 20.7 million kilometres. Their crews had conducted 108,800 activities, benefiting almost 152.5 million people. A survey indicated that 96% of people who visited them considered that science wagons were novel and content-rich, and that they wanted to see more of them.

Mobile science museums

In 2010, CAST began a project to develop mobile science museums, with the theme of 'Experiencing science'. Each mobile science museum includes three thematic exhibition zones: scientific exploration, scientific life and scientific practice. Ten sub-theme exhibition areas have 50 exhibits, combined with scientific demonstrations, experiments and science popularization films and TV, to allow visitors to participate in science. Exhibits are packed and transported in large containers. Their design is modular, according to the theme or sub-theme, to allow them to be easily split or combined.

The targets of the itinerant Chinese mobile science museum system are remote counties that have no conventional science museum. After a two- or three-month exhibition in one county, the museum travels to another county, or station. Every set of exhibits is required to cover four stations each year.

The project has wide coverage, serialization and sustainability as its basic objectives. It is aimed at providing basic coverage for the general public (and especially for primary and secondary school students) in remote counties.

By the end of 2014, Chinese mobile science museums had been equipped with 77 sets of exhibitions and had exhibited in 378 counties with a combined population of more than 15 million.

Digital science museums

As part of the Chinese basic platform for science and technology, the China Digital Science and Technology Museum[3] (CDSTM) was jointly developed by the China Science and Technology Museum, the Ministry of Education and the Chinese Academy of Sciences and launched in December 2005. It aims to conduct free web-based science and technology education by integrating and sharing high-quality science popularization resources to enhance the scientific literacy of the public and allow all sectors of society to participate in science communication. For rural or remote areas with poor internet access, CDSTM selects high-quality resources for use offline. By August 2013, the website had more than 500 million pages, total resources of more than 4.8 terabytes, an average of more than 1.8 million page views per day, and had supplied downloads of 1.8 million items. Fans of the CDSTM on

[3] http://www2.cdstm.cn/english.

Sina, Tencent and Sohu (three gateway websites with great influence in China) numbered more than 160,000 (Ren & Yin 2015).

5.2 Social context and strategy selection for science communication

This section explores the relationship between social contexts and choices of strategies for science communication.

5.2.1 The social contexts of science communication in China

The social contexts for science communication are multiple and complicated. This discussion focuses on four aspects of social context that have direct impacts on China's strategies for developing science museums.

Unbalanced regional development

China is a vast country with higher altitudes in the west, temperate and subtropical zones and a small area in the tropics, which makes the climate uneven. Rainfall decreases from the south-east to the north-west. The geography and geology mean that resources, and therefore economic development, are also unevenly distributed. While some eastern coastal regions have reached the economic level of developed countries, many western regions are still developing or even below the poverty level.

China's geography has also contributed to the development of cultures with regional characteristics. The eastern coastal regions have been relatively prosperous since ancient times; education and culture have always been valued more highly there than in the western parts of the country.

These factors explain China's regionally unbalanced social development, which is an objective fact in the country's social contexts. According to data provided by the Renmin University of China (Yuan & Peng 2012), regional differences in overall social and economic development have increased since 2005. The whole country's living standards are improving each year, but faster in some areas than others, contributing to the imbalance.

Unbalanced regional development leads inevitably to an unbalanced distribution of public services and infrastructure, including public science communication infrastructure such as conventional 'reach-the-standard' science museums.

China's development of the four-in-one system is therefore a logical response to a social context characterised by uneven regional development.

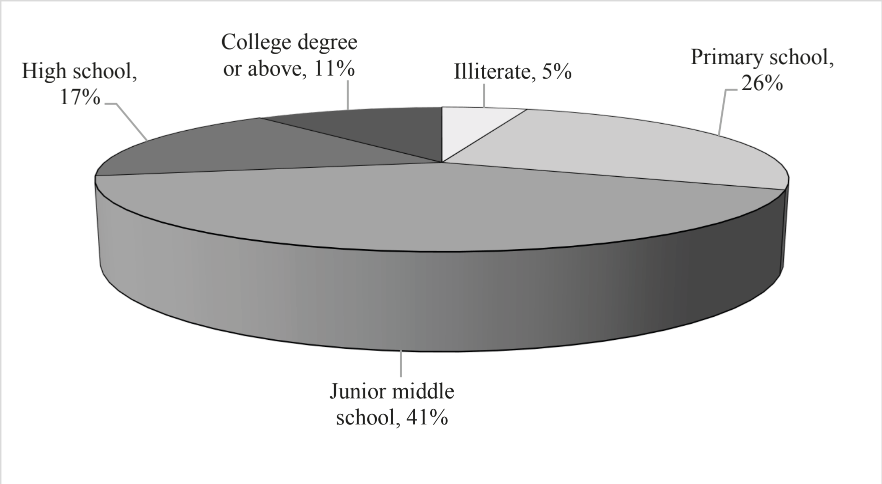
Demographic characteristics

China's social context includes its demographic characteristics.

The proportion of Chinese citizens who were elderly and dependent on others was 12.3% in 2011, and that proportion continues to grow as people live longer.

The level of education of the population has improved significantly. In 2011, the average length of citizens' education was 8.5 years; among those entering the workforce, it was more than 10 years. Both figures exceed global averages, but are still regarded as low. According to the 2010 census, just under 11% of citizens had a higher education qualification, while just under 58% had secondary education. Figure 5.1 shows the distribution of educational attainment.

Fig. 5.1. Chinese citizens' educational attainment



Source: NBSC (2013).

China's population structure is changing in other respects, too, as number of 'urban new residents' who migrate from rural areas to settle in the city surges. According to a report on China's internal migration (DNH-FPC 2013), internal migrants totalled 236 million, or more than one-sixth of the population, in 2012.

The country's ageing population, overall low educational levels and high demographic mobility create challenges in supplying public science communication services evenly.

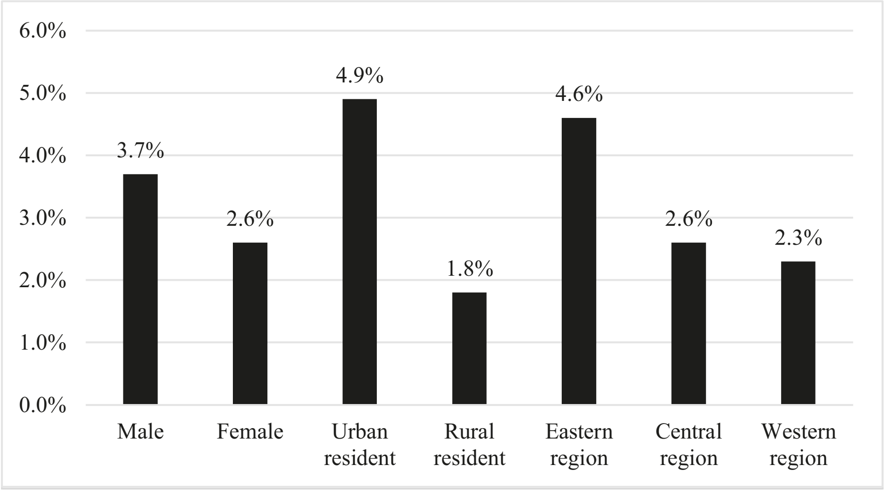
In this social context, China has to nurture its citizens' capacity for lifelong learning and build their ability to acquire scientific knowledge. Most are keen to know more, although some have doubts about genetically modified food and waste products from the chemical industry.

This social context also explains China's development of the four-in-one science communication system.

Variation in the scientific literacy of Chinese citizens

According to the results of the Eighth Chinese Citizens' Scientific Literacy Survey in 2010, the scientific literacy levels of Chinese citizens differ significantly between the urban and rural areas and between regions (Ren 2011). The proportion of urban residents with basic scientific literacy is 4.9%, while among rural residents it is 1.8%. The proportion of residents in eastern regions with basic scientific literacy is 4.6%, which is higher than that in the central and western regions (2.6% and 2.3%, respectively). Figure 5.2 shows the proportions for men and women, urban and rural residents, and the three regions.

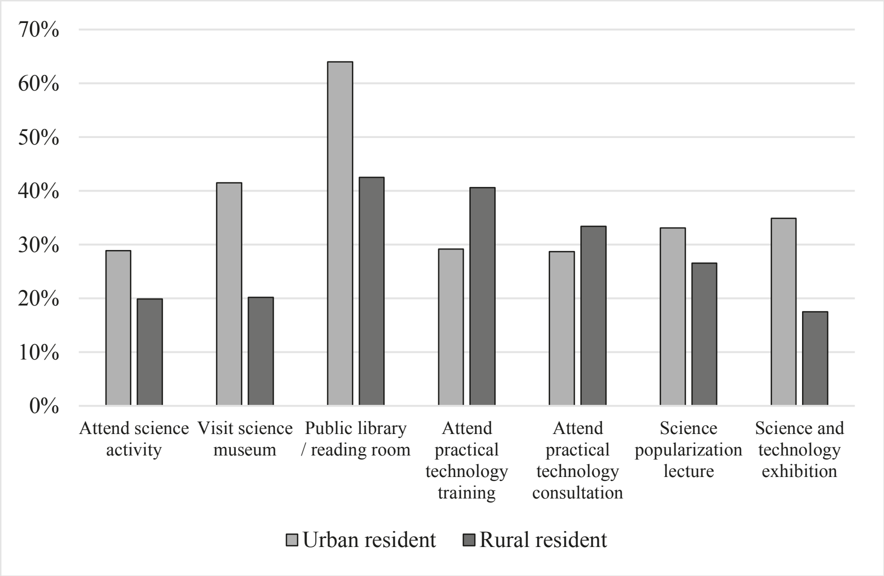
Fig. 5.2. Distribution of scientific literacy among different groups of Chinese citizens, 2010



Differences in participation in science communication activities

The survey also noted differences in participation in science communication activities, such as science and technology (S&T) weeks and festivals and science popularization days, between urban residents (28.9% of whom participated) and rural residents (19.9%). Urban residents were more likely to attend S&T exhibitions and lectures, while rural residents were more likely to participate in technical consultations and practical technical training.

Fig. 5.3. Chinese citizens' participation in science popularization activities, 2010



Among the 27% of citizens who have ever visited S&T museums (Table 5.2), urban residents make up 41.5% and rural residents only 20.2%. There is also a gap among those who have ever used a public library or reading room (64% of urban residents to 42.5 % of rural residents).

The proportion of Chinese citizens who use science popularization infrastructure has increased steadily over the years (Table 5.2).

When people who had not visited science popularization facilities were asked why they had not, 41.9% opted for 'no natural museum is available locally' and 37.6% answered with 'no science museum is available locally'.

Table 5.2. Chinese citizens visiting science popularization infrastructure, 2001 to 2010

	Year				
Facility	**2001**	**2003**	**2005**	**2007**	**2010**
Reading room	25.2%	24.3%	29.2%	43.7%	54.5%
Public library			26.7%	41.0%	50.3%
Science popularization gallery and bulletin board	–	31.8%	36.7%	46.8%	48.7%
Science and technology demonstration site, science popularization activity station	–	25.9%	30.9%	29.1%	35.5%
Agricultural and industrial production park	–	–	–	30.0%	34.2%
S&T venue, such as a science museum	12.2%	7.9%	9.3%	16.7%	27.0%
Natural history museum		4.9%	7.1%	13.9%	21.9%
Laboratories of colleges and universities as well as research institutes	–	–	–	2.7%	11.2%

Sources: Zhang et al. (2014), Cheng (2014b).

5.2.2 The Outline of the National Scheme of Scientific Literacy

With the development of Chinese society, the relatively low overall scientific literacy level of the public is attracting the increasing attention of the government, the academic community and the media. In a society experiencing fast development and deep transformation, citizens urgently need scientific literacy to master scientific knowledge and technical skills to advance their careers and professional development, to solve the practical problems in daily life, and to participate adequately in public debates, many of which are caused by or related to the rapid development of S&T. However, uneven regional development, relatively low education levels and a lack of lifelong informal learning opportunities make raising scientific literacy levels difficult in the Chinese social context.

In view of this, the State Council of China issued the *Outline of the National Scheme for Scientific Literacy* (referred to below as the *Outline*) in 2006 as a top-level policy for public science communication services in China (State Council 2006).

The *Outline* aims to substantially improve scientific literacy for all through the development of S&T education, communication and popularization. It is a comprehensive programmatic document to guide performance in those three areas. Its implementation has had enormous influence on public science communication in China since it was issued a decade ago.

Main content of the *Outline*

The core objective of the *Outline* is to enhance the scientific literacy of the general public. It defines civic scientific literacy as learning about necessary scientific and technological knowledge, mastering basic scientific methods, building scientific concepts, advocating a scientific spirit and being equipped with certain abilities to use all the above-mentioned elements to handle practical issues and participate in public affairs. Scientific literacy is very important for strengthening the ability of citizens to acquire and apply scientific and technological knowledge, improving the quality of life, realizing integrated development and promoting sustainable socio-economic development.

To realize those objectives, the *Outline* put forward four action plans, for young people, farmers, town labourers, and leading cadres and civil servants. Those groups were chosen because of their importance, to make the best use of resources and to make a difference quickly.

To deal with China's relatively weak science literacy and regional imbalances in S&T education, popularization and communication, the *Outline* proposed specific measures for the implementation of four foundational projects: a scientific education and training project; a science popularization resource exploitation and sharing project; a mass media S&T communication capacity-building project; and a science popularization infrastructure project.

Although the improvement in citizens' scientific literacy is 'the long-term mission of the state and the common task of the whole society' (Hu Jintao 2008), the current development of scientific literacy should centre on the most significant issue—the realization of Chinese sustainable development.

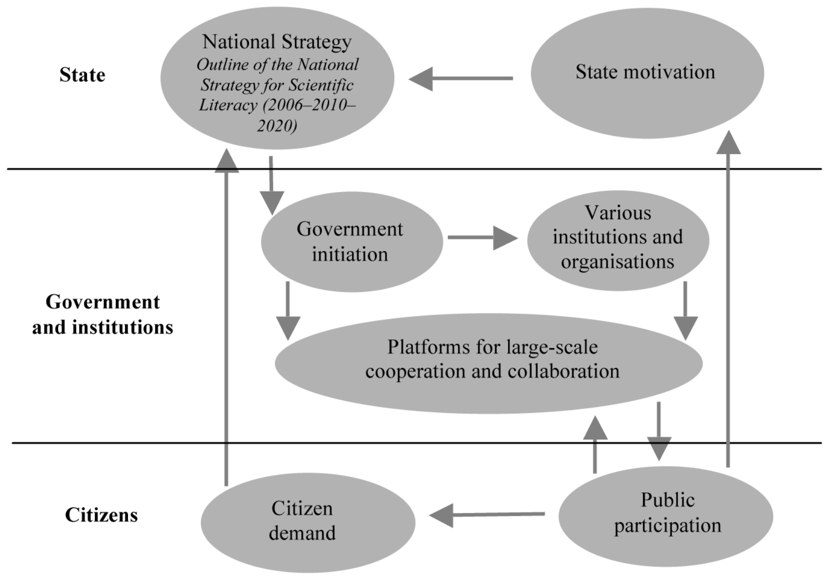
Taking the improvement of farmers' scientific literacy as an example, the *Outline* explicitly proposed orienting farmers to a scientific outlook on development. It stated that education and communication programmes and activities should emphasize ecological and environmental protection, the conservation of water resources, the protection of cultivated land, disaster prevention and reduction, and advocacy in health and hygiene. It called for opposition to superstition and outmoded conventions in order to promote the construction of a new socialist countryside.

Strategy and mobilization mechanism to implement the *Outline*

Figure 5.4 sets out the implementation model for Chinese science communication development, including drivers, objectives and supports.

The *Outline's* implementation is demand-oriented, including to state demand and citizen demand.

Fig. 5.4. Implementation model of the *Outline of the National Scheme for Scientific Literacy*



Source: Adapted from Cheng & Yin (2012).

At the state and government levels, the improvement of the citizens' scientific literacy is in the overall interests of the state. It relies on the quality of the workforce to transform China's economic growth model from one driven by natural resources and investment to one driven by innovation. It needs to narrow the scientific literacy gap between people of different cultural backgrounds and professions to realize its plans for urban and rural development, as well as for the development of different regions. It also needs to enhance the scientific literacy of the citizens to strengthen China's competitiveness in S&T.

At the level of individual citizens, people want better scientific literacy to achieve all-round personal development. They are motivated by the needs of daily life, and want to learn new skills and techniques to earn career promotions. Scientific literacy is a prerequisite for being an actor in public affairs and for expressing opinions on social issues related to S&T.

In response to demand at all three levels, scientific literacy for all is now one of China's national development goals.

The mobilization mechanism of the *Outline* is 'Government boosts and people participate'. All levels of government are responsible for ensuring that the national strategy is implemented. At the state level, under the leadership of the State Council, 33 ministries and other agencies, academies and non-government organizations are coordinated by the government to implement the four action plans and four foundational projects. Local governments are in charge of the local implementation of the *Outline*, formulating matching policy, raising the budget and staffing.

The platform for social involvement in science communication and popularization activities plays a supporting role in mobilization. With the encouragement of the government and the full cooperation of various social organizations, science popularization platforms create favourable conditions for public participation.

The Science Popularization Infrastructure Project

Among the four foundational projects defined in the *Outline*, the Science Popularization Infrastructure Project is the key to implementation. It aims to overcome two main problems: the inadequacy of resources in science popularization facilities and the failure to meet public demand for scientific literacy. The project has three objectives:

- Consolidate the science popularization and education functions of existing infrastructure; renovate existing science popularization facilities; enrich the content; improve services; integrate and use related social resources; and develop the S&T education base for adolescents.
- Use research and advocacy to raise funds through multiple channels to establish a number of S&T museums, such as science museums, and natural history museums (at least one large or medium-sized science museum in each provincial capital city, and a dedicated S&T museum in every large city with population of more than 1 million).
- Develop science popularization facilities at the grass-roots, including science popularization activity rooms and galleries; use internet connections for remote science popularization and education in urban and rural communities; provide science wagons and mobile science museums for communities and schools, especially in poverty-stricken and remote areas.

It is evident that the Science Popularization Infrastructure Project and the development of a science museum system with Chinese characteristics go hand in hand. The implementation of the *Outline* creates a positive policy context for the system, provides new development opportunities for science communication and puts forward new, achievable objectives.

5.3 A science museum system with Chinese characteristics

In the Chinese social context, the construction of a science museum system with Chinese characteristics is the basic strategy for current Chinese science popularization infrastructure development:

- Construct conventional science museums where conditions allow it.
- Provide science popularization services for local people using mobile science museums and science wagons (designed and built by national and provincial science museums and staffed through cooperation between local S&T associations, education authorities and the like).

- Develop digital science museum websites to provide experiential science museum services for netizens and to integrate science popularization resources to serve science popularization organizations at the grass-roots.

5.3.1 The social context shaping the system

The strongest social factors challenging Chinese science communication are the nation's relatively low level of education and scientific literacy, unbalanced regional development, and the rural–urban divide. Therefore, the priority is to provide the public with learning opportunities and environments.

Conventional science museums are quite popular among the public, especially the youth, and can play a unique role in science popularization. However, some central and western regions lack the financial and social resources to fund them.

By the end of 2013, the number of 'reach-the-standard' conventional science museums in China was only 102, or one per 13.2 million people (the global average is one per 3.5 million people). The 102 museums are unevenly distributed, as 60% of them are in big cities in eastern China.

In addition, the Survey of Civic Scientific Literacy in China showed that the distribution of science popularization infrastructure, resources and services between urban and rural areas is unbalanced. China's mobile science museums and science wagons are designed to redress those imbalances by providing services to people in economically underdeveloped regions. Supported by the Ministry of Finance, CAST develops science wagons and allots tasks to them. By 2014, the wagons had already had notable positive effects.

Besides the three limiting factors noted above, Chinese science communication also faces challenges brought by new media and information technology. Knowledge acquisition modes among the public, especially adolescents, change quickly and usually unpredictably. To adapt to such changes, Chinese science communicators also try to use digital technologies, including internet, mobile internet and multimedia technologies, to communicate science and provide educational science exhibition resources to various institutions. The China Digital Science and Technology Museum (CDSTM) was launched in December 2005 and soon became a platform for science popularization on the web. It combines the exhibition resources in science museums with information technologies, overcomes the time and space obstacles of real science museums, is open remotely and 24 hours a day, enables science popularization services to cover netizens and mobile phone users at any time and anywhere, and extends the service scope of science museums significantly.

5.3.2 Synergized service mechanisms: practical cases in Shandong Province and Yunnan Province

Operational service mechanisms

Because most science museums in China are sponsored by the government, the science museum system can synergize the operations of the museums by using strategic planning, management and coordination by government and CAST. This allows for the optimal allocation, co-development and sharing of science popularization resources and multiplies the social benefits of the museum system

The system has three layers of services (Qi et al. 2014):

- The *core* layer comprises the conventional science museums throughout the country, which develop, collect and distribute science popularization resources.
- The *unified-planning* layer includes mobile science museums, science wagons and digital science museums, which are developed, managed and maintained by local science museums.
- The *radiating* layer includes public science popularization facilities at the grass-roots level (rural middle school S&T halls, adolescent science studios, community science popularization activity stations and science popularization galleries) that are developed and managed by relevant organizations and provided with technical maintenance and resource update services by science museums. The radiating layer includes science popularization activities conducted by organizations and institutions other than CAST. Nearby science museums provide technical maintenance, exhibition or education project design, resource development, and activity sites.

For example, in Yunnan Province, science communication infrastructure development (of mobile science museums and science wagons), supported by CAST and the China Science and Technology Museum (CSTM), is based on the provincial science museum system. Three levels of the system operate: the national science museums; provincial and provincial capital science museums (or S&T associations); and city- or county-level S&T associations. The science museums at the top level provide radiating services for the science museums or S&T associations at lower levels, as well as the mobile science museums and science wagons. This structure branches like a tree.

Many science museums' science popularization services, such as science popularization drama and scientific mini-talkshows, have provided radiated services for public science popularization facilities and social institutions at the grass-roots in surrounding areas, so as to form a of grid services.

In this way, the science museum system in Yunnan uses explicit channels and distinct responsibilities for resource allocation and support services in a combined radiating and grid structure.

Resource-sharing mechanisms

The resources in the science museum system are sharable. Sharing experiences in developing exhibits can reduce operational costs, and sharing science popularisation resources, including exhibits, allows museums to keep up with demand, which varies over time and from place to place. The sharing system also includes digital assets and itinerant exhibitions.

The classic exhibits of CSTM have been reflected in exhibit designs for mobile science museums and science wagons. In addition, CDSTM content has often been used in the activities of mobile science museums and science wagons.

In Shandong Province, mobile science museums are researched and developed by the Shandong Science and Technology Association and Shandong Science Museum, which also handles the overall management. The exhibitions of Shandong's mobile science museums and science wagons all rely on the design and development of exhibitions at the conventional science museums. As well as offline exhibitions and resource-sharing, mobile science museums in Shandong have pioneered special internet experience zones, the virtual content of which comes from CDSTM and science popularization websites operated locally.

Management of the system

The coordination of China's science museum requires thorough, systematic arrangements, appropriation guarantees, organizational coordination and sound management. Coordination and management are extremely important, because the system is composed of diverse subject organizations and its structure and operation are complicated.

Scientific and effective system management allows science communication services, produced from limited resources, to be used to maximum effect. In a mobile science museum project piloted in Shandong Province, a special leading group based at Shandong Science Museum and established jointly by the Shandong Science and Technology Association and the provincial finance and education departments is responsible for organizing and leading the project. The group assigned responsibilities among S&T associations, finance agencies and education authorities at the province, city and county levels, convened a special working meeting of the city S&T association, and prepared thoroughly before inaugurating of the project. A training workshop was organized for exhibition counsellors and management personnel in nine cities on the content of the exhibition and its technical maintenance, improving the basic skills of local staff in charge of the operational management of the itinerant exhibition in their locations.

In Yunnan Province, Yunnan Science and Technology Museum always communicates in advance with the authorities in places where the mobile science museum will exhibit. The regional and city party committees and governments in the areas visited have all attached great importance to the project. Local governments and education authorities issue statements recommending that schools and government agencies at all levels support and cooperate with the project. They encourage students, civil servants and local residents to visit and participate in the mobile science museums' science communication activities.

Evaluation mechanism for the system

The public science communication services provided by China's science museum system have specific objectives. The system's behaviour and results must be evaluated regularly to ensure the system's effectiveness.

Current research is examining the evaluation and assessment of four components of the system. Both Shandong Province and Yunnan Province have assessed their mobile science museum projects.

However, I have noted several problems in assessments of the science museum system as it stands. First, current assessments are of single projects or subjects, not of the system as a whole; for example, there is as yet no overall evaluation mechanism for the national or regional science museum systems. Second, current evaluations and assessments are mostly service or performance assessments, and do not assess visitors' satisfaction: they should assess both, using integrated qualitative and quantitative methods.

5.4 Effect assessments of the Chinese science museum system

This section review the literature on effect assessments of the system and examines the results of empirical assessments.

5.4.1 Summarised literature review of effect assessments by scholars and institutions

In recent years, various research bodies have assessed the performance and impact of the conventional science museums, science wagons and mobile science museums, and the digital science museum.

From 2009 to 2014, the China Research Institute for Science Popularization (CRISP) published a series of annual assessments of the development of science popularization infrastructure in China as *Blue books for Chinese science popularization infrastructure development* (Ren & Li, various years). The Ministry of Finance, CAST and CSTM have also sponsored expert teams to research and assess the operational performance of the infrastructure.

Research on the conventional science museums has been the most extensive. In 2012, CAST sponsored the Nationwide Science Museum—Rational Layout research project, which was jointly conducted by the Institute of Science and

Technology Policy and Management Sciences of the Chinese Academy of Sciences and CSTM. The project surveyed 89 museums and analysed their spatial arrangements and service bottlenecks. This research revealed the following for 2011:

- The average number of visitors to the individual museums was 355,000.
- The museums received 23.2 visitors per square metre of floor area.
- China had one conventional science museum per 14 million people. The ratio in developed countries was one per 700,000 people; in developing countries, one per 12 million; globally, one per 3.5 million.

This means that China's conventional science museum infrastructure is equivalent to one-quarter of the global average and one-twentieth of the average for developed countries.

The research concluded that, in general, science museum construction was at a 'favourable' level. However, construction in the central and western regions lagged behind, especially construction of medium-sized and small museums at the city level.

As part of its work on drafting implementation measures for a 'free opening' policy for science museums in 2012, CAST's Science Popularization Department investigated the fee-charging policies of museums nationwide.

Because science wagons are supported by government funding, their performance has been evaluated by the Ministry of Finance. An appraisal in 2009 showed that the wagons had brought to rural and remote residents some exciting exhibits that had previously been available only to urban residents. To some extent, this had mitigated the problem of the unbalanced distribution of science popularization resources.

As the project manager for Chinese mobile science museums, CSTM conducted a monographic study and assessment of the service performance of the project in 2013. The evaluation was based mainly on three indexes: social benefit, sustainable influence and visitors' satisfaction. The report indicates that the mobile science museum project played a big part in mitigating the shortage of science popularization exhibition resources in the central and western regions, promoted the sharing of resources, communicated scientific ideas, improved citizens' scientific literacy, and boosted the influence of the Chinese science museum system.

Based on the various assessments and research into the science museum system in recent years, we can say that China's strategy of developing a science museum system with Chinese characteristics is meeting the challenges of the social context in China and is responding to public demand. Its major functions and features are optimal allocation, synergistic interactions, a branching structure and layer-by-layer coverage, delivered by conventional science museums, mobile science museums, science wagons, digital science museums and various public science popularization facilities at the grass-root level to maximise impact and social benefits.

5.4.2 Empirical research on mobile science museums

Most evaluations of China's science museum system have been based on macroscopic perspectives and have lacked detail. There is little or no literature on evaluations from the perspective of mobile science museums' visitors and local administrators, perhaps because the mobile museums are the newest part of the system.

To remedy this shortcoming, a small research team was set up to study mobile science museums in 2014. After reviewing the literature, the team conducted field work (including questionnaire surveys and in-depth interviews of science communication workers and the general public) to empirically assess the operational performance the system from the perspective of workers and citizens.

Research method for effect evaluation

The research subjects were visitors to mobile science museums with the same types of exhibition content in the eastern and western regions of China in 2014. To ensure the comparability and representativeness of the samples, the researchers chose one county in Shandong Province and one in Yunnan Province.

The survey was conducted in Xintai City and Laiwu City, Shandong Province, from 25 to 28 November 2014, and in Lufeng County and Heqing County, Yunnan Province, from 15 to 18 January 2015. The researchers distributed 400 questionnaires; 336 were returned, of which 324 (81%) were valid. Four focus group meetings were held, and 16 people (museum visitors and workers) were interviewed in depth.

In the questionnaire survey, respondents were selected randomly. The designed sample size in each county was 50–80, giving a total designed sample size of200~320.

From the interviews of museum organizers, the researchers learned mainly about the current situation and problems in such areas as resource content, the integration of exhibition and education resources, operational management and finding appropriate staff.

From the interviews with visitors (typically adolescents and community residents), the researchers learned about visitors' science communication needs, the channels they routinely use to obtain S&T information, and their perceptions of the availability of public science communication services.

Evaluation results

The research made three major empirical findings.

First, the lack of conventional science museums is the main reason why respondents had not visited such museums. Among those who had not been to a conventional science museum, 68% said that the reason was that 'there is no science museum nearby'. People in the eastern region had more opportunities to visit conventional science museums than people in the western region. Asked whether their visit to the mobile science museum was the first time they had visited any science museum, 39% of respondents in Shandong Province and 52% in Yunnan Province answered affirmatively. From this result, we can see that popularization infrastructure such as mobile science museums plays an important role in the absence of conventional museums, such as in county-level cities, especially in the central and western regions of China.

Second, from the perspective of visitors to mobile science museums: 98% liked the exhibition, and 70% liked it very much

- 93% were satisfied with the service
- 99% would like to visit again
- 62.4% said that their visit allowed them to gain scientific knowledge
- 57.8% said that their visit had inspired their interest and curiosity
- 50.7% considered that they had experienced a scientific atmosphere
- 40.5% felt that they had strengthened their knowledge and understanding of scientific principles.

However, only 26% considered that their visit had helped them to understand the impact of science on their daily life.

Of the exhibits, those that were interactive were the most popular.

Third, the respondents identified three ways to improve the mobile science museums' exhibitions:

- Increase the frequency and duration of the exhibitions (over two-thirds hoped that they would be able to visit at least once per month).
- Make the exhibitions' content richer and more interesting.
- Increase the proportion of interactive items and the quantity of the multimedia equipment.

For content, most people expected to see thematic exhibitions in such fields as the life sciences, medicine, mechanical engineering, information science and food science.

From interviews with the mobile science museum organizers and some science teachers, the researchers found that running mobile science museums has some problems and challenges:

- The publicity for the service should be increased and should use additional media.
- Collaboration between museum organizers, education authorities and schools should be optimized.
- The routine maintenance of the museums should be improved (this type of exhibition makes maintenance more difficult)

5.5 Problems and challenges

In this section, I outline some challenges and some opportunities to overcome those challenges.

5.5.1 The challenge of using mobile internet developments to construct digital science museums

According to the 2013–2014 China Mobile Internet Survey research report (CINIC 2014), by June 2014 China had 527 million mobile phone netizens (who made up 83.4% of all netizens). The popularity of smartphones and the availability of mobile phone applications (apps) has led to much growth in this sector. According to the survey:

- 36.4% of mobile phone netizens surf the internet for more than 4 hours every day (up from 36.4% the previous year)
- 87.8% surf the internet at least once a day
- 66.1% surf the internet 'many' times a day.

Mobile internet services are deepening their penetration into China's social life, led by mobile banking and map apps (in the software industry's jargon, the apps have great 'stickiness'). These changes in the way citizens acquire information lead to qualitative changes in the social context of science communication and to new challenges for the Chinese science museum system.

In particular, there is a need to formulate a future science communication strategy for digital science museums that takes into account Chinese citizens' affinity for mobile internet services.

5.5.2 The challenge of meeting diversified public demand for museum content development

Currently, China's science museum system is unable to satisfy the diverse science popularization needs of the public; there are resource shortages, and much content is yet to be developed.

In general, the content of exhibitions in the conventional science museums in the various regions is almost identical: innovation is lacking.

Exhibition content is usually restricted to the communication of scientific and technological knowledge, and fails to reveal the relationships between science and society and between humans and nature, or the scientific spirit, thoughts and culture behind the exhibits and scientific principles.

Almost half of the museums do not conduct scientific education activities other than exhibitions, such as performances of science popularization plays, scientific experiments, hands-on demonstrations, interest groups and winter/summer camps.

The existing exhibition education method fails to fully reflect modern science education practices, such as inquiry-based learning. Over half of the museums have not established websites. Those that have use the websites mostly as information release platforms rather than science communication platforms. Even the science museums that have developed internet science popularization are mostly using sub-websites of the CDSTM.

In addition, content developers for mobile science museums and science wagons cannot meet the demand for grass-roots scientific knowledge.

To overcome these challenges, the content and presentation of basic scientific exhibits should be updated continuously. The system needs more and better thematic exhibitions, content based on experiencing the scientific process, and exhibitions on the application of high and new technology.

The following steps should be taken:

- Transform planning and design for science communication service content to produce more interactive exhibitions that easily enable the audience to be integrated into the activity.
- Introduce market mechanisms and mobilize social forces in the content development mechanism to develop innovative and vibrant content.

5.5.3 The gap between public science communication service coverage level and the public's urgent need

Since the launch of the *Outline of the National Scheme for Scientific Literacy* and the implementation of the Chinese Science Popularization Infrastructure Project, China's science museum system has remained embryonic. The coverage of public science communication services in China is still quite low compared with the average level of coverage in European countries. This has a lot to do with the imperfect development of the science museum system at this time.

The system requires:

- the development and proper layout of such 'hardware' as conventional science museums, mobile science museums, science wagons and digital science museums
- the development of such 'software' as science popularization exhibition education resources, operations, management, service capability and regulation.

The hardware and software supplement each other, as hardware boosts the software while the software drives the hardware. In one sense, in the development of the science museum system, software development is more important and difficult than hardware development.

We must develop the software to integrate formerly dispersed and isolated hardware into a uniform science museum system, so as to benefit from the unified planning, coordination, synergies and radiative structures described in Section 5.3.2 of this paper. In that process, the greatest challenges will be in transforming concepts, building awareness, overhauling administration, systems and mechanisms, and building capacity and human resources.

We can then complete the building of a world-class science museum system with Chinese characteristics. That system will improve our ability to produce and distribute excellent resources for science popularization, communication and education. It will also greatly improve our conventional science museums, strengthening their functional and radiating capacity, and so increase the coverage of China's public science communication services.

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Acknowledgement

I express my gratitude to the head and colleagues of CRISP and CSTM who supported and participated in the research project. Special appreciation goes to Liu Xuan, Yin Lin, Qi Xin, Shi Lei and Yang Xi, who provided their sincere help in writing this chapter.

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Based upon her experience in leading the development of the new China Science and Technology Museum, Dr Cheng is now leading CANSM, promoting the innovative development of science communication institutions (including science museums, natural history museums, planetariums, geological museums and wetland museums).

Dr Cheng has been actively involved in various international programmes. She is a member of the Scientific Committee of PCST, the international network on public communication of science and technology. She has been a member of the ad hoc Committee for Science Education of the International Council for Science. She has also been invited by UNESCO to regional and international science education conferences as a resource person in non-formal science education.

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6 Citizens in the scientific process

Marc Lipinski

In science, the beginning of the 21st century is marked by avalanches of data piling up in the memory banks of computers and scientists increasingly confronted with data too massive to be analysed with available forces and resources. Largely the result of the tremendously increased performance of laboratory equipment, this phenomenon is also due to a renewed engagement of non-professionals participating in the gathering and production of scientific observations using sensors, smartphone applications and other digital tools. In this paper, I show that actively engaged non-professional volunteers can usefully and efficiently complement professional work.

Striking results have been obtained through the online involvement of hundreds of thousands of people motivated by their interest in science or by a taste for competition in gamified citizen science projects. At a smaller scale and more local level, groups of people acting within civil society organizations can also engage in specific studies defined and conducted in close cooperation with professional scientists. The natural world, the environment and topics relating to health and disease are favourite fields for such projects.

In my view, cooperation between laypeople and researchers should be encouraged and better supported by institutions for the mutual benefit of all shareholders in society.

Starting this year, a network based on 100 digital cameras surveying the French sky will help scientists search for meteorites. The Fireball Recovery and InterPlanetary Observation Network, or FRIPON, is subsidized by the French Research Agency. Each year, around 15 big meteors enter the atmosphere above French territory as fireballs, but very few resulting meteorites are ever retrieved. The project's objective is to automatically detect most events, make calculations to predict the trajectories of the meteors and, consequently, the 'exact' location of ground impacts. Since it is crucial to recover the meteorites as quickly as possible, say within a week, the innovative idea is to pre-enrol thousands of amateurs throughout the country so that a few dozen can be readily dispatched to any place as soon as a specific location has been determined. FRIPON adds one more flower to the growing bouquet of science projects engaging volunteer citizens.[1]

[1] The word 'citizen' has different meanings in different contexts and different languages. In French, for example, 'citizen science' can be translated into 'science citoyenne' or 'science des citoyens', which, for some influential critics, carries a very deprecative meaning. 'Participative science' may sound better but says nothing about who participates. In addition, non-professionals who may be non-citizens can also participate. Discussing the issue, however, is beyond the scope of this paper. The expression 'citizen science' is now largely adopted by the scientific community, which uses English as its main communication language, and by most people who are interested in the interactions between amateurs and professionals in science. In fact, 'citizen science', which was recognized as early as 2005 by Wikipedia, has now entered the *Oxford English dictionary* with the following definition: 'The collection and analysis of data relating to

6.1 From amateurs to professionals

Citizen science projects capitalize on the desire and willingness of amateurs to freely provide time and effort to something that they consider worthwhile. Indeed, etymologically, an amateur is a person who *likes* something, and it is evident that the heavens were among the first 'objects' that early humans 'liked'. In astronomy, as in other scientific disciplines, a clear distinction between amateurs and professionals took a long time to emerge. In the 18th century, for example, German-born William Herschel, who made a living as a musician, practised astronomy as a demanding hobby. In England, he started building his own telescopes with the support of King George III, himself an amateur astronomer. Among many celestial objects, Herschel discovered a new solar planet later named Uranus.

However, for two main reasons, it proved more and more difficult to do serious astronomy as a pure amateur. The instruments became more sophisticated, and the craftsmanship necessary to build them, optimize their use, accumulate data and analyse the data required more and more brains and money. Without personal wealth or a sponsor of King George's calibre, doing astronomy or science in general progressively came to mean being employed by an organization, whether public or private, endowed with that very mission. Still, in many disciplines, progress has continued to heavily rely on the voluntary engagement of laypeople.

This is particularly true in the vast domain of the natural sciences. Dedicated museums and other institutions have accumulated their collections thanks to naturalists who explored the world, picking up specimens and having them delivered to their home countries. Who were they? For the most part, they were not scientists but explorers, adventurers, chasers of the unknown. Somewhat surprisingly, this still goes on. For example, the Paris-based Muséum National d'Histoire Naturelle continues to receive exotic specimens shipped from distant locations.

So what else is new? Is 'citizen science' just a new term for something that has been going on ever since observations started and experimental procedures were defined and developed into what is now known as the scientific approach? Alternatively, are we witnesses to a real change in paradigm, in the way science can be done? When we talk of citizen or participative sciences, are we just tossing around more words soon to be replaced by others with another passing wave? Or are there objective reasons for a real evolution to take place in science, as in so many other domains of our developed societies, in this 21st century?

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the natural world by members of the general public, typically as part of a collaborative project with professional scientists.' Thus, the main notions underscored are the collaborative nature of the project and the participation of non-professionals. As to whether citizen science projects will be, or are, restricted to the 'natural world', the question is moot.

6.2 Crowd power

In 2011, Michael Nielsen, an Australian scientist, writer and programmer, published a remarkable book, *Reinventing discovery* (Nielsen 2011), which one reviewer regarded as 'the most compelling manifesto yet for the transformative power of networked science' (Wilsdon 2011). In his book, Nielsen enthusiastically emphasized how motivated individuals with no extraordinary expertise but acting in a cooperative mode are able to raise their collective accomplishments, such as when a group of chess players could compete successfully with grand master Gary Kasparov. If so, why not apply this kind of cooperative approach to scientific research? The book was a 'thought-provoking call to arms' to many, including Chris Lintott, now a professor of astrophysics at Oxford University, who with his colleague, Kevin Schavinsky, had co-founded the Galaxy Zoo project in 2007. With FoldIt (described further below), Galaxy Zoo provided evidence that thousands of lay participants connecting from around the world to a dedicated web portal could rapidly accomplish organized tasks of great scientific interest and successfully contribute to the advancement of knowledge.

Lintott and Schavinsky's original idea stemmed from a constraint: the time limitation encountered for a research project in which galaxies in a million or so photographs had to be examined and classified on the basis of both their size and their colour.[2] The work was arduous, because the galaxies had to be looked at one at a time. The two colleagues imagined a website where anyone could look at the photographs and answer simple queries on the galaxies in a questionnaire. When the site was launched, it was hoped that 20,000 to 30,000 people would eventually participate, but in less than half a year more than 100,000 amateurs had connected to the website and together contributed more than 40 million galaxy classifications! In other words, each galaxy had been classified 38 times on average, resulting in high levels of confidence in consensus descriptions.

Lintott and Schavinsky had clearly hoped for success, but certainly not such a stunning one. The number of the participating amateurs' questions, commentaries and original observations was even more stunning. There was a need for participants to share observations and ideas (the veterans training the beginners), and for scientists to oversee what was going on among the crowd, so a forum was created on the website.

Very soon after the project was launched, a Dutch schoolteacher, Hanny Van Arkel, observed a small greenish-looking object that attracted her attention. On the forum, she posted 'Give peas a chance', a pun on John Lennon's famous lyric, 'Give peace a chance'. It was not just a joke, though: within weeks, more 'green peas' were observed. More than 250 of these 'new' galaxies have now been identified by the amateurs and characterized by the professionals as having 'some of the highest specific star formation rates seen in the local universe' (Cardamone et al. 2009).

This had to stimulate some serious thinking. For Chris Lintott, crowdsourcing

[2] The photographs had been taken through a telescope as part of the Sloan Digital Sky Survey (www.sdss.org, accessed 15 February 2015).

could obviously be used to accelerate the pace of knowledge creation not only in astronomy but probably in many other scientific disciplines. Rather than initiating a second and then a third project, each time starting from scratch to create a new website, assemble a dedicated community and so on, why not develop a digital platform that could be used for a variety of citizen science projects? As a rule, the projects should have a clear scientific goal requiring repetitive tasks that an army of volunteers would accomplish better than a robot, as the human brain is still much more clever at recognizing patterns than the best image analysis software. Also, this would yield results much quicker (and cheaper!) than working only with students and staff scientists.

When the Zooniverse platform[3] appeared on the net at the end of 2009, potential volunteers could read that they had the expertise and the power to help scientists do complicated tasks and to reach goals that would be unattainable without them. All in all, over a million people have now registered as Zooniverse volunteers, and their participation has resulted in more than 100 published scientific reports.[4] Hardly two months after its launch, the platform presented its first project outside the astrophysical domain. Five years later, even if space exploration remains important among the 27 projects on the website's home page, it is now outnumbered by proposals in other domains, mostly in natural sciences but also in climate studies, the humanities, physics and biology. That diversity should continue to increase in the zoo, as the platform is about to evolve with a selection process better adapted to projects more limited, if not in ambition then at least in size: they should not require huge numbers of participants to succeed.[5]

[3] The Zooniverse platform (www.zooniverse.org) was set up by the Citizen Science Alliance: 'a collaboration of scientists, software developers and educators who collectively develop, manage and utilise *internet-based citizen science projects* in order to further science itself, and the public understanding of both science and of the scientific process. These projects use the time, abilities and energies of a *distributed community* of citizen scientists who are our collaborators.' See www.citizensciencealliance.org (accessed 22 February 2015).

[4] The latest one at the time I write (February 2015) stems from another unexpected observation made by the Zooniverse 'classifiers', as they like to call themselves. In the Milky Way project (www.milkywayproject.org, accessed 22 February 2015), the images offered for analysis have been taken by the NASA Spitzer spatial telescope, which operates in the infrared. Among billions of stars revealed in these beautiful photographs, some amateurs picked up a new kind of object that they termed 'yellow ball', yellow being a color artificially assigned in the images. As with the green peas in the Galaxy Zoo project, professionals paid attention when more yellow balls were reported. Almost 1,000 have now been spotted. They are believed to be a hitherto missing link 'between the very young embryonic stars buried in dark filaments and newborn stars blowing the bubbles' says Grace Wolf-Chase of the Adler Planetarium in Chicago (www.jpl.nasa.gov/news/news.php?feature=4462 accessed 22 February 2015).

[5] Another interesting platform worth a visit is at www.citsci.org. This totally open platform has been specifically designed to be usable by a diversity of citizen science project initiators.

6.3 Science by game

These few examples are representative of one of the trends evident in citizen science: volunteers are called on for help by scientists whose overabundant data cannot be analysed efficiently by the available staff, with the available money, or both. However, there is no rule that people should participate in citizen science projects only for the sake of science. Some people's motivation lies more in playing exciting games—an alternative orientation first exploited by the FoldIt project.[6] Launched at the University of Washington in Seattle at the same time as Galaxy Zoo in Oxford, this biology project got started when Zoran Popovic, a computer scientist with an inclination towards educational games, joined forces with biochemist David Baker and others to create a game in which players would compete online to determine the best possible three-dimensional structure for a given protein, in this case one encoded by a virus in the HIV family. In the game, the better the folding, the higher the score. For researchers who had failed at the task despite their sophisticated tools and recognized expertise, this was a bold move, but 'People exert large amounts of problem-solving effort playing computer games', as underlined in a *Nature* article relating the first FoldIt success (Cooper et al. 2010). Indeed, thanks to the stunning capacity of some of the best videogame players, a convincing prediction was obtained for the structure of the protein. Later on, analysing how the different players had ended up with the same folding, scientists identified two distinct strategies that the players had used and then introduced those strategies into their own protein folding tools to improve future predictions.

Some participants in the EyeWire project[7] obviously share a keen taste for competition with FoldIt players. EyeWire was launched in December 2013 by Jinseop Kim and colleagues, whose objective is to understand how motion is detected in the retina—a classic unresolved problem in visual neuroscience. The challenge is to reconstruct the intricate 3D network of neuronal cells in a mouse retina. As the researchers noted in their *Nature* article (Kim et al. 2014):

> For this activity we hired and trained a small number of workers in the laboratory and also transformed work into play by mobilizing volunteers through EyeWire, a website that turns 3D reconstruction of neurons into a game of coloring serial electron microscopy images. Through EyeWire, we wanted to enable anyone, anywhere, to participate in our research. The approach is potentially scalable to extremely large numbers of citizen scientists.

Thus, by February 2015, 175,000 players from 165 countries had entered the game, most of them recruited within days of a 'major media event'.[8] In EyeWire, the training period for players to become really efficient proved longer than in

[6] http://fold.it/portal/

[7] www.eyewire.org (accessed 20 February 2015).

[8] Most of the time, a 'major event' is a new report appearing on social media or in the EyeWire blog, rather than an article in the *New York Times*, according to Amy Robinson, one of the authors in the *Nature* paper and a keynote speaker at the International Conference on Citizen Science, San José, California, February 2015.

other citizen science projects, but then the consensus reconstructions attained by Eyewirers proved particularly accurate, again underlining the power of crowds. In this case, the competition was stimulated from the scientists' side but then rapidly turned into challenges raised by players within the 'FTW' ('for the win') community, where prestige is strictly related to performance—that is, number of neurons totally reconstructed in a given period (sometimes 24 hours of continuous gaming!). As a result, the 100 top players contributed almost half of all the neurons reconstructed. In any case, competition and challenges appear to be essential to sustain participation, along with the quality of the design for the website. To ensure that volunteers come back again and again, graphic designers have to make the site 'both pretty and functional'.[9]

Is continuous innovation necessary for citizen science projects to reach an audience and succeed? EteRNA[10] is another fairly recent game-based scientific challenge. Imagined by Rhiju Das and Adrien Treuille, two of the younger scientists in the initial FoldIt project, EteRNA aims at predicting the structure of ribonucleic acids (RNAs).[11] Compared to FoldIt or EyeWire, EteRNA presents with an innovative offer: the plausibility of players' predictions is assessed by the other players. A 'democratic' online vote then decides which structures should be tested experimentally by biochemists at Stanford University in California. To provide players with an initial 'training' phase for the game, RNA sequences were proposed whose structures had previously been determined experimentally. Some players made 'predictions' that perfectly matched the known structures. Subsequently, qualified players were challenged with new, uncharacterized RNA sequences. In this second phase of the game, the best players proved consistently more efficient at predicting 2D structures than the reference algorithms used by the scientists. Examining the tricks the contributors had discovered while playing, the scientists could introduce new rules into their own algorithms, resulting in more efficiency in structure prediction for new RNAs (Lee et al. 2014).

[9] Amy Robinson, keynote speaker, International Conference on Citizen Science, San José, California, February 2015.

[10] http://eterna.cmu.edu/web/.

[11] In a given cell, messenger RNAs are the intermediate molecules between the coding gene localized on a specific chromosome in the cell nucleus and the protein to be synthesized outside the nucleus. Right after their synthesis, RNAs and proteins fold to adopt complex structures of the utmost functional importance. However, whereas proteins are assembled linearly with a combination of 20 different basic units (amino acids), each with its own properties, RNAs consist of only four different elements, the sequence of which, three at a time, defines which amino acids will be incorporated in turn in the protein during assembly. Despite limitations, as in the case of the HIV-related protein, the algorithms developed by the scientific community are reasonably efficient at predicting the 3D structure of a protein but much less so for the essentially flat RNA molecules. Conversely, RNAs are more amenable to *in vitro* synthesis than proteins, which allows scientists to test experimentally, in the laboratory, whether a 2D structure predicted for a given RNA will prove correct.

6.4 For whose benefit?

Let us now ask whether the deals made between the professional scientists and the amateurs are, if not balanced, at least mutually advantageous. On the academic side, satisfaction clearly prevails. At a recent conference on citizen science attended by 650 people from many different countries,[12] it was repeatedly stated that the inputs provided by volunteers are generally valid and trustworthy. Importantly, beginners are always ‘tested’ through simulated challenges that are set up specifically to detect—and rule out—inadequate contributions and contributors.

One possible risk would be that participants are merely used as unpaid labourers. Understandably, it is more difficult to know the feelings of the hundreds of thousands of citizens who have participated in one or another citizen-science project so far, but as science develops on the very topic of citizen science, useful information begins to emerge.

Aside from online players whose main motivation might be simply to play the game, it is usually the scientific project that is the main trigger for voluntary participation. Citizen scientists *like* science. They feel that they can be useful in something of general interest: the hours they spend are really worth it. In this respect, they truly behave as citizens. They enjoy contributing, the more so when the project initiators are able to assemble a crowd of isolated volunteers into a real community, regularly fed with news and results. Communication from the scientist side towards the citizens is therefore crucial (Twitter and Facebook are apparently the best suited tools). But discussions must also be facilitated within the community of volunteers with minimal interference from the scientists. Each project has to include a dedicated forum, and conversations and knowledge transmission between amateurs—whether they are experienced or just beginners—in that forum can be extremely lively.

Obviously, volunteers must be publicly recognized for their accomplishments. In the articles relating the outcome of the research that they have participated in, they can be acknowledged as a group, and some may even be listed individually as authors along with the professionals if their contribution has been particularly important.

Whether gamified or not, all the projects mentioned so far originated in the minds of professionals who realized that, thanks to the internet and social media and with digital tools now readily available to virtually everybody, amateurs could be engaged efficiently to boost the pace of their research. As summarized on the home page of the Zooniverse platform: ‘We make citizen science websites so that everyone can be part of real research online’. In a way, however, this merely constitutes a continuation of century-long practices being renewed and transformed through the recent emergence of powerful information and communication technologies. Still, citing the young Bob Dylan, ‘the times, they are a-changin’’, and citizen science can be and is much more than that.

[12] International Citizen Science Conference, San José, California, 11–12 February 2015 (http://citizenscienceassociation.org/conference/citizen-science-2015).

Other projects are more oriented towards needs or desires expressed by motivated groups of people asking professional scientists to join them to undertake targeted research. This should not come as a surprise, considering the expanding reservoir of highly educated people with a major interest in health, the natural world or environmental matters. As more people retire, more leisure time will be dedicated to this particular kind of scientific activity.

There are various ways whereby people can engage in scientific projects at the local or regional level. Acting as part of a group, a civil society organization (*association* in French) or a non-government organization, not only can they use their own senses and brainpower or capture data through low-cost technological sensors or using smartphone apps, but they can also initiate projects with a scientific content. Automatically located through the GPS function of their smartphone, their observations and captures are transmitted to centralized repositories.

For example, with members in France and elsewhere, Tela Botanica[13] is a very large network of French-speaking non-professional botanists. It gathers and diffuses observations on the plant world, but also develops its own scientific projects, often in local or regional cooperation with professional scientists from such institutions as the Centre National de la Recherche Scientifique. At the Muséum National d'Histoire Naturelle, another major French research organization dedicated to the study of fauna and flora, a large emphasis is placed on participative research, for example through existing Vigie-Nature, Vigie-Mer and Vigie-Ciel programmes now included in an even wider enterprise.[14]

The health sector is another in which close cooperation between academics and groups of patients has led to scientific results of local or global importance. As early as the 1960s in the United States, environmental health sciences had already been recognized as a major field for investigations by the creation of a dedicated institute within the National Institutes of Health,[15] but relationships between the academic sector and non-professionals took a totally new path when the AIDS epidemic erupted in the early 1980s, sparking a revolution of sorts. Activist groups exerted extreme pressure to convince scientists to reorient (part of) their research. The retrovirology field, once virtually abandoned, was repopulated. This resulted in, if not sufficiently rapid progress, at least relatively rapid progress for people with HIV.[16]

Fights against environmental hazards, usually more geographically localized, are also often led by civil society organizations. Pollution is a common reason for scientific questioning and investigations initiated by those who are most affected—the local inhabitants:

- A well-documented case that required important health studies occurred in the

[13] www.tela-botanica.org

[14] 65 Millions d'Observateurs, a vast program coordinated by Romain Julliard, professor at the museum and recently selected for support by the national Programme Investissements d'Avenir.

[15] The mission of the National Institute of Environmental Health Sciences (www.niehs.nih.gov) is to discover how the environment affects people, with the aim of promoting healthier lives.

[16] In France, the 'mission associations' created within the National Institute of Health and Medical Research (Inserm) provides a direct link between scientists and patients' associations (www.inserm.fr/associations-de-malades/mission-associations).

late 1970s and early 1980s around Love Canal in New York state, where hundreds of houses had been built on top of a toxic dump. This was the starting point for a long-lasting movement for environmental justice, as the website of the Boston University School of Public Health reminds us.[17]
- In 1986, the Chernobyl nuclear disaster in Ukraine spread radioactive material throughout Europe. In France, the total lack of scientific transparency about the very existence of the contaminants and the possible consequences triggered the creation of Criirad,[18] an independent association of volunteers that continues to perform studies and analyses on radioactivity.
- In 2010, the explosion of a BP platform in the Gulf of Mexico was the subject of an information blackout on both the subsequent oil spill and its likely effects on local residents. This was one reason for the creation of Public Lab, a non-profit laboratory for open science and technology that aims to provide local communities with scientific tools and techniques to participate in decision-making, especially when they are confronted with environmental hazards.[19]

6.5 Further support for citizen science

Not surprisingly, local citizens' groups often feel a need for scientific expertise to carry out their mission and reach their goals, and they seek it out. In France, access to such expertise remains difficult, however, despite noteworthy initiatives such as the recent opening of a science shop inside Université de Lyon[20] in connection with the European Living Knowledge network,[21] which has grown from an initial example set up by the Dutch.[22] This was one reason that I created a programme called Picri (Partnerships between Institutions and Citizens for Science and Innovation).[23]

With this regional instrument, three-year subsidies can be granted to scientific projects co-created and developed in close cooperation between civil society organizations and professional scientists. Every year since 2005, an average of 10 such projects have been selected by the Regional Council of Île-de-France. Similar initiatives have been taken in other French regions. At the national level, however, Picri-type projects are not favoured and are sometimes even derided as 'not science'

[17] www.bu.edu/love canal/ accessed 22 February 2015.

[18] www.criirad.org.

[19] Many different do-it-yourself projects involving citizen communities (referred to as 'civic science', rather than 'citizen science') are now made possible with the support of hardware and software produced by Public Lab (http://www.publiclab.org/wiki/stories).

[20] www.universite-lyon.fr/sciences-societe/boutique-des-sciences-239852.kjsp.

[21] www.livingknowledge.org/livingknowledge/.

[22] The science shops movement started in Gröningen in the Netherlands in the late 1970s and has since spread throughout Europe and beyond (for an introduction, see, for example, http://en.wikipedia.org/wiki/Science_shop).

[23] The Picri program was started in 2005 when I was the elected Vice-President in charge of Higher Education, Science and Innovation in Région Île-de-France (the greater Paris area).

or, worse, 'anti-science'. The rare but influential criticisms are propagated by opponents of any scientific endeavour that takes place outside the ivory tower, the only place where, according to the critics, 'science tells the truth'. The idea that amateurs can usefully participate in the creation of knowledge and at the same time further their own education seems to be totally unknown to the vast majority of institutional and political leaders in charge of (higher) education and science in France; nor does the current Head of the Centre National de la Recherche Scientifique, France's most important national scientific organization, appear to believe it.[24] Such resistance and lack of vision are in sharp contrast to the support and advocacy elsewhere, for example within the European Commission[25] and in other countries. That includes the United States, where citizen scientists are not only sought out and encouraged at all levels but recognized for their contributions, including in the White House, where President Barack Obama has hailed them as 'champions of change' and 'makers, builders and doers'.[26]

In this article, I have stated my conviction that innovative modes of cooperation between individual amateurs, civil society organizations and professional researchers are important not only for the creation and dissemination of new knowledge but to stimulate and improve scientific culture and practices more widely. Using a number of successful projects of scientific and general interest, I have shown why and how the involvement of citizens in science should be supported at all institutional levels. In this way, results can be expected to be mutually beneficial for science advancement, citizen empowerment and further progress in our societies of the 21st century.

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[24] Given the task of investigating 'Science and citizens' by the President of CNRS at the beginning of 2013, I wrote a report in February 2014, the proposals in which have been neither discussed nor publicly communicated.

[25] For example, in Socientize Project (2014), which was delivered to the European Commission's Digital Science Unit.

[26] See www.whitehouse.gov/champions and www.whitehouse.gov/nation-of-makers.

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7 Public understanding of science and social studies of science: convergence or parallel paths?

Pablo Kreimer

Despite their relative semantic proximity, the fields of public understanding of science (PUS) and social studies of science (SSS) / science and technology studies or science, technology and society (both STS)[1] appear to acknowledge their origins in different traditions, types of practice and trajectories. My purpose in this paper is to examine recent developments in both fields, observing the way they have been shaped in varying contexts and attempting to establish the extent to which they are converging towards a unified space of theory and practice, or whether each one operates relatively independently from the other. With this in mind, I provide a brief summary of the emergence of these fields in Europe, the United States and Latin America in order to identify the modulations characteristic of each context. I then go on to discuss the role played by PUS studies at two types of congress: the European Association for Social Studies of Science and Technology (EASST) and the Latin American Society for Social Studies of Science and Technology (ESOCITE). Finally, I present a number of conclusions.

7.1 The emergence of STS in the United States, Europe and Latin America: three contexts, three modulations

7.1.1 1940s–1950s United States: functionalism and the protection of science

As is commonly accepted, the works produced by the functionalist sociologist Robert Merton from the 1930s on marked the pivotal moment when science and technology (S&T) became an object of study for the social sciences. *Science, technology and society in seventeenth century England*, published in 1938, even supplied the title for this new field of study. Let us note in passing the innovation, at the time, of bringing together in the same title three conceptual orders (science, technology, society) that had hitherto appeared to belong to quite distinct epistemic spaces.

Merton's subsequent works were more geared towards studying the scientific

[1] I use the initialisms SSS (social studies of science) and STS (science and technology studies or science, technology and society) interchangeably. The differences between these terms are not relevant for the purposes of this paper. For a discussion of this matter, see Cutcliffe (2000), Sismondo (2008) and others.

community and, in particular, to proposing the (now well-known) rules that govern it, in addition to certain mechanisms of knowledge accumulation and exchange among its members. Essentially, Merton's fundamental principles can be condensed into three: autonomy, accumulation and self-regulation. Autonomy was understood at the time in a dual sense: on the one hand, it was postulated that the historical development of science had achieved a particular kind of autonomy (as a sort of social subsystem), allowing free exchanges among its practitioners. On the other hand, science not only *was* inherently autonomous but also *had* to be, because any intervention by forces extraneous to it posed the gravest risk: that of not being able to generate true knowledge.

The consequence of autonomy thus leads to the following two dimensions—accumulation and regulation. Accumulation, which is the result of the free work of scientists, who by applying standards such as universalism, communism, disinterestedness and organized scepticism are wont to accumulate certified knowledge. Self-regulation ensures that autonomy is put into practice through 'democratic' forms that contribute to the functionality of science as a system and, therefore, to generating knowledge to be made available to society at large.

Let us now put things into context. One of Merton's most emblematic papers ('Science and technology in a democratic order') was published in 1942, in the middle of World War II, at a time when hundreds of European scientists and intellectuals were arriving to take refuge in the United States. Against that backdrop, Merton and his disciples had in full view the consequences of two—sadly famous—processes with extremely grave consequences. On the one hand, the Nazi regime declared that there was an experimental and 'pure' Aryan science, typical of the Germanic tradition, pitted against a speculative, theoretical, 'Jewish' science. In the Soviet Union, on the other hand, the Lysenko affair and the declaration of a distinct agricultural science, in which cultivation factors and other dimensions might affect the genetic quality of crops, was seen as the application of dialectical materialism to science and therefore involved renouncing Mendelian genetics, which was banned in 1938 after the Moscow purge trials.

Given this scenario, it is understandable that social studies of science should at the time have sprung from the aim of protecting science from such attacks and that the proclamation of autonomy was meant to operate as a brake on totalitarian interventions in a 'free' space.

The functionalist analytical framework operated in practice as the dominant paradigm in studies on STS until well into the 1970s, when some of its principles were challenged and a number of groups more closely aligned with constructivist perspectives simultaneously began to emerge.

7.1.2 1970s Europe: constructivism and the questioning of science as a 'place of truth'

The situation in Europe in the late 1960s and 1970s was very different from the one I have described during the previous decades in the United States. A number of elements came together to question the role of science as the only form of legitimate knowledge and, furthermore, as 'state knowledge', as had largely been established since the so-called 'scientific revolution' of the 17th century, led by Newton (Salomon 2006). This was part of the reigning sense of 'unease', shared by contemporary movements in Europe and the United States (usually referred to as 'anti-science' movements), about the close association between capitalist development and the intensive use of scientific knowledge, which gave rise to a development model that was regarded as having numerous perverse effects.[2] The 'optimistic equation', according to which the greater the scientific and technological development, the greater the wellbeing of society, was thus called into question. Instead, there was a growing perception of the unwanted effects of S&T development, among which the most obvious were unemployment and environmental degradation. It was also observed that, contrary to what had hitherto been maintained, science was not equipped to solve the problems that it had itself created, and thus there was a certain irreversibility about the course of events.

Within this context, in the early 1970s, the so-called 'sociology of scientific knowledge', whose origins were constructivist and relativistic, began to question the role of science as the only source of legitimacy in public decision-making. Based on a questioning of the concept of autonomy, it proposed that, far from being something 'pure', scientific knowledge was strongly impregnated with—and even determined by—values, beliefs, interests and conflicts. Indeed, the authors of the constructivist programme (Bloor, Barnes, Collins, Latour, Callon, Knorr-Cetina, Lynch, Edge, and so on) proposed the need to get rid of the idea of a 'black box' from which scientific knowledge is somehow produced, and study scientific activity systematically from the perspective of the social sciences, giving it the status of collective beliefs, without an epistemological status that differed from that of other social beliefs. Thus, it was argued, knowledge that is accepted as true undergoes an arduous process of production resulting from struggles, negotiations, representations and so on and so forth.

Several years after the Nazi regime had been destroyed and the most radical form of Stalinism had been left behind, it was no longer, therefore, a question of 'protecting' science from possible threats, but of questioning it. This was done in order to warn of its risks and make decisions about its development more democratic by

[2] Dutch (2002) provides a good summary of the arguments that mobilized the anti-science movements in the 1960s and 1970s: 1) S&T are out of control; (2) S&T force workers into degrading and monotonous jobs; 3) Technology forces people to consume unnecessary goods and services; 4) S&T place decision-making in the hands of a technocratic elite; 5) S&T cut man off from the natural world; 6) S&T make man superficial; 7) Technology creates worse problems than it solves; 8) S&T restrict freedom; 9) The scientific worldview robs the world of mystery and beauty.

opening the borders of an enclosed space and extending debate to both experts and laypeople. In the words of Brian Martin (1993), 'the critique of science becomes academic', even if the very representatives of academia have sought to clearly differentiate themselves, as did Bloor (1976), who emphasized the *scientific* nature of his proposal, or Harry Collins (1990), who ignored movements such as 'Science for the People' as precedents in the critical perspective on science.

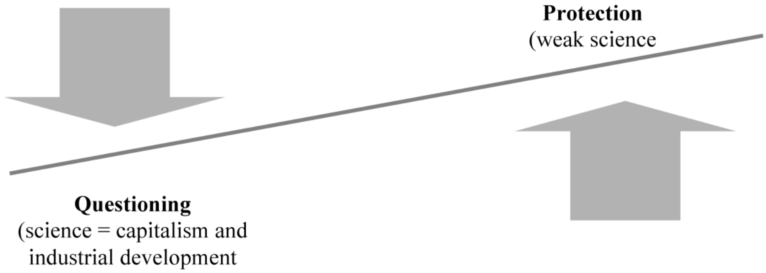
As in the United States, the field of STS in various European countries steadily became more professionalized in subsequent years through successive conceptual and methodological innovations and the establishment of research and training centres, discipline-specific associations, periodic meetings and so on.

7.1.3 Latin America: tensions of development

In Latin America, the issue of S&T began to feature on the public agenda in the postwar years but was given greater emphasis in the 1960s, when the question of development and the role that S&T should play in that process began to be systematically discussed. The United Nations' Economic Commission for Latin America and the Caribbean (ECLAC) questioned the 'single track development' model, exemplified in the stages proposed by Rostow (1960), pointing out that, far from being two separate stations on the same track, development and underdevelopment are interconnected and complementary processes. Within that perspective, various studies show that developed countries (those grouped in the OECD) are, at the same time, those that have invested the most resources in S&T. The question then arises of determining the root of the causality: Is it that these are rich countries and are therefore able to invest in S&T? Or are they, on the contrary, rich precisely because they have invested in S&T? This gives rise to a number of questions, which I shall discuss briefly under the following schema: 'questioning versus protection'; 'science for development versus science for revolution'; and 'radical positivist perspectives versus radical questioning perspectives' (Feld, forthcoming).

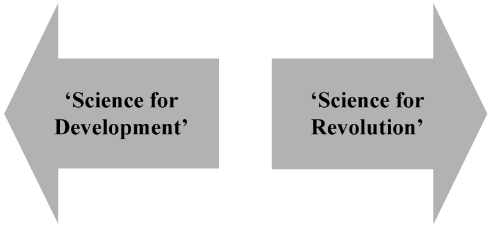
The first source of tension goes hand in hand with movements that, as they do in European countries, question the role of scientific development as being strongly associated with a type of knowledge-intensive industrial development, but that also follow a model typical of the central countries. It is thus postulated that there is a close correlation between 'one type' of S&T development and 'one type' of industrial capitalism. Conversely, other groups note that, unlike what happens in European countries and the United States, where science has accrued great strength and is therefore able to resist the questions raised about its development and its positive and negative consequences, science in Latin America is still very weak and, were it questioned according to similar parameters, what little there is might unravel. Figure 7.1 shows the schema.

Fig. 7.1. Tensions (I): Questioning versus protection



A second source of tension relates to the uses of science in terms of its social and economic role. Thus, in line with the models recommended by the OECD (Salomon 2001), certain sectors advocate the establishment of policies and instruments to promote scientific development (such as giving impetus to scientific fields that are less developed or even non-existent, or training human resources for research), and in particular to generate mechanisms for linking the realm of science and the industrial world (Sabato & Botana 1968). In contrast, other authors have argued that such policies would only serve to reproduce the type of science that prevails in the central countries, but this it is not a strategy adapted to the needs of Latin American societies. Instead, under the powerful influence exerted on broad groups of intellectuals and scientists by the Cuban revolution after 1959, they have proposed mobilizing science as part of a pathway towards a socialist revolution. The schema would run as shown in Figure 7.2.

Fig. 7.2. Tensions (II): Science for development versus science for revolution



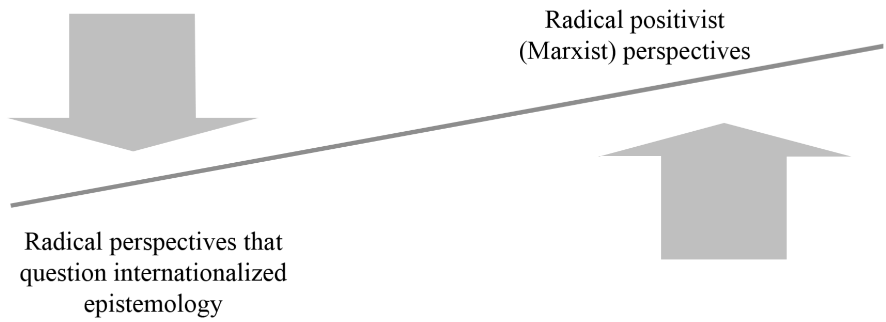
A third source of tensions, about the very conception of science, gradually emerged from among radicalized authors. In line with the traditional Marxist understanding, some approaches proposed an effective mobilization of science aimed at gearing it towards revolutionary objectives, but without interfering in its analyses, its methods or its theoretical conceptions, since, according to such approaches, there can be no ideological contamination or influence of any kind in the context of justification, although it is agreed to exist in the context of discovery or application (Klimovsky 1975).[3] In contrast, other authors pointed out that the questioning of

[3] According to Klimovsky (1975): 'I cannot find any ideological aspects that affect the

science should not be reduced to its role in relation to development, or to its positive or negative effects, but that it is the epistemological matrix itself that must be challenged. Authors such as Varsavsky (1969), who were writing before the emergence of the 'strong programme', had already pointed intuitively to the need to question 'the ways in which knowledge is produced', particularly industrialized forms of science (in OECD countries as well as in the Soviet bloc). He thus noted that the separation between 'contexts' in fact 'separates that which we wish to see together', and that ideological elements are inseparable from any development of knowledge.[4]

All of these tensions gradually crystallized over the subsequent years into a dual intellectual concern (Figure 7.3): on the one hand, the reflection on modes of public intervention into science, which veered between imitating the institutions and policy instruments of the most developed countries and the quest for home-grown policies; on the other hand, the analysis of the scientific relations between centres and peripheries, as the flipside of the 'diffusionist' models that, analogously to Rostow's stages of economic growth, proposed a series of stages in the spread of western science (Basalla 1967). These two schools of thought, along with the active (and sometimes acritical) reception of constructivism, were to mark the development of the field of STS in Latin America over the following decades.

Fig. 7.3. Tensions (III): Radical positivist perspectives versus radical questioning perspectives



7.2 The evolution of the public understanding of science: a brief overview

In 2009, Martin Bauer, the well-known editor of the *Public Understanding of Science* journal, published a text proposing a periodization of discursive development in the field of 'public understanding of science'. As we shall see, it appears to be no coincidence that it was published in *Science, Technology and Society*, a journal from the field of STS itself and which is also devoted to such studies in developing countries. Since Bauer's paper has so far been subject to no major objections,[5] I will use it as

objectivity of knowledge from the point of view of the context of justification'.

[4] For an in-depth analysis of this debate, see Feld (forthcoming), Chapter 3.

[5] It should be noted in passing that this text has been cited relatively infrequently: 65 citations

the basis for a brief overview of the development in this field. This will enable us to observe the parallels with the three contexts identified above in the field of STS.

Bauer proposes considering three broad periods, for which he identifies paradigms, main problems and strategies. The first paradigm, which predominated from the 1960s to the 1980s, focused on *science literacy*, and its discourses were based on the belief that the public has a knowledge deficit when it comes to scientific issues. The dominant research strategy was therefore that of the measurement of science literacy. According to Bauer (2009: 223):

> an influential concept of science literacy includes four elements: (a) knowledge of basic textbook facts of science, (b) an understanding of methods such as probability reasoning and experimental design, (c) an appreciation of the positive outcomes of science and technology for science, and (d) the rejection of superstitious beliefs such as astrology or numerology.

The second period emerged, in Bauer's view, in the latter half of the 1980s, when a new paradigm came to the fore, based on the concept of the *public understanding of science*, the starting point for which, as in the previous phase, was that of a public deficit. However, the emphasis in this new paradigm was on understanding *attitudes* to scientific knowledge, breaking down the assumption according to which greater knowledge will automatically be followed by more positive attitudes, which can be observed in particular in the treatment of controversial issues. Research problems were becoming more complex, because the lack or abundance of knowledge was no longer sufficient to explain the attitudes of the public. Instead, in order to provide an explanation for them it was necessary to resort to a variety of rhetorical tools.

The third period identified by Bauer is that of *science-in-and-of-society*, which has been unfolding since the 1990s. Here the paradigm is quite different: it is no longer a matter of a deficit but rather of a *loss of trust* among the audience in relation to S&T. Most of the activists within this paradigm are committed actors, who do not usually separate analysis from action. Since these forms of action often involve events (hearings, citizen juries, deliberative opinion polling, consensus conferencing, round tables, scoping exercises, science festivals and national debates), those responsible for organizing them assume the role of mediators ('angels' to use Bauer's term) between 'a disenchanted public and the institutions of science, industry and policy making'.

since 2009, according to Google Scholar Citations, which contrasts with the more than 600 citations of his text on 'Qualitative research', and even more sharply with the more than 2,500 citations for the same text in Portuguese.

7.3 A preliminary analysis of both fields

7.3.1 Intervention versus analysis

In Bauer's view, the field of 'public understanding of science' apparently tried to sit on the fence, since:

> … it is on the one hand a field of activity of outreach from science to the public. This includes traditional activities like lecturing, writing popular books and organising science museums, to making radio and television programmes, to more recent science centres, cafe scientifique [*sic*], and consensus conferences and deliberative forums on controversial matters. It seems that this field of activity has expanded considerably over the last 10 or more years, internationally. (Bauer 2009: 235)

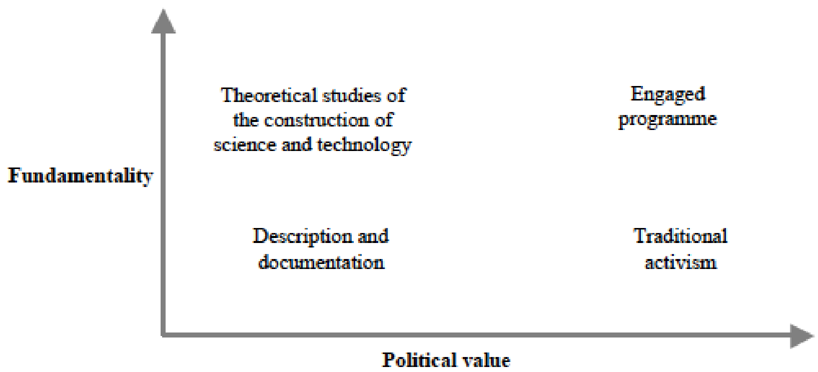
However, 'on the other hand, public understanding of science is a small field of social scientific research full of common sense speculations.' It may be that Bauer himself has tended to downplay the size of his own field; after all, he is the editor of one of the most important journals in that 'small field', which enjoys a relatively high status in terms of academic consideration, and whose influence extends beyond its own boundaries.

At first glance, this would seem to contrast with the field of STS, which is perceived as being more academically solid, somewhat more homogeneous, more firmly anchored to academic institutions and further away from activism. However, that is far from being the case: tensions between the committed nature of the field of STS and more academic postures have certainly existed for a number of decades. Steve Fuller (1993) labelled the two currents as a 'high church' (identified with more academically oriented studies, whether innate to or inherited from constructivism and part of university training programmes) and a 'low church' (composed of those who take a more committed stance that is not confined to intellectual critique but instead seeks active intervention, aimed at influencing the political and social world). According to Fuller, the former tends to be associated with the European tradition, which is more concerned with social causes than their consequences, while the latter is regarded as being more characteristic of the United States, where the emphasis is just the opposite. Although the distinction of interests is valid, I believe it makes no sense nowadays to associate them with particular regions.

In reference to the field of STS, Susan Cozzens, for her part, stated some years back that 'what actually goes on under this label is much broader than any academic endeavour. STS is not a discipline, field or area: it is a movement' (Cozzens 2001: 53). In Cozzens' view, there are two ways of looking at STS: either as 'STS, The Problem' or as 'STS, The Response'. Thus, 'everyone who is part of STS, The Response, is involved in both thought and action in relation to science and technology in society, although the mix between the two differs in different positions'.

Fuller's distinction between 'high' and 'low' churches was taken up by Sergio Sismondo (2008), but with the aim of proposing a framework resulting from the intersection of two variables that might provide the field with a degree of unity. The variables are *fundamentality* and *political value*, which produce the result shown in Figure 7.4.

Fig. 7.4. Fundamentality and political value



Source: Adapted from Sismondo (2008).

Here Sismondo outlines a scenario in which practitioners can move around within the two variables, from a lesser to a higher degree of academic content, and from a lower level of political commitment up to the 'Engaged programme' quadrant, where greater scientific rigour is accompanied by political values. This attempt at conceptualization and unification is extremely attractive, but difficult to verify in practice, where the actors belonging to each quadrant tend to display heterogeneities that rarely allow them to move within the same framework.

It should also be noted that this distribution according to the quadrants proposed by Sismondo is not neutral with respect to the location of groups and individuals at the international level. As suggested by various authors (Vessuri 1983, Kreimer 1998), conceptual output in different scientific fields—including the field of STS—tends to be concentrated among certain hegemonic groups, usually located in the central countries, while 'peripheral' groups are, to varying degrees, more likely to be 'appliers' of theoretical frameworks than producers of theory. The situation is different for the activism axis, since there are more engaged groups in the different contexts, although when it comes to questioning S&T, its objects are in constant tension between the local and the global, as exemplified by the case of the Landless Movement in Brazil and the questioning of GMOs (Pellegrini 2009).

As I have already pointed out, in Latin America the debates took their own course, which was heavily influenced in the 1960s by the implications and the symbolic power of the Cuban revolution across the whole of academia (Gilman 2003). However, with regard to the field of STS, colleagues and I (Kreimer et. al 2014) have noted that a shift in tensions took place from the initial concerns of the first generation, which were purely political, towards an academic institutionalization of the field in the 1980s, with an inverse relationship between the degree of intellectual rigour and political concerns: this was a new generation that institutionalized the academic components of the field by establishing institutions, journals and interacting collective bodies typical of a scientific field. However, this relationship, which gradually intensified from the beginning of the new century, has begun to reverse itself in recent years through a resurgence of various modes of intervention and engagement, as well as through attention being focused on the consequences—or absence thereof—of the knowledge that is produced, although this does not necessarily signify the abandonment of academic canons and structured scientific careers.

As we have pointed out, in this region the articulation of the field of STS is also permeated by a specific debate about the acritical application of conceptual frameworks and the adaptation—or not—of those frameworks (which circulate at the international level), in order to analyse—and/or intervene on—local objects of research (Dagnino 2011).

7.3.2 Consequences of the epistemic changes

It is safe to say that the 'broad constructivist avenue' has for several decades exerted a strong influence on the ways science is conceived from the viewpoint of the social sciences and, therefore, on the ways it is researched. Indeed, the process of demystifying science (for example, Latour & Woolgar 1979) implies that its status as place of truth cannot only be questioned (as a politicocognitive position) but above all can also be researched, both in regard to its construction processes (which include, de facto, various social, economic and cultural factors) and its various consequences on society. This conceptual shift affected the field of STS as well as PUS, although not at the same pace or at the same time.

Within the more academically oriented field of STS, the break with traditional models made possible two types of studies, *grosso modo*.[6] On the one hand, so-called laboratory studies (not limited, in fact, to laboratories in the strict sense), which enabled sociologists and anthropologists to penetrate the spaces where knowledge was produced, observe them as ordinary social spaces, and demonstrate that their purported objectivity, rationality and, above all, autonomy were idealizations that proved impossible to observe. In effect, the knowledge production processes did involve scientists, but also a multiplicity of other actors, whose participation was not merely incidental or marginal but rather indispensable to those processes (Knorr-Cetina 1981). On the other hand, studies on scientific controversies suggested that commonly accepted truths were not the reflection of rational procedures but instead of complex disputes, rhetorical mechanisms, the mobilization of interests of various kinds, and so on. They also showed that controversies were not settled exclusively by epistemic factors but instead that the participation of other actors was crucial to their resolution.

Moreover, if science does not consist of a 'closed package' but is instead the result of an active process of construction, then the so-called 'deficit model',

[6] It might be objected, quite justifiably, that this classification does not cover the new research that has been emerging since the 1970s. However, I offer it merely by way of example, as comprising two of the most common avenues of research.

characteristic of the various stages of PUS, is devoid of meaning: since there is no set of determined, complete, true and non-conflicting representations to transmit, the very idea of transmission (whether it is termed 'literacy' or 'mediation' matters little) becomes meaningless. New questions arise, then, that are no doubt more complex to resolve than the issues of an operative nature that characterized the preceding paradigms.

Those studies belong to the past; very few scientists now work on laboratory studies, following the assumption that the modes of knowledge production are already sufficiently well known and that there is little left to add.[7] However, the other issue, which permeates both fields, is even more interesting: although both the analytical and the committed perspective of the STS and PUS fields note that science is not something exclusive to scientists, they are led as a result to analyse the way other actors participate in these processes and observe the consequences, or else to recommend who should participate and under what circumstances.

Thus, the (analytical) notion that we are faced with complex networks of heterogeneous actors with varying degrees of knowledge, power and negotiation is accompanied by the (interventionist) notion of becoming one of those actors and forming part of those processes in order to steer them in the desired direction(s). All these operations can perhaps be condensed into the complex relationship between science and democracy, which now features among the essential concerns of both fields. This encompasses multiple cross-cutting issues, such as the role of experts (or whoever speaks on behalf of knowledge), the *scientific* basis for decision-making and the direction of agendas, among many others.

7.4 An example: STS congresses

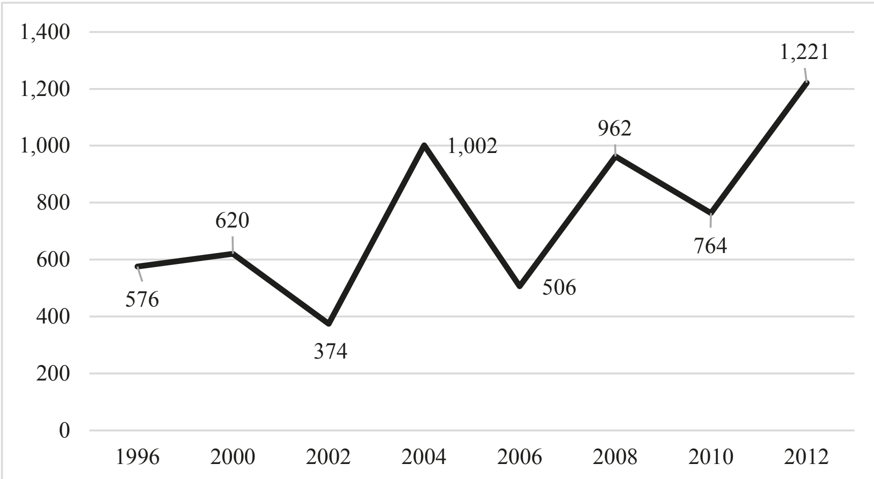
Before setting out my conclusions to the question in my title, I would like to examine briefly the congresses of three international associations: the European Association for the Study of Science and Technology (EASST), the Latin American Society for Social Studies of Science and Technology (ESOCITE) and 4S (the Society for Social Studies of Science).[8] The aim here is to observe the relative importance that the papers most closely associated with PUS have had in these areas.

The evolution in the number of papers presented is shown in Figure 7.5 (the highest figures correspond to joint congresses).

[7] Unfortunately, I do not agree with this idea. I believe that there is still much to learn within the various spaces where knowledge is produced, not only about the epistemic or disciplinary changes that have occurred over recent decades, but above all about the consequences of technological change for research. Indeed, a modern-day laboratory has little in common with those observed by Latour, Lynch or Knorr-Cetina in the 1970s (which were perhaps just as different from the laboratories of the 1930s, which were separated by the same temporal distance). However, a discussion on this topic is clearly beyond the scope of this paper.

[8] EASST has been holding a congress every two years since 1983, and every four years it is held in conjunction with 4S. For its part, ESOCITE has been organizing a congress every two years since 1995.

Fig. 7.5. Participants in EASST congresses, 1996 to 2012



Let us look in particular at the evolution in the number of papers most closely related to studies on PUS (Table 7.1).

Table 7.1. Percentage of PUS papers at EASST congresses and joint meetings

EASST/ 4S	Place	Total	PUS	%	Joint meetings
1996	Bielefeld	576	38	6.6	4S
2000	Vienna	620	79	12.7	4S
2002	York	374	60	16.0	
2004	Paris	1,002	81	8.1	4S
2006	Lausanne	506	61	12.1	
2008	Rotterdam	962	73	7.6	4S
2010	Trento	764	71	9.3	
2012	Copenhagen	1,221	99	8.1	4S

The first conclusion that emerges from the analysis is that the absolute number of papers presented on PUS-related topics has been increasing over the past two decades, although the percentage rises in the case of the exclusively European congresses and falls when congresses are organized in conjunction with 4S. Indeed, the average for EASST congresses is 12.5% of the total, while at EASST–4S joint meetings it drops to 8.6%.

In the case of Latin America (ESOCITE), the papers presented followed the distribution in Table 7.2.

Table 7.2. Percentage of PUS papers at ESOCITE conferences and at the joint meeting

ESOCITE	Place	Total	PUS	%
1995	Buenos Aires, Argentina	114	3	2.6
1996	Caracas, Venezuela	71	4	5.6
1998	Querétaro, Mexico	72	2	2.8
2000	Campinas, Brazil	186	10	5.4
2004	Toluca, Mexico	179	0	0
2006	Bogota, Colombia	156	1	0.6
2008	Rio de Janeiro, Brazil	229	15	6.6
2010	Buenos Aires, Argentina	424	37	8.7
2012	Mexico City, Mexico	290	23	7.9
2014	Buenos Aires, Argentina	1,100	22	2.0

In this case, there has also been a slight increase in the number of papers presented, although their relative share within the thematic orientations is considerably lower than in Europe.

We must, however, qualify this analysis by underlining the fact that not only are 'purely' PUS sessions held at both types of congress, in Europe and as well as in Latin America, but that an analysis of the papers reveals a significant increase in 'PUS papers or perspectives' in various thematic panels, the most obvious case being that related to the study of technical and scientific disputes, which for years has constituted a cross-cutting issue.

The drop in the percentage share of PUS papers when the congress is jointly organized by EASST and 4S appears to indicate that a clearer separation between the two fields persists today in the United States. Those who work on these topics in the United States feel less drawn to general issues concerning STS than their peers in Europe and Latin America, but there is no indication that this will intensify in the future.

7.5 Conclusion

The tension between the two sides of the fence—and between academic practice and committed action—does not appear to have been resolved in either field, despite Sismondo's attempt to unify the conceptualization (2008). In academic terms, although STS and PUS seem to have parallel structures of legitimization (postgraduate courses, congresses, journals), in practice it might be possible to predict a greater degree of academic convergence, which could, in the future, help to shape one broad, diverse and heterogeneous field. Indeed, although a few decades ago the field of STS seemed to be relatively hegemonized by the sociology of scientific knowledge in its different variants, one of the directions that can be observed in the academic 'STS movement' is an increasing openness towards (and intersection with) various fields of the social sciences, including on relating to art, aesthetics, postcolonial studies and urban planning, among others.

This view is further reinforced by the existence of a set of cross-cutting topics that appear to bring together scholars from both traditions. To the matter of technical and scientific controversies, I must add issues relating to the complex relationships between science, technology and democracy, the public participation of various groups of actors in decision-making and the consequences of the digital revolution, among the hottest issues.

However, although it is possible to imagine this convergence within academia, the situation seems to be different with regard to the 'committed' or activist aspect of these two fields. While in the field of PUS we can see a predominance of the different professional profiles associated with these practices, such as science journalism, science/technology museum management and the organization of various spaces and events, public activism in the field of STS (which, according to Sismondo, goes from activism or from the academic field to the 'engaged programme') takes much vaguer forms, and it is difficult to associate it with a clearly defined professional profile. It seems to be more of a *desideratum* with multiple openings than a precise definition relating to modes of public intervention.

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Acknowledgement

I would especially like to thank Luciano Levin for his contribution to the analysis of the various congresses, as well as to the general discussion presented in the text.

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8 Curating the future: the science museum for creativity and sustainability

Sook-kyoung Cho

The beginnings of science museums can be traced to the ideas of Francis Bacon, who was born in 1561, although some drawings of plants and astronomical records had been held as a science collection in the ancient Library of Alexandria, which was part of a museum. In *The new Atlantis*, published in 1627, he suggested the collection of scientific instruments and experimental apparatus used for producing new knowledge. Later, the 'cabinet of curiosities' and the 'wonder-room', used to display natural history and geology specimens, historical relics and works of art, became very popular among the nobility and wealthy merchants. One of the most famous was King George III's collection of scientific apparatus, which later became part of the Science Museum of London.

As the industrial revolution accelerated from the end of the 18th century, collections of patent models of machinery and various inventions began to multiply. In France, the Conservatoire National des Arts et Métiers was first proposed in 1794 as a depository for machines, models, tools, drawings, descriptions and books in all the areas of the arts and trades. In the United Kingdom, the first world expo—the Great Exhibition at Hyde Park in 1851—was a great opportunity for amassing huge collections of items related to science, technology and industry. Based partly on those collections, South Kensington Museum (which included the Science Museum of London) was begun in 1857.

In 1969, a completely new type of science museum, the Exploratorium in San Francisco, began to emphasize visitors' participation and self-investigation. The world's better known science centres soon followed, including Questacon in Australia, the Ontario Science Center in Canada, La Cite des Science in France, and Miraikan (meaning 'emerging science and technology') in Japan.

Since the turn of the century, under the banner of the Science Korea Movement (SKM), Korea has also invested a great deal of its energy in establishing new science centres across the country, especially after it became clear that proportionally fewer young Koreans were studying science and technology at universities.

In this paper, I first recount a brief history of science museums and examine the their conceptual development from 'eyes-on' to 'hands-on' and from 'minds-on' to 'feels-on'. I then describe successful Korean experiences of establishing new science museums under the SKM. After that, I examine some experiences of exhibition and education at the Gwangju National Science Museum, which is one of the outcomes of the SKM. Finally, I discuss what science centres can do for 'science and the public' and for 'science and future society' on the basis of feels-on science, in which individual creativity and community sustainability are important.

8.1 The conceptual development of science museums: from eyes-on to feels-on

The philosophy behind science museums has changed as science museums have evolved into science centres. From the 17th century until the 1960s, their most important jobs were to collect peculiar things and to preserve and exhibit them. In this 'age of the collection of science', their key offering was 'eyes-on' science, in which visitors received information and messages from the exhibits as they moved along a one-directional path. There was no interaction between exhibits and visitors, and seeing was the main way to understand the exhibits. The early years of the Science Museum of London, before the opening of the Children's Gallery in 1923, were part of this period.

After the San Francisco Exploratorium was established in the 1960s, a new conception of science museums developed: 'hands-on' science called for interactions of art, science and human perception and was based on the idea that science should be fun and accessible to people of all ages. It was championed by Frank Oppenheimer, who was one of the physicists involved in the Manhattan Project. He wanted children to learn the basic physics of sound and light through the exhibits. That was why all the exhibits had participatory components and few historical displays. Visitors could wander around the museum and learn and understand by playing with exhibits in an open space. This started an 'age of entertainment with science', in which interactions among visitors, exhibits and researchers were most important.

From the 1980s, a new conception—'minds-on science'—developed to overcome the limitations of hands-on science. Visitors differed greatly in how well they understood participatory exhibits because of their differing background knowledge, so there was a need for a kind of helping system to aid them. Science communicators, demonstration shows and public lectures were introduced one after another. By focusing on real understanding of exhibits by visitors, the minds-on concept opened an 'age of science learning'. The Miraikan in Japan successfully applied this concept by using volunteer retired scientists.

However, to us living in 21st century, science goes far beyond objects that we simply see, enjoy and understand. Cutting-edge science and technology (S&T) might promise a rosy future without cancer and incurable disease, but it might also produce an S&T-addicted future generation unable to distinguish between the real world and the cyber world. During the last century, S&T brought enormous material prosperity to humankind, along with many startling inventions, such as information technology. However, at the same time, it also caused serious and global problems that had hardly been imagined before, such as climate change, water pollution, new diseases and energy deficiencies.

The irony is that S&T itself is the most powerful tool, if not the only one, for solving these newly created problems: it is both the source and the solution of the problems. This is why science should be strongly supported financially, researched in a collaborative way and understood in a much broader context. It is also why science goes beyond objects to be seen, enjoyed and understood. It is why we, the public, should be involved more in science through engagement and daily practice, not just through mere understanding and awareness.

For these reasons, a new conception of science museums has appeared: 'feels-on' science. In feels-on science, the most important task is to secure creativity and sustainability in society. In museums, this means that science should be represented not only in the context of human history (present and future), but also in coalition with the humanities and arts. From here, an 'age of appreciation of science' is emerging.

8.2 Establishing new science museums under the Science Korea Movement

Korea, which was among the poorest countries during the 1950s and 1960s, is now the world's ninth largest economy. What made that possible? The answer is believed to be human resources and S&T.

However, at the turn of the century, Korea faced two serious social issues:

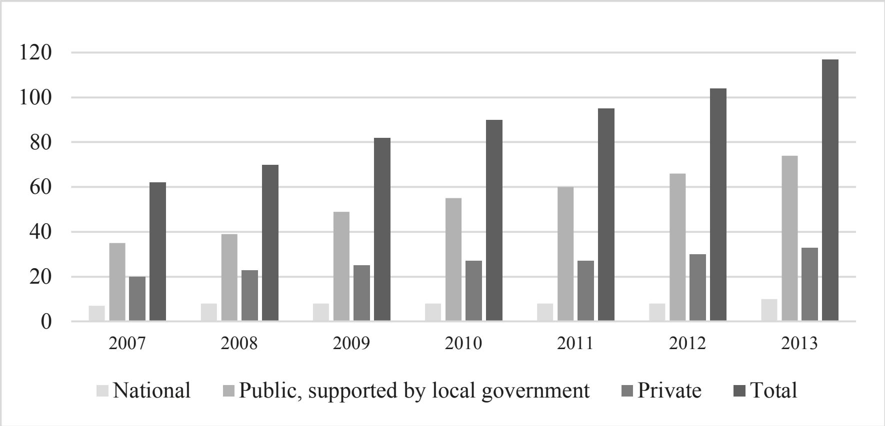
- Most high-performing high school students preferred to go on to study medicine at university. The proportion of university students majoring in S&T dropped sharply from 42.5% in 1998 to 29.5% in 2001.
- The scientific community lost its eagerness to do research when scientific jobs became insecure, especially after the 1997 Asian financial crisis (which is known as the IMF crisis in Korea).

After a national survey of the public's attitude to S&T (KSF 2002), the Korean Government, using the Korea Science Foundation[1] as a secretariat, launched the SKM.

From 2003 onward, 10 major programmes were implemented under the SKM, one of which was the construction of new science museums. The first national five-year plan for constructing science museums was drawn up, and the central and local governments worked together to establish the museums. The central government provided funding, while local governments donated the land. As a result, the number of science museums in Korea, including national, municipal and private museums, grew from 56 in 2004 to 117 in 2013, when the second five-year national plan finished. This was an exceptional success that most other countries would have found hard to achieve. Of the four new national science museums, Gwacheon Science Museum was opened in 2008, Gwangju and Daegu Science Museums were opened in 2013, and Busan Science Museum is to be opened at the end of 2015. Figure 8.1 shows the development of the science museum sector from 2007 to 2013.

[1] Later renamed the Korea Foundation for the Advancement of Science and Creativity.

Fig. 8.1. Science museums in Korea, 2007 to 2013



8.3 Creativity and sustainability at the Gwangju National Science Museum

The construction of Gwangju National Science Museum (GNSM), in the south-western part of Korea, was proposed in the first five-year plan in 2003. Planning and construction took 10 years, before the museum opened in 2013.

That period included debates about who the main operator should be and who should pay for operating expenses. Construction was suspended for a period because of a change of political leadership at the central government level. In 2008, the central government and Gwangju city signed a memorandum of understanding, allocating responsibility for 80% of operating expenses to the central government.

GNSM tries to reach all age groups with its exhibits, education programmes and cultural activities. Based mainly on minds-on science, 85% of permanent exhibits are hands-on, with friendly panel explanations and illustrations. Science communicators and part-time volunteers help visitors by doing experiment demonstrations and explaining the principles behind the exhibits. GNSM is slightly different from other science centres, in that a quarter of all its exhibit area is allocated exclusively to special exhibitions, making the planning and curating of those exhibitions one of the main jobs at the museum.

GNSM has so far run five different special exhibitions: 'Robot Story', 'Imagination Factory', 'Science Meets Mummy', 'Roman War Technology' and 'The Lost Dinosaur'. Under the feels-on science concept, they were carefully planned and curated to enhance visitors' creativity and the community's sustainability. For example, the robots in 'Robot Story' were made from wood, rather than steel or plastic. The wooden robots play guitars, ride bicycles and even send love messages, like humans and not like machines. This appeals to people's feelings, rather than reasoning or scientific facts, to ask them how we can have happiness and sustainability in a future dominated by robots.

‘Imagination Factory’ also encouraged people to think about creativity and sustainability. All the exhibits were animals made from junk or recycled materials and objects. A pelican made of scrap iron, an eagle made of motorcycle parts and a squirrel made of old tyres are unusual enough to excite people’s curiosity and imagination. One of the exhibits, named ‘Not Me’, was oriented to a global issue. The artist transformed small red fire extinguishers into penguins. Real penguins are black and white, but red suggested higher atmospheric temperatures. The red penguins made visitors think more closely about climate change and environmental problems.

For science education, GNSM has a series of classrooms with interesting themes to encourage and enhance children’s creativity: the CSI Investigation Lab, the Medi+ Lab, the Imagination Lab, the Mechanics’ Shop and the 3D printing Lab. Each lab has been equipped like the real thing so that children can experience being an investigator, a doctor, a mechanic, an engineer and a designer. For example, the CSI Investigation Lab re-enacted a murder scene, and children played with an equipment bag containing polarizing spectacles, an infrared lamp and a fingerprinting machine contained to investigate the crime. In the Medi+ Lab, where a real operating room was set up, children experience being doctors by measuring people’s temperatures, listening to the chest with a stethoscope and looking inside the mouth with a lamp.

Through these sorts of direct, real experiences, children can learn more about science and have fun doing it. In a survey of visitors, most children said that their interest in science, especially in biomedical science, had increased very much. Many decided that they wanted to become scientists after having classes in the thematic classrooms.

8.4 Conclusion

During the later 20th century, science centres evolved from science museums by emphasizing active communication and engagement. The conceptual basis for exhibitions also developed, from eyes-on to hands-on and then to minds-on. However, science in the 21st century goes far beyond seeing objects, enjoying them and learning about them. The impacts of S&T on our lives are already wide and strong, making science one of the most powerful forces shaping our future. Our need to use S&T to solve some of the environmental and social problems that have arisen because of S&T calls for feels-on science, in which people’s creativity and the community’s sustainability are most important.

The prospects for feels-on science museums in Korea are good. The number of museums overall has doubled since 2007, and the SKM has delivered four new national science museums. One of them, Gwangju National Science Museum, has pioneered new, feels-on ways of curating and exhibiting, exciting visitors’ curiosity and helping them to be creative and build sustainability.

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9 Science–society relations seen through the prism of technology promises

Pierre-Benoît Joly

The way we see the future is a key component of societal life and is deeply rooted in the ways we know and in our trust in progress. As argued by Antony Giddens (1998), contemporary societies are far more intensely future-oriented than those of the past. Our travel towards the future is accelerating (Rosa 2010), and the future colonizes the present in many ways. Climate change is a paramount example of close entanglement of the future in the present. It illustrates how representations of adverse irreversible futures shape current behaviours when we are collectively convinced that this is the only way to avoid the unacceptable. In this case, the future is so strong that it determines the present. As suggested by Jean-Pierre Dupuy, we then observe an inversion of the arrow of time (Dupuy 2002).

Our present time is perhaps best characterized by the combination of the omnipresence of the future and its strong contestability. Intensifying engagement with the future is leading to a paradoxical effect. The production of information on the future goes hand in hand with a proliferation of possible futures; it becomes a part of the problem rather than a solution by making the future more, rather than less, opaque (Brown & Michael 2003).

The role of the future is particularly important for innovation and technological change. Recent literature has drawn attention to the importance of imaginaries and expectations. Indeed, the capacity to imagine futures is a crucial element in sociotechnical creation. Sociotechnical imaginaries encode visions of a 'good' society (whatever it may be) in sociotechnical networks; they are instrumental in mobilizing resources and fostering future-oriented coordination (Jasanoff & Kim 2009). As shown by Flichy (2004), basic characteristics of the internet (free access, distributed action, interaction and cooperation in communities of equals, and so on) have stemmed from the imaginaries of the researchers in computer science who initially developed the new technology according to their own values, visions and social organization. In their analysis of pharmacogenomics, Hedgecoe and Martin (2003) identify two competing imaginaries, and show how each of those visions is actively shaping the trajectory of this nascent technology and its potential socio-economic consequences. The acknowledgement of the role of expectation and future-oriented coordination has led a group of European scholars to propose a sociological frame for analysing the role of technoscientific expectations (Brown et al. 2000, Borup et al. 2006).[1]

In this paper, I draw attention to a specific modality of construction of collective futures: regimes of economics of technoscientific promises (ETP).[2] I first present

[1] Consider also the papers published in the special issue of *Technology Analysis & Strategic Management*, 18(3–4), 2006.

[2] This paper is adapted from Joly (2010).

the general characteristics of technoscientific promises and explain why they are currently important. I then discuss internal contradictions and possible problems related to the ETP.

9.1 About the economy of technoscientific promises

Technoscientific promises are a way of communicating science and technology to their publics, and I claim in this section that they have imposed a master frame that conditions relationships between science and society.

The first step in the production of a promise is problematization. The sentence, 'You have a problem and I have *the* solution'—which instantiates the promisemaker as an obligatory passage point—involves the definition of the problem that has to be fixed. For instance, in the 1980s, genetically modified organisms (GMOs) were claimed to be the solution for the world hunger problem and many deadly human diseases. Today, they are also claimed to be able to solve global warming and to be the key for sustainable agriculture. For those claims to be credible, molecular biologists had to dismiss alternative solutions. In fact, they were eager to present plant breeding as an old technology whose potential had vanished (Joly & Ducos 1993).

The same thing has occurred with nanotechnology. To take but one example—in an area were promises proliferate—consider this statement by the Undersecretary of Commerce for Technology at a Swiss Re conference on nanotechnology in December 2004:

> Given nanotechnology's extraordinary economic and social potential, it would be unethical, in my view, to attempt to halt scientific and technological progress in nanotechnology. Nanotechnology offers the potential for improving people's standard of living, healthcare and nutrition; reducing or even eliminating pollution through clean production technologies; repairing existing environmental damage; feeding the world's hungry; enabling the blind to see and the deaf to hear; eradicating diseases and offering protection against harmful bacteria and viruses; and even extending the length and the quality of life through the repair or replacement of failing organs. Given this fantastic potential, how can our attempt to harness nanotechnology's power at the earliest opportunity—to alleviate so many earthly ills—be anything other than ethical? Conversely, how can a choice to halt be anything other than unethical? (quoted in Rip 2006)

The more urgent and widely acknowledged the problem, the more attractive the promise and the more legitimate the actions taken. Technoscientific promises are strongly associated to the urgency to act, which may result from the gravity of the problem to be solved and/or (very often in the contemporary discourse) from the need to remain competitive and not lag behind.

The second ingredient of a technoscientific promise is credibility. Credibility is determined *inter alia* by past activities (see the cycles of credibility, Latour 1987) and by the social network of whoever made the promise (be it an individual or a wider collective). Both components of scientific credibility are also relevant for the credibility of technoscientific promises.

Promises are all the more important when innovation or technological change requires huge resources for financing activities, adapting regulations, designing adequate policy frames, shaping new uses and new users, and so on. The mobilization of resources then requires that large audiences in heterogeneous public arenas be convinced. Biotechnology and nanotechnology are but two examples illustrating such a configuration. The very coining of such expressions has a performative effect (a new technology exists because we name it); it fits with discourses and narratives that frame the technology and define both the good futures it brings into existence and the adverse futures it helps to avoid. These narratives are not necessarily accepted at face value, and they may bring about counternarratives and trigger sociotechnical controversies. I suggest that the wider the claims of the narrative related to an innovation, the stronger the counternarrative. Therefore, it is common in these areas (and in others) to find that futures are contested.

There are many precursors to current technoscientific promises. The 'green revolution' was designed in the 1960s to fight against world hunger, while the 'war on cancer' was launched by President Nixon in 1971, to take just two examples among many others. Hence, the phenomenon is not new at all. However, its intensification creates a new situation. This intensification is related to three interrelated elements. First, since the 1970s, we have lived in a regime of historicity (Hartog 2003) where the future is contested and it is more a threat than a source of hope. Second, research and innovation are now often presented as the only way to address great societal challenges. This may be observed in Europe, first with the Lisbon Agenda (2001) and the narrative of the knowledge economy and more recently with Horizon 2020. The third element is observed at the micro level. The impact of the new public management on research means that research actors, from individuals to organizations, have to demonstrate their societal impacts and to promise that their research will address societal needs. These three elements have a systemic effect and produce a new form of governmentality, which we call an economics of technoscientific promises (ETP). Although addressing key societal issues through research corresponds to the best intentions, ETP may raise important issues that I discuss in the following section.

9.2 Why might ETP regimes be problematic?

I now focus on several drawbacks that may result from the generalization of an ETP. These limitations are very much related to the discursive structure of the ETP, which clearly separates those who produce the promise and those who are supposed to accept it.

9.2.1 *Technoscientific promises and their publics*

The ETP regime works with a specific governance assumption: a division of labour between technology promoters and enactors on the one hand, and civil society on the other: 'Let us (= promoters) work on the promises without too much interference from civil society, so that you can be happy customers as well as citizens profiting from the European social model.' The Aho Report (2006) for the European Commission is explicit about this assumption in its recommendations, when it discusses:

> The need for Europe to provide an innovation-friendly market for its business … This needs actions on regulation, standards, public procurement, IPR and fostering a culture which celebrates innovation.

And:

> Europe and its citizens should realize that their way of life is under threat but also that the path to prosperity through research and innovation is open if large scale action is taken now by their leaders before it is too late.

In addition to the need to foster 'a culture which celebrates innovation', so that technoscientific promises (if and when realized) will have fertile ground, the ETP regime now also recognizes the need to consider societal embedding and public reactions at an early stage. Lessons from biotechnology and, in other respects, from pharmaceuticals have been important here. One could argue that big promises inevitably run the risk of attracting big concerns. Indicative of how lessons are taken up is the way in which the promotion of nanotechnology in the United States and Europe is accompanied by considerations of current and future ethical, legal and social aspects.

Promoters of technological innovation and policymakers can fall into the trap of seeing civil society, under the rubric of 'the public', as outsiders, to be taken into account, for sure, but as 'irrational', prone to be scared without reason, and always to be monitored by opinion polls. 'Fears of the public fears' (Rip 2006) have been closely studied by social scientists, who demonstrate that the 'deficit model' is inappropriate (Wynne 1992). But neither those analyses nor the continued public interest in new science and technology—and the overall trust in the institutions of science 'in general' that is found in such polls, including the Eurobarometer—change anything of these myths.

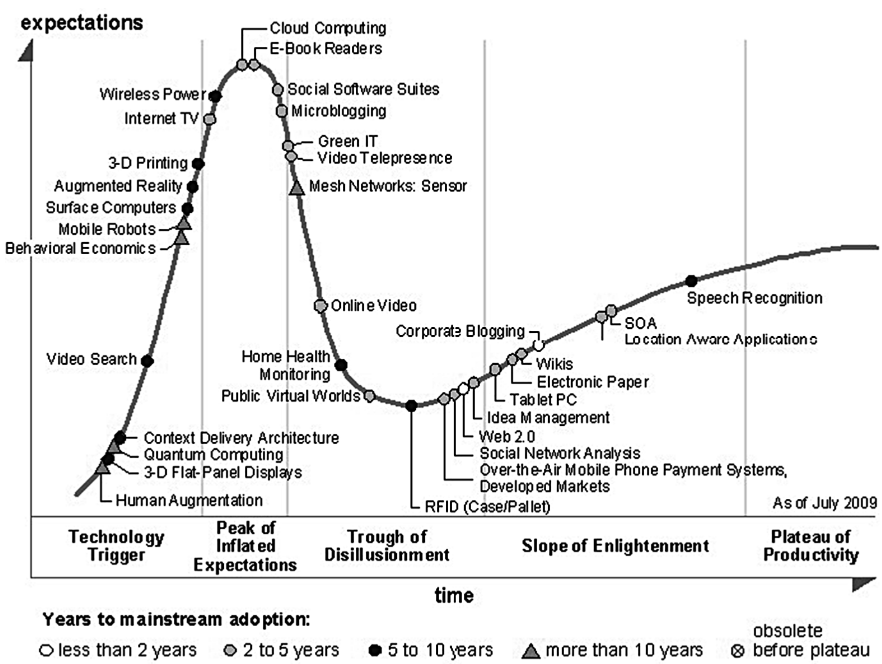
This relation is deeply entrenched in the ETP regime; it is not specific to our time. In her study of electrical engineers in the United States towards the end of the 19th century, Carolyn Marvin shows that they were eager to dismiss negative attitudes of the public as naive and irrational, and that they felt invested with the task of teaching the public 'proper' promises concerning electricity (Marvin 1988).

When government agencies and political representatives become the advocates of promise, a confusion of roles and accountabilities may result. The role of policymakers, promoting specific interests around technoscientific promises while being in charge of the public interest, may become problematic when concerns are raised about the new developments. Space for public deliberation quickly becomes reduced to polarized interactions for or against the technoscientific promise.

9.2.2 The hype–hope cycle

Promises are closely related to hype and hope and, interestingly, recent fashionable management models are built on them. The hype–hope cycle (Figure 9.1) was identified in the late 1990s by Gartner, one of the largest IT consultancy companies in the world. The basic idea is that new technologies tend to follow different trajectories of hype, hope, and despair as they are discovered by different groups of people and finally adopted. In Gartner's worldview, the visibility of new technologies peaks early as initial excitement gains steam. This phase is followed by a 'trough of disillusionment' in which inflated expectations hit reality. But, as technologies prove themselves, their visibility begins to grow again at a more measured pace. Thus, knowing the position of a given technology in the cycle is necessary for designing corporate strategies and deciding when and how to engage.

Fig. 9.1. The hype/hope cycle



Source: Gartner's 2009 Hype Cycle Special Report—press release.

This model has been criticized by various scholars on various grounds (see, for instance, Borup et al. 2006). However, although technically sound, such criticisms miss an important point: the hype–hope cycle is not useful for analysing the quality and accuracy of the representation of a reality, but it is interesting for what it represents and what it does not. According to the model, any technology follows the hype–hope cycle. The model assumes that there is a systematic lag between the dynamics of the social and the sticky processes of technological creation. In the world of the hype–hope cycle, everybody wants the technology before it even exists. It is, frankly, a strange world, and very different from the relations between innovators and users performed by old-fashioned diffusion models.

One of the effects of the cycle is to naturalize the disillusionment. Hence, there is no accountability in the promises that nurture hype and hope; there is just a 'natural' cycle. Such a representation obviously overlooks key problems. Consider health technologies, which are rightly called technologies of hope by Sarah Franklin. Speculative claims may induce great expectations from those who suffer from incurable diseases, which may lead to painful disappointments. The GM case offers an interesting example of how expectations related to medical treatment were highlighted in order to foster the acceptance of the technology. In the French debate, anti-GM activists were accused of hindering the procurement of treatment for children suffering from cystic fibrosis because they opposed the production of transgenic corn expressing a gastric lipase.[3] It was then discovered that alternatives to GM plants existed and that risks related to pollen contamination were to be considered seriously. Serious moral issues associated with the ETP regime can thus be found.

With the hype–hope cycle, there is also little to learn about promises that are not fulfilled. Critical returns on the failure of promises to deliver may, however, be highly instructive. Nightingale and Martin (2004) show the importance and the fertility of this approach in the case of medical biotechnologies. This type of analysis could usefully be taken much further.

9.2.3 Breakthrough versus control

Technoscientific promises rest on the rhetoric of novelty or breakthrough. Since mobilizing resources requires old technologies to be dismissed, promoters usually highlight the radical novelty of the new technology. However, such a strong discontinuity means radical uncertainty about how it may affect health and the environment, or even ontological uncertainties. This explains why narratives about new technologies follow a common pattern. The technology is presented as brand new (it will create a new society through genetic modification or offer nano-implants for human enhancement) when technological elites speak to investors, policymakers or patent offices, and to publics to be enrolled in the new venture. But the same technology is said to be nothing unusual (we have been modifying the genetic make-up of organisms for millennia, nanotechnology is just about making things smaller and faster) when actual or anticipated concerns have to be assuaged. When the two

[3] On this case, see the activists' report at www.local.attac.org/rhone/article.php3?id_article=799 (accessed 1 October 2009).

claims encounter each other, this dual narrative may be a source of distrust because of the lack of consistency.

There is a huge communication problem associated with the ETP regime, but there is also something more profound. In such a regime, promoters tend to overstate the capacity of control associated with the power of the new tools. For instance, genetic engineering was presented as a much cleaner and more precise technology than plant breeding. The promotion of GMOs was thus based on a representation of genes and molecular biology that is now considered widely inaccurate (see Fox Keller 2000 on this point). The same applies to nanotechnology (Rip 2006). The promise of control over matter on a nanoscale is a recurrent element in public statements about nanotechnology. Conversely, Jean-Pierre Dupuy convincingly argued that nanoscientists and technologists are just sophisticated tinkers or intentional sorcerer's apprentices (Dupuy 2002). Confronted with the emerging properties of complex systems, there is no possibility for prediction: we have to experiment. The problem with the ETP regime is that it compels all the actors to run after the novelty, thus transforming society into a laboratory (Krohn & Weyer 1994).

9.2.4 Escalation: utopian versus dystopian pronouncements

The bigger the promise, the stronger the reactions it triggers. Huge promises may lead to endless discussions on pointless issues, thus preventing relevant ones from being correctly addressed. Take the case of nanotechnology, in which the debates were prompted by prophecies on human enhancement or the controversy about 'grey goo'. This helped draw attention to nanotechnology, but on issues only loosely articulated with the research agenda. However, the process of escalation is so intensive that nanotechnologies have been considered as an ideal laboratory for the study of the matrix of futures (Chateauraynaud 2005).

GM plants have been promoted as *the* solution to the world hunger problem and an obligatory passage point on the route to sustainable agriculture. However, this technological fix has been challenged on the grounds that the origins of the problem are merely socio-economic or political. The promise has also been challenged from a technological standpoint. Opponents have claimed that, when considering the world hunger problem and resources conservation, the kind of agriculture at stake is locally adapted peasant farming. And small peasants cannot afford GMOs, which are designed by agri-investors as the big universal solution. The claim of a technoconspiracy is then opposed to the technoscientific promise. In a way, pros and cons are locked in an escalating process in which each one is trapped by its own hyperbole.

9.2.5 Technological fixes

Escalations related to promises overshadow some important problems and may lead to unwittingly excluding certain futures (Rose 2005). Biomedical research is the extreme case where (bio)technologies of hope mobilize resources, while epidemiologists have shown that common disorders such as obesity, stomach ulcers and heart disease are determined by environmental and socio-economic factors such as poverty. Nightingale and Martin (2004) rightly contend that:

> Unrealistic expectations are dangerous as they lead to poor decisions, misplaced hope, and distorted priorities, and can distract us from acting on the knowledge we already have about the prevention of illness and disease.

These arguments relate to the debate on the limitations of technological fixes, or the technicization of social problems. It has been observed that many technologies, although designed to solve some problems, often create some others. But we can go a step further. The ETP regime may be a way to legitimize technoscientific programmes that pursue concealed vested interests. The 'green revolution' was primarily designed as a geopolitical instrument that aimed to keep third-world countries under the influence of the Western capitalist ones, while preventing social transformations such as land reform (Cornilleau & Joly 2014). The 'war on cancer' resulted from the lobbying of the medical–industrial complex in the United States (Coleman 2013) and it strengthened the position of those who produced non-knowledge on environmental sources of cancers (Proctor 1995).

9.3 Conclusions

As argued by Daniel Innerarity (2012), it is currently of crucial importance to defend the future from its enemies and to recreate a politics of hope. This means that we have to find ways to deal collectively with the current challenges we have to address, ways to construct debates on contested and uncertain possibilities of research and innovation to address those challenges, and ways to seriously integrate these issues in our democratic institutions.

In this paper, I argue that the ETP regime is one of the enemies of the future. This is related to the way it reproduces a clear-cut separation between those who formulate the promise and those who are supposed to accept it. This is also related to the series of pathologies that come along with the ETP. Hence the risk of the ETP is that it could amplify distrust in our political institutions and in the ability of research to address important issues seriously.

This does not mean that public policies that aim at directing research and innovation towards grand challenges are a deadlock. On the contrary, they are extremely important. However, it is urgent to get rid of the pathologies of the ETP regime. This first requires us to be humble about the possibilities of science and technology, and to acknowledge that the directionality of innovation means a radical shift in innovation policies.

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10 Thirty years of the OPECST: thirty years of investigating ahead of legislation

Jean-Yves Le Déaut

Science has been spurred on by humankind's basic desire to always better understand the mechanisms governing nature and the universe. Over the centuries, it has also become a lever for transforming living conditions, helping to control the scourges of famines and epidemics better, ensuring ever greater daily comfort for the burgeoning middle class, and helping realize eternal dreams, such as that of travelling in the air, sailing under the sea or transmuting matter.

The ever-growing presence of science in daily life could not fail to make it a subject of political interest. The idea gradually arose that we need to assess technology so as to better master its progression by anticipating the consequences.

In the early 1980s, during a number of debates, such as those concerning nuclear, space or cable programmes, the French Parliament came to the conclusion that it was unable to assess government decisions on the major directions of scientific and technological policy. It therefore decided to establish its own structure for assessment: the Parliamentary Office for Scientific and Technological Assessment (OPECST).

The OPECST, which was set up by law on 8 July 1983, following a unanimous vote of parliament, aims, within the terms of the law, 'to inform parliament of the consequences of the choice of scientific and technological options, in particular, so as to enable it to make enlightened decisions.' To do this, it 'collects information, launches study programmes and carries out assessments.'

10.1 The structure of the OPECST

The OPECST is an independent body made up of parliamentarians. With the assistance of a scientific council, it investigates matters referred to it by parliamentary bodies.

10.1.1 An independent body

The OPECST is an unusual structure within parliament: its members, who are appointed so as to ensure the proportional representation of political groups, belong both to the National Assembly and to the Senate. It is composed of eighteen MPs and eighteen senators; each member may be appointed as a *rapporteur*. A rapporteur is an MP or a senator in charge of writing a report on a given subject.

The OPECST is chaired alternately for periods of three years by a member of the National Assembly or the Senate. Internal rules stipulate that the First Vice-President shall belong to the other house of the parliament.

10.1.2 Only MPs or senators may refer matters to the OPECST

A matter can be brought before the OPECST in the first instance by an internal parliamentary body; in other words, either by the bureau of either chamber (on its initiative, on request by the chairman of a political group, or else on request by 60 deputies or 40 senators), or by a special or standing committee. Since 1991, some Acts have also directly entrusted a study or assessment mission to the office. Until now, the topics dealt with have been in four main areas: energy, environment, new technologies and life sciences.

Some matters referred to the OPECST have been re-examined several times, such as problems connected with the safety and security of nuclear installations. Others have required the updating of one of the OPECST's previous reports (such as the development of the semiconductor sector, high-definition digital television, high-activity nuclear waste, biotechnology and bioethics). The renewal of such referrals allows the office to follow up the topics concerned very closely.

Several times a year, the board of OPECST may decide to organize a public hearing to gather information about an unexpected matter brought up in the news or to assess the situation in a field that had been studied earlier.

10.1.3 The Scientific Council

The OPECST acts as an intermediary between the political world and the world of research. It must listen to researchers and requests authorized opinions. In order to carry out its task, the OPECST is assisted by a scientific council reflecting the diversity of scientific and technological disciplines in its composition. The council is made up of 24 leading figures selected on the basis of their expertise.

10.2 The study programmes

10.2.1 The appointment of the rapporteurs

Any matter referred to the OPECST leads to the appointment of one or two rapporteurs, always selected from among the members of the OPECST. Most study programmes bring together an MP and a senator. OPECST also tries to match rapporteurs so that the left and the right wings are included, and both genders too. This is called ‘triple parity’ matching.

10.2.2 The feasibility study

Once appointed, the rapporteurs first make a feasibility study. The study aims to provide a snapshot of knowledge on the topic, determine possible research avenues, consider the possibility of obtaining relevant results in the required time period and determine the necessary means to start a study programme.

The rapporteurs then submit the conclusions of the feasibility study, together with methodological remarks, to the members of the OPECST. At that stage, they either suggest that the study be closed (this happens very rarely), propose modifications the extent of the study (a study first dealing with biofuels was thus extended to consider prospects for the development of non-food agricultural products), or, much more frequently, that a study programme be set up and lead to the drawing up of a report.

10.2.3 The drafting of a report

The rapporteurs hold hearings to enable them to gather, without exclusion, all opinions from concerned people and organizations. They can also travel in France or abroad to inspect installations and firms connected with their work.

Throughout the study, the rapporteurs are assisted by a parliamentary civil servant and, if need be, by a study group made up of specialists from outside parliament. They can hire French or foreign freelance experts and consultants for further investigation into specific items. They can gather the opinions of trade unions, professional bodies, and organizations for the protection of the environment or consumers.

However, OPECST reports are not restricted to setting out the experts’ points of view. Their conclusions are the work of parliamentarians and may go beyond merely informing, by including suggestions and recommendations.

If the rapporteurs deem it necessary, public hearings open to the media are organized to gather and hear the opinions of leading figures and organizations wishing to express themselves on the subject under discussion.

The rapporteurs draft the report. The minutes of their hearings may then be annexed to the report.

10.2.4 The rapporteurs' powers

The OPECST rapporteurs have powers identical to those of budget reporters of the financial standing committee: they may therefore carry out direct investigations on any state agency and have access to any available document, with the exception of those dealing with military matters or state security. In addition, if they encounter difficulties in exercising their mission, the OPECST may request that it be given the prerogatives granted to parliamentary committees of inquiry.

10.2.5 The publication of reports

At the end of their work, the rapporteurs submit their draft report and their conclusions to the members of the OPECST. The conclusions are presented in such a way that they can be used directly for legislative work or budget discussions. Members of the OPECST must decide whether they will publish the report and all or part of the minutes of the hearings and the contributions by the experts. In this respect, the OPECST's decisions are mostly unanimous: consensus decisions are one of the office's main features.

The documents from the OPECST, which make up a special collection within all the parliamentary reports, are on sale at the National Assembly and Senate bookshops and at the State Editing Department, and are available on each assembly's website.

Since its creation, the OPECST has published more than 170 reports. Table 10.1 lists selected recent investigations.

10.3 The OPECST's influence and international activities

The OPECST has progressively become an acknowledged instrument of parliamentary action. Several laws make provision either for it to be informed of or to participate in the appointment of representatives of the parliament to various bodies, or for its representation, by its president or one of its members, on the boards of directors of various organizations.

As part of the control activity of parliament, OPECST has become more and more involved in French science policy. The office has been asked for advice about a national research strategy plan and about encouraging a new policy organization based on five large 'thematic alliances'.

Once the Investments for the Future programme was launched, OPECST first connected it to the 'thematic alliances' organization and then assessed the first outcomes of the programme.

Every year, the OPECST organizes several conferences and seminars, either in relation to one of its reports or on other scientific or technological subjects.

The office also contributes to the development of international parliamentary relations and takes part in various congresses and events, in particular at the European level. Thus, over the past few years, we have seen the setting up of an information and exchange network, the European Parliamentary Technology Assessment, bringing together the European organizations responsible for conducting scientific and technological assessments for national parliaments and the European Parliament.

Table 10.1. Recent work by the OPECST

Recent reports
To build a new society and improve competitiveness thanks to environmental research, report of the public hearing on 3 July 2014 and conclusions of 28 January 2015, by Mr Jean-Yves Le Déaut and Mrs Anne-Yvonne Le Dain, MPs, and Senator Bruno Sido. National Assembly report 2626 (14th legislature), Senate report 333 (2014-2015)
Assessment of the conditions of the public debate about the end of life, provided for in article L. 1412-1-1 of the public health law, by Mr Jean-Yves Le Déaut, MP, and Senator Bruno Sido. National Assembly report 2621 (14th legislature), Senate 326 (2014-2015)
Numerical safety and risks: Issues and chances for firms, by Mrs Anne-Yvonne Le Dain, MP, and Senator Bruno Sido. National Assembly report 2541 (14th legislature), Senate 271 (2014–2015)
The German energy turning point: Which learnings for the French energy transition?, report of the public hearing on 25 September 2014 and conclusions of 9 December—two volumes, by Mr Jean-Yves Le Déaut, MP, and Senator Bruno Sido. National Assembly report 2440 (14th legislature), Senate 176 (2014–2015)
The innovation principle, by Mr Jean-Yves Le Déaut, MP and Senator Bruno Sido. National Assembly report 2409 (14th legislature), Senate report 133 (2014–2015)
Assessment of the national plan on radioactive waste management, PNGMDR 2013–2015, by Mr Christian Bataille, MP, and Senator Christian Namy. National Assembly report 2226 (14th legislature), Senate report 805 (2013–2014)
Regulatory barriers to innovation for energy savings in buildings: The need for a shake-up, by Mr Jean-Yves Le Déaut, MP, and Senator Marcel Deneux. National Assembly report 2113 (14th legislature), Senate report 709 (2013–2014)
Maritime fishing: How to reconcile exploitation and preservation of fishing resources?, by Senator Pierre-Marcel Cléach. National Assembly report 1920 (14th legislature), Senate report 495 (2013–2014)
Genetics advances: Towards a precision medicine? Scientific, technological, social and ethical challenges of personalized medicine, by Messrs Alain Claeys and Jean-Sébastien Vialatte, MPs. National Assembly report 1724 (14th legislature), Senate report 306 (2013–2014)
The new dispassionate and lasting mobilities: Designing and using ecological vehicles, by Mr Denis Baupin, MP, and Senator Fabienne Keller. National Assembly report 1713 (14th legislature), Senate report 293 (2013–2014)
Raising awareness and knowledge of and sharing scientific, technical and industrial cultures: An imperative, by Mrs Maud Olivier, MP, and Senator Jean-Pierre Leleux. National Assembly report 1690 (14th legislature), Senate report 274 (2013–2014)

Continued on next page.

Table 10.1 (continued). Recent work by the OPECST

Recent reports (continued)
Hydrogen, an energy carrier for the energy transition?, by Mr Laurent Kalinowski, MP, and Senator Jean-Marc Pastor. National Assembly report 1672 (14th legislature), Senate report 253 (2013–2014)
Alternative techniques to hydraulic fracturing for the exploration and exploitation of unconventional hydrocarbons, by Mr Christian Bataille, MP, and Senator Jean-Claude Lenoir. National Assembly report 1581 (14th legislature), Senate report 174 (2013–2014)
Energy transition in the light of innovation and decentralization, by Mr Jean-Yves Le Déaut, MP, and Senator Bruno Sido. National Assembly report 1352 (14th legislature), Senate report 838 (2013–2014)
Organ transplants: The case of non-heart-beating donors, report of the public hearing on 7 February 2013 and conclusions of 10 July 2013, by Messrs Jean-Yves Le Déaut, Alain Claeys and Jean-Sébastien Vialatte, MPs, ande Senator Bruno Sido. National Assembly report 1247 (14th legislature), Senate report 747 (2012–2013.
Digital threat: To be aware of it as a first step to dealing with it, report of the public hearing on 21 February 2013, by Mr Jean-Yves Le Déaut, MP, and Senator Bruno Sido. National Assembly report 1221 (14th legislature), Senate report 721 (2012–2013)
Outlook of civil aviation to 2040: To preserve the French and European lead, by Senator Roland Courteau. National Assembly report 1133 (14th legislature), Senate report 658 (2013–2013)
Topical public hearings
The French seeds industry: Inventory of fixtures and prospects, by Mr Jean-Yves Le Déaut and Mrs Anne-Yvonne Le Dain, MPs, and Senator Bruno Sido
Assessment of how pain is presently taken into account and medical prospects for its improvement, by Mr Jean-Yves Le Déaut and Mrs Catherine Lemorton, MPs, and Senator Bruno Sido
Drones and the security of nuclear plants, by Mr Jean-Yves Le Déaut, MP, and Senator Bruno Sido
The German energy turning point: Which lessons for the French energy transition?, by Mr Jean-Yves Le Déaut, MP, and Senator Bruno Sido
To build a new society and improve competitiveness thanks to environmental research, by Mr Jean-Yves Le Déaut and Mrs Anne-Yvonne Le Dain, MPs, and Senator Bruno Sido
The innovation principle, by Mr Jean-Yves Le Déaut, MP, and Senator Bruno Sido
The vaccine adjuvants: A disputed issue, by Messrs Jean-Yves Le Déaut and Jean-Louis Touraine, MPs, and Senators Bruno Sido and Corinne Bouchoux
The orientation of the national debate about the energy transition, by Mr Jean-Yves Le Déaut, MP, and Senator Bruno Sido
Ongoing studies
The issues and perspectives of epigenetics, by Messrs Alain Claeys and Jean-Sébastien Vialatte, MPs.
About the various uses of biomass, by Senator Roland Courteau.
The strategic issues of rare earths, by Mr Patrick Hetzel, MP, and Senator Delphine Bataille.
Digital technology in the service of health, by Mr Gérard Bapt, MP, and Senator Corinne Bouchoux.

The author

JEAN-YVES LE DÉAUT, MP, has been a member of parliament representing Meurthe-et-Moselle in the French National Assembly since 1986. He obtained a PhD in science from the Université Louis-Pasteur in Strasbourg and is now president of the OPECST (Office Parlementaire d'Évaluation des Choix Scientifiques et Technologiques [Parliamentary Committee for the Evaluation of Scientific and Technological Choices]). He has also been Vice-President of the Conseil Général in Meurthe-et-Moselle and was First Vice-President of the Lorraine Regional Council from 2004 to 2013, in charge of higher education, research, innovation and economic development. As a parliamentary commissioner, he was given the task of enshrining in proposed legislation the conclusions of the Assises de l'Enseignement Supérieur et de la Recherche (the Higher Education and Research Conference) by the Prime Minister, and in January 2013 submitted his report, *Refonder l'université dynamiser la recherche: Mieux coopérer pour réussir* [*Reshaping universities, revitalising research: Improving cooperation for success*], which was extensively incorporated into the law on higher education. In particular, he regretted the fragmentation of the French university system and called for the creation of communities of universities and higher education establishments. In his role at the OPECST, he has produced more than a dozen studies, including of biotechnology; renewable energy; the information society and internet governance; and questions at the heart of science–society controversies, such as nuclear waste, asbestos and genetically modified organisms.

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11 Science and society in Morocco: what role for public understanding of science?

Aziz Bensalah

This paper describes the public understanding of science (PUS) landscape in Morocco and the genesis of the National Network for the Promotion and Dissemination of Scientific and Technical Culture (known by the initialism RNCST), of which I was the coordinator from the RNCST's inception in 2008 until November 2014. The paper is not exhaustive; interested readers can fill out the story told here by referring to Dessajan & Ramos (2006) and Mikou & Bensalah (2012).

11.1 The need for action

In recent years, in its urgent quest for development, Morocco has shown a reformist excitement that is at once political, economic, social and cultural. This has resulted in many development projects and many bodies supposed to ensure their proper conduct: the National Council for Human Rights; the Higher Council for Education, Training and Scientific Research; the Economic, Social and Environmental Council; the National Council of Languages and Moroccan Culture; the Advisory Council for Youth and Community Action; the High Authority for Audiovisual Communication; and so on.

The symbol of this 'Morocco of renewal' undoubtedly remains the current Moroccan Constitution, adopted by referendum on 1 July 2011. Decidedly progressive, putting human development at the centre of Moroccan social concerns, containing many assertions, proclamations and decisions to be translated into fact, it is the driving force behind the many development projects dedicated to profoundly transforming the society. The projects have the full attention of state institutions, active political, union, cultural and community forces, and the media.

However, despite these promising development activities, and without prejudging future outcomes, it is also clear that a major project is conspicuously absent: an analysis of the role of science and technology (S&T) in Moroccan society.

Obviously, in Morocco as elsewhere, economic and social progress and human development are conditioned by the place given to them, and especially by their levels of dissemination and individual and collective appropriation. In this respect, it is fair to say that science and the science and society relationship are in crisis in Morocco. The dialogue between science and society is typified by a mutual indifference between science workers' and the public's opinion in a context of distrust of the public education system.

For the first time in a Moroccan constitution, the 2011 document mentions the need for public authorities to:

> facilitate the access of young people to culture, science, technology, art, sport and recreation, while creating the conditions for full deployment of their creative and innovative potential in all these areas.

However, what was announced as good news about S&T in the following year (Mikou & Bensalah 2012) has gone practically unheeded. Today, as yesterday, the role of S&T in Moroccan society is not on the agendas or in the programmes of the Moroccan political parties, is not subject to any debate in the national parliament and is absent from the media. That it is more or less, even unconsciously, equated with problems of higher education and scientific research cannot justify the omission.

How is it that Morocco, as a developing state, cannot manage to initiate its science project? It is certainly not because of its history, or economic and social changes since independence, or the current democratic process, but because the traditional activists are dormant on the issue and the state is slow to provide the necessary impetus.

For a decade or so, an associative movement of scientists, science communicators and others has been working to put S&T at the heart of Morroco's development agenda. The aim is to allow the country to move towards individual and collective appropriation of S&T through the vigorous development of the public understanding of science (PUS).

This project was not planned in advance, so 'the path was made by walking along it'! It was the subject of a survey and study in 2006, almost at its beginning (Dessajan & Ramos 2007). Even now, that study remains important for understanding the current landscape of PUS in Morocco. Similarly, in a synthesis published six years later (Mikou & Bensalah 2012), we exposed the problem of PUS in Morocco. The problem was a driver for the creation in 2008, by the National Centre for Scientific and Technical Research (CNRST), of the National Network for the Promotion and Dissemination of Scientific and Technical Culture (RNCST). This network of academic clubs dedicated to PUS was a recommendation of the study by Dessajan and Ramos (2007).

11.2 Non-operating assets

11.2.1 Post-independence development

Post-independence Morocco has been through most of the changes experienced by post-colonial societies: mass education; industrial and agricultural development; a multiplication of institutions of higher education and research; an explosion of traditional and new media; and, recently, more freedom and democracy.

The world's advanced economies went through similar changes during their development, and it is arguable that those changes made possible the development of S&T in those economies and then maintained it.

So, why have these factors not produced the same effects in Morocco and similar countries, even on a smaller scale? Why have they not caused significant and continuous production of added scientific and technological value?

We could always question the system of education and scientific research, or stress that industrial and agricultural development can occur in the absence of domestic firms doing R&D, but to me that seems like mistaking a consequence for a cause.

In my view, the main reasons are that the development of S&T in a society depends heavily on public awareness of S&T in that society. What in the Western nations was a natural outcome of a long accumulation of scientific knowledge or, particularly in Asia, resulted from more recent policies to support a new scientific and technological revolution, has yet to be built in Morocco.

11.2.2 History and values

Morocco is a Muslim country: Islam is taught not only in mosques but in primary schools. The 'cultural ontogenesis' of Moroccan citizens is naturally and strongly marked by the history of the wider Muslim world and the values advocated by Islam, but with a strong dose of Western culture in urban areas.

Morocco took part in the Arab–Islamic 'Golden Age', marked by learning and teaching in madrasahs (precursors of universities), which internalized respect for empirical learning among educated Muslims, particularly in the Maghreb (roughly, North Africa minus Egypt) and Andalusia (Muslim Spain). The emotions that an evocation of the Golden Age causes among the Moroccan people are astonishing; it is a source of both pride and pain (people are missing it!) for those who know much about it and those who do not.

The scientific and technological heritage from this era remains visible in monuments, artefacts and literature. It included contributions, some derived from earlier Greek or Indian thinkers, some original, but most new to people in Europe, in chemistry, geometry, art, mathematics, medicine, astronomy, mechanics, military technology and civil, hydraulic and agricultural engineering.

There is a strong affective link between Moroccans and this heritage, but it is hardly used by the Moroccan authorities to boost awareness of and interest in S&T. The Ministry of National Education (MNE) continues to ignore the relevance of the history of S&T, particularly the Muslim history, in its educational approaches for young students. In contrast, the French La Main à la Pâte Foundation offers two educational projects in this area to students from elementary schools and from colleges: 'European discoveries' and 'The discoveries in Islam', based on two books with those names. In 2010, in collaboration with La Main à la Pâte and an MNE service, RNCST tried to implement an experimental project along those lines in Morocco, but after a promising start the attempt was aborted.

Islamic values in connection with science are expressed in many verses of the Qur'an and some *hadiths*. However, a verse from the Qur'an and a *hadith* symbolize what the relationship between Muslim and science should be:

- 'Ask those who know if you do not know.' (Sura 21, verse 7)
- 'Seek science, even though it would be in China.' (the *hadiths*).

In Morocco, as elsewhere in the Muslim world, people in general are convinced that these religious values were the foundation of Islam's Golden Age, so why are they not a stimulus for S&T development and the appropriation of S&T? And why not, when everyone in Morocco—rulers, elites, citizens—wants to 'catch up' with the Western countries? How is it that the Moroccan elites, in particular, who so enthusiastically claim ownership of the Golden Age, have so little impact on the science–society relationship in their own country?

11.2.3 Technological consumption

Moroccans, including rural residents, are consuming technology at an ever greater rate. People not only use mobile phones, satellite televisions, domestic appliances and solar collectors but are also confronted by other new technologies in public transport, health services and education, and of course young people share in the craze for using social media.

Moroccan citizens of all ages are strongly affected by technological change. Some are coping with it very well; others—the majority—feel disoriented. It is no longer possible for the government to ignore the great socializing power of these technologies, which are ultimately based on science.

In the cities a very successful informal sector has sprung up, based on the diffusion of ICT. Most of it is located as groups of shops in medinas or in flea markets, where it sells, installs and repairs all types of computer, electronic and telecommunications equipment. The clientele sees these 'ICT centres' as temples of technology; it is very impressed by the technical know-how and ingenuity of the service providers, who are mostly young people. One does not know *a priori* whether they are graduates or have learned on the job!

11.3 The PUS movement

11.3.1 Motivations

While the PUS movement in Morocco is united in the belief that, by 'allowing understanding, development and widespread use of science and technology', PUS is a key lever for the development to which Moroccan society aspires, the movement has many motivations. Nevertheless, one can distinguish three broad categories:

- The first is an extension of educational concerns: the assimilation of the scientific method, knowledge of scientific facts, and knowledge and mastery of

technology.
- The second resonates with decision-maker concerns: fighting the disaffection of young people with science subjects, strengthening the research sector, facilitating the penetration of science into industrial practice, and promoting the spirit of innovation.
- The third is a social solidarity commitment through the fight against the knowledge divide in a country officially engaged in the fight against the social divide through its National Human Development Initiative.

If it is necessary to locate our PUS movement in relation to theoretical referents, I would say that we apply the deficit and contextual models, along with, little by little, the participatory model.

11.3.2 The paradox

Developing PUS in Morocco might seem, at first, a hard task in the light of the country's:
- weak education system
- near absence of media
- lack of science infrastructure (science centres and museums)
- lack of big S&T events (science days, festivals, fairs, and caravans)
- illiteracy rate (although that is decreasing)
- large regional, social and gender differences (although gender differences are decreasing as a result of specific programmes, such as boarding facilities for girls in rural areas)
- abundance of unemployed graduates.

The public is greatly diverse in age, social background, education level, spoken language and educational language.

Despite all this, as already pointed out in Mikou and Bensalah (2012), Morocco is a favourable ground for PUS development because there is now a strong and increasingly expressed societal demand. Evidence for this assertion includes the success of numerous, even though modest, PUS actions carried out for multiple audiences, and the international partnerships that the PUS movement has put in place in a short time. Thus, the current PUS commitment is a commitment for the future.

11.3.3 The actors as a whole

PUS associations in Morocco, which are mostly open to all citizens, have different forms. They include national and regional networks; national, regional and local associations; private and non-profit organisations; and academic associations. The most prominent are:
- at the national level, the Association of Life Science and Earth Teachers, the

Moroccan Association of ‘Petits Débrouillards’ and the RNCST

- at the regional and local levels, the Nature and Heritage Association (an RNCST member) and the Consortium for Environment and Heritage of the Oriental in the eastern region, and the Sigma Foundation in Tangier.

In addition, some associations, scientific departments and laboratories in universities or enterprises are working to strengthen the research and innovation sector. Formed by researchers and technical executives, they are currently on the fringe of the PUS movement but could soon interact with it, perhaps via the participatory model.

We use many of the methods, tools and practices of the PUS movement elsewhere, but adapt them to specifically targeted local audiences, ideally taking into account expectations (that one perceives), needs (that one assumes) and capacities (that one estimates). For the most common practices (exhibitions and thematic workshops), the scientific method and interactivity are, in principle, at the heart of the action.

Our most successful activities are those on national issues that speak directly to the public (exhibitions and workshops on Arab–Muslim sciences, biodiversity, sustainable development, natural disasters, marine pollution or water stress) or allow people to communicate on internationally hot topics (conferences, debates and *cafés scientifiques* on science and food scandals, loss of biodiversity and climate change).

The cost of these actions, excluding international projects, is always modest. Financial and logistical support come mainly from:

- the only two Moroccan institutions of which PUS is an official mission—the Hassan II Academy of Science and Technology (AHIIST) and the National Centre for Scientific and Technical Research (CNRST)
- foreign cooperation services or organisations—the French Institute of Morocco, the British Council, the German Technical Cooperation Agency and the Swiss Agency for Development and Cooperation.

The main difficulties that we face in organizing activities are in recruiting scientific presenters (who are mostly student volunteers) and quickly training them for the specific activity. Morocco has no professional or academic training for scientific presenters and mediators. Dessajan & Ramos (2007) addressed the issue of the professionalization of the PUS field in Morocco in 2006, but it is clear that professionalization has not advanced since. The relative optimism at that time is contradicted by today’s reality.

Another type of difficulty concerns the academic associations. Working within public institutions, they are subject to the administrative and financial regulation in force in the public sector in Morocco. Our public regulation is excessive, fairly inflexible and bureaucratic (as everywhere?), and can be totally unsuitable for some PUS actions. The academic actors say that it is the main limiting factor on their potential for action.

11.4 The RNCST and the education sector

Although some RNCST activities are open to the general public, most target high school and university students. They include local club activities, some annual events (three of which have gained reputations outside Morocco[1]), actions in the framework of international projects, and actions for PUS institutionalization in Morocco.[2]

Because the education sector is so important in PUS, the RNCST focuses much effort on strengthening the role of S&T in that sector. It initiates and implements pilot projects in partnership with educational institutions, which it hopes will generalize the projects if they prove positive. In addition to the experiment conducted with La Main à la Pâte involving elementary schools and colleges (see Section 11.2.2), I will cover two other pilot projects here: one for high schools, on science museums; the other for university students, on scientific communication.

11.4.1 Training in scientific museology

In 2013, the RNCST helped to organize the first scientific museology training in Morocco. We were partners with the CNRST, the National Centre for Educational Innovation and Experimentation (part of the MNE) and the Office of Museum Cooperation and Information (OCIM, University of Bourgogne, France). The project had the support of the AHIIST and the French Institute of Morocco.

The course, titled 'The management and mediation of heritage collections in relation to public understanding of science', ran from 22 to 24 October 2013 in Rabat. The training aimed to develop the skills of personnel to take part in the management and presentation of S&T museums in high schools and universities. It had two components:

- providing knowledge on museums' approaches to conservation/management, mediation and valorization
- developing mediation activities for young audiences as part of leisure or school visits.

The course was delivered by four trainers from the OCIM, and was attended by 17 people: 10 teachers from five high schools, three university professors, two technicians, one administrative officer and one doctoral student.

[1] Festival du film scientifique, organized by the Club of Scientific Journalism, UCAM, Marrakech; La traversée de l'Oriental, organized by the Association for Nature and Heritage, University Mohammed I; Journées scientifiques, organized by the Natural History Museum of Marrakech, UCAM, Marrakech.

[2] 1st International Conference in Morocco on Scientific and Technical Culture, 'The Scientific and Technical Culture in Morocco: Outline of the state of art and prospects of a national policy in the light of foreign experience', 26–28 October 2009, Rabat; 1st International Conference in Morocco on the relationship between Science and Society, 'Science–Society: Building a creative relationship in Morocco', 25–27 June 2012, Rabat.

It involved three one-day sessions in three different institutions:

- 'Collections and welcoming the public' at the Scientific Institute of Rabat (Mohammed V University), which houses the National Museum of Natural History
- 'Designing mediation activities for young audiences in museums' at the CNRST, which houses several exhibitions, including two bilingual ones ('Quand les sciences parlent arabe' in Arabic and French[3]; 'Knowledge of Moroccan biodiversity' in Arabic and English[4])
- 'Project approach to preserve collections and diversify mediation' at the Lycée Hassan II, a prestigious high school dating from 1919 (when it was Lycée Gouraud) and featuring a fine collection of scientific objects.

For us and for our partners, this course was an experiment to test working methodologies, tools and organizational factors. It was very successful and created a great stir among teachers and school administrators. We are now working to have it reproduced and extended by the MNE.

11.4.2 'My thesis in 180 seconds' competition

The development of PUS is certainly inseparable from that of science communication, and the gap between developed and developing countries is large in both areas.

The RNCST has long advocated the development of science communication in Morocco. One of our founding organizations was the Club for Scientific Journalism at the Marrakech Cadi Ayyad University (UCAM).

At the 2012 international conference on the science and society relationship, two workshops strongly advocated the creation of a branch for 'scientific journalism' in the main school of journalism in Morocco and 'science communication' masters courses at universities, along with units on scientific communication in all science courses.

In May 2013, the University of Lorraine, with which we have an excellent cooperative relationship, proposed the participation of Morocco in the first international edition of the French-language 'Ma thèse en 180 secondes' ('My thesis in 180 seconds') competition, to be held in the following year. The competition is open to PhD students and dedicated to scientific communication, and we were keen to have Moroccan students compete.

The Moroccan contribution was organized by the CNRST in partnership with the Mohammed V University in Rabat, UCAM and the University Mohammed I in Oujda. It consisted of three regional qualifiers in three academic areas, organised by the three university partners, and a national final. In each region, 30 candidates were

[3] Interactive exhibition conducted in 2005 by the Orléans Sciences Centre, the French Culture Centre and Cairo Cooperation with the support of the Ministry of Foreign and European Affairs; attributed to CNRST/RNCST by the ministry in 2009.

[4] Exhibition in 2011 by the CNRST/RNCST and the Moroccan Association for Biodiversity, with the support of the British Council.

selected, in proportion to the number of graduate schools at each university. Three trainers from the University of Lorraine conducted mandatory two-day training for the three groups of candidates in each region.

The challenge was great: to ensure that each candidate could deliver a three-minute address meeting the criteria of the competition (scientific structuring, simplification, scientific popularization, involvement, charisma) to an audience of other candidates and faculty members involved in organizing the competition.

The exercise was all the more difficult for candidates whose science education has been provided in Arabic in secondary schools and in French at university.

The training paid off in two ways: it developed the communications skills of the candidates very rapidly, and it created links between PhD students from different disciplines.

The regional play-offs and the national final were tough but fair and friendly. In our opinion, the highlight was the audience's reaction: scientists and laypeople alike were astonished at how well the candidates communicated science.

11.5 Conclusion

Reformist Morocco is at a crossroads. A reasonable optimist might see it as an emerging country on a steady development path; a reasonable pessimist, without being alarmist, might see that it is not well equipped to meet the challenges of development. Both would agree that the future role of S&T in the country's development is central to the development project: S&T must be embraced by all segments of society, and without delay.

We in the Moroccan PUS movement understand this national priority and have pressed ahead. After about a decade since our movement was first organized, we have managed to influence and make some gains in the secondary and tertiary education sectors, triggering a positive dynamic. However, we are aware that this process is far from irreversible. We will operate in a fragile environment until we institutionalize and, to the extent that we can, professionalize science communication and PUS activities in our country.

Naturally, most of the power to achieve institutionalization and professionalization lies with the state and the political forces in Morocco. We call for legislation to launch a national initiative to appropriate S&T for the whole nation and to create a Science and Technology Observatoire.

The second most powerful actor is Morocco's combined intellectual, scientific, cultural and even artistic elites, which have already backed the idea of building a 'knowledge society' in our country. However, they neglect to promote a national debate about that proposition, particularly by ignoring PUS. They should reflect on and study this question, anticipate societal responses to S&T, and stimulate public discussion and government responses.

The third most powerful actor is made up of Morocco's universities and their associated research organisations. They should take on five urgent social and moral missions:

- Initiate research and establish courses in ‘Science, technology and society’.
- Establish courses for professional science communicators.
- Strengthen scientific culture among all students.
- Create and institutionalize links, based on science and science communication, with primary schools, high schools and colleges.
- Overhaul their systems so that they can share scientific knowledge with all Moroccan citizens.

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Part 3: Closing remarks

12 Science communication and democracy

Bernard Schiele, Joëlle Le Marec and Patrick Baranger

It should first be noted that the topic here is science communication and not scientific discourse. A primary scientific discourse is one produced by a researcher for another researcher. Science textbooks fall into this category, and such discourses are generally geared to specific audiences. Science communication, on the other hand, is not aimed at specialists but at a broader, more disparate, audience. This means that communications about science geared to lay audiences and delivered via various types of media, including the printed press, radio, television and the internet (Jacobi 1999, Schiele 2001), are received and interpreted in a cultural, institutional and political environment that is broader than the scientific context of the original discourse (Gregory & Bauer 2003). They also get caught up in issues of professional communication and the general business of media and networks that generate a very heterogeneous social structure.

Our focus here is on science communication in the areas of professional communication and media, apart from the strictly educational and cultural fields. This paper investigates contemporary modes of science communication in society. We wish to show that, contrary to the spirit of the Enlightenment, which fostered the free flow of ideas in the public sphere, making it a condition of democratic debate (Habermas 1978), science communication is today beset by many and varied attempts to control it, and which ultimately threaten the relationship between science, an informed public, and the functioning of democracy.

12.1 Knowledge and democracy

Modern democracies entertain a seminal, and essentially political, relationship with knowledge and its dissemination. In his *Cinq mémoires sur l'instruction publique* (1994), Condorcet analyses how knowledge begets freedom and how shared knowledge is a fundamental safeguard against an absolute monarchy, tyranny and other more modern forms of totalitarianism. Republican and democratic citizenship is practised through voting, and this voting can only have real democratic power if citizens are enlightened by genuine knowledge. Voting is the constitutive tool of democracy, but a vote 'clouded' by ignorance, fanaticism, prejudice, disinformation, propaganda etc. would be a sham democracy. The appropriation, retention, secrecy, concealment, or non-disclosure of knowledge and also its distortion, misrepresentation, deformation are prime obstacles to democracy.

Dewey further pursues this analysis of the relationship between knowledge and democracy, seeing individuals not as isolated but as continuously immersed in social interactions, and thus constituting a 'public'. In this sense, freedom—the essence of democracy—is the opportunity to participate in social and political life, to actively 'live together'. This activity entails a cognitive practice, a process of learning, socially and politically through inquiry (Dewey 1938). Such inquiry, or investigation, has its roots in the methodology of scientific research, and is akin to inquiry in investigative journalism. The 'public' is invited to be informed, and any appropriation of knowledge runs counter to the exercise of democracy.

12.2 Science is everywhere

In an article entitled 'Ce qu'il faut de culture (scientifique) pour lire un journal quotidien' ('The science you need to know to read a daily paper'), Daniel Jacobi (2005) noted that, while science and technology (S&T) appear in *Le Monde*, they are not major news themes. They are simply mentioned here and there, by chance. This might suggest that science news is getting short shrift, but that conclusion would be misleading. More significantly, Jacobi further shows that 'science and technology is mentioned almost everywhere' in the paper, 'in keeping with the space they represent in our society'. So, tallying science news coverage by analysing the sections that explicitly write about science does not give an accurate picture. It blurs just how regularly those themes do appear. In fact, S&T are omnipresent in the newspaper, 'in every section without exception. In the social and business pages, and also in those devoted to contemporary art'. In today's world, S&T are everywhere, wrote Jürgen Habermas (1973): newspapers give them vent 'because they infiltrate all the social concerns relayed to their readers'. This implies that reading a daily paper to get information, to understand and interpret, requires a core knowledge of S&T as a basic reference and guide.[1]

The evidence suggests that what we see in newspapers generally applies to the entire media field, resulting as it does from the unprecedented expansion of the means of communication starting in the 1960s, when television went global and became the benchmark *par excellence* of the media world.[2] Media, especially TV, became the realm of choice, where social and cultural realities converge and articulate. Society defined itself in and through the dynamics created by the media, which in turn served as catalysts for social and cultural change. This same period saw the shaping of a communications utopia summarized in the metaphor of the 'global village' (McLuhan 1962, 1964)—a society recast as informational beings, or 'social beings completely defined by their capacities to communicate socially' (Breton 1977: 51). Today, the internet symbolizes that recast society. So it is natural to assume that the diversification of sources, the access to data and the constant interaction through a widening range of traditional media also help to create 'new

[1] Of course, readers will sort and filter sections according to their interests and spontaneously pick the subjects that interest them, but this does not change the reference to S&T.

[2] The first televised US presidential debate, between Nixon and Kennedy on 26 September 1960, was watched by 70 million viewers. It is considered to have been the turning point: from then on, everything went through television. The second such moment, broadcast worldwide, was the live transmission of Neil Armstrong's first steps on the Moon on 21 July 1969.

knowledge areas' that may lead to a 'collective intelligence' (Lévy 1999). In other words, S&T should not only be everywhere in an intensely communicating society but must also openly reflect S&T's own self-generated debates, if only through a cross-control exerted by those involved in the media and networks as if the authenticity of reported facts and the objectivity of debates would be guaranteed by a increasing number of media points and interactions.

Yet, in every society, 'the production of discourse is monitored, selected, organized and recast, all at the same time, by a certain number of procedures that play the role of guarding against its powers and dangers, of managing unpredictable events', wrote Michel Foucault (1971: 10). And this applies today, despite the proliferation of modern means of communication that lay claim to transparency and openness. There is something skewed about producing scientific knowledge whose potential must be channelled and whose would-be risks curbed.[3] We see serious actions being taken to limit the scope of science discourse circulating in the social field. This is short-circuiting democratic debate.

However, explicit control procedures that apply to information such as classified military secrets or industrial and government secrets must be distinguished from implicit procedures. Our focus here is on implicit procedures precisely because they are hidden and conceal 'the why' and 'the how we struggle' (Foucault 1971: 12).

Thus, the question of communicating science to the general public, from popularizing to publicizing, no longer raises issues concerning the required competency and skills. For many years, researchers queried which means of communication would best convey scientific information to the public. That question no longer applies. Knowledge and know-how are now constantly updated and widely circulated through research and the development of new communication practices (websites, web media, social media, blogs and so on), and training is available on a global scale. Scientists themselves are students of communication, and have included many outstanding writers (Hubert Reeves, Stephen Hawking), interviewers (Etienne Klein) and TV and radio hosts (Jacob Bronowski, Carl Sagan), among others.

The real problem concerns the nature and form of the information being purveyed or which should be purveyed. To distort information or to distract the public from information deprives individuals of the opportunity to make real choices. It withholds their right to make enlightened decisions about their own lives, and to understand the role that S&T plays in an evolving society (Shortland & Gregory 1991: 6–7, *passim*). Only to the extent that people are informed can they form valid

[3] For example, the physicists who, with a sense of urgency, worked determinedly towards the completion of the Manhattan Project, convinced that Nazi Germany was also working on the creation of an atomic bomb, were the first to understand that mastering nuclear energy would irrevocably change the course of all human history. Niels Bohr, to mention just one of them, immediately realized that it would be impossible to keep the secrets of the bomb's production because there would be an atomic arms race as soon as the first one had exploded. He vainly tried to convince Franklin Roosevelt and Winston Churchill to reveal the secret once the war was over and to hand over surveillance to an international organization, as he was convinced that a more open world would be less subject to conflict. Roosevelt and Churchill, refusing to reveal anything whatsoever to the Soviets, brushed off his proposal. The Cold War started well before the end of World War II. See Rhodes (1986: Chapter 16).

opinions on the nature and value of science. Communicators and scientists are adamant that the exercise of democracy today demands that scientific facts be brought to public attention and critically discussed.

12.3 Recent changes in science communication

To understand the current issues affecting science communication, we must examine recent transformations in the written press and journalism in general, and the factors propelling these changes.

Up until World War II, many scientists were helping to circulate scientific thinking and the spirit of science. In the tradition of the great 19th century popularizers, it was normal for many already well-known scientists to share the results of their work with the public at large, and by the late 1940s science had achieved a pinnacle of prestige. In the United States, the Manhattan Project exemplified the power of fundamental research and led to the creation of the atom bomb (Rhodes 1986). Based on that contribution to military success, science was expected to serve social and economic progress just as effectively. With the media extolling a positive image of science and with public funding of research, the scientific community sought to enhance its own interests by drawing closer to a media culture that both highlighted and glorified scientists. During the 1950s, the scientific community began promoting an image of science 'as a guardian of democracy and cultural values' (Gregory 1988: 77).

While journalism had become a structured profession before the research field did, the science journalist as such really only appeared in any numbers during the the 1950s,[4] a more or less golden age for the image of science. Science was grabbing headlines and enjoying ample media coverage. Scientist and writer C. P. Snow (1956) predicted that scientists, and especially the hyper-popular physicists, were key to the future, while literary culture, for all its tradition, would become mired in the past. The space race between the United States and the Soviet Union (after its successful launch of Sputnik, the first artificial satellite) further reinforced a positive perception of science, waiting to conquer the last frontier.

A threefold shift occurred in the late 1960s. First, science journalism became autonomous, asserting its independence at arm's length from science. Science journalists became 'sceptics' in a 'spirit of free inquiry' (Gregory & Bauer 2003: 48). They began questioning the ability of scientists to speak to the public and touted their own legitimacy as professionals. They saw themselves as the ideal intermediaries between science and the public.[5] As a result, the scientists so accustomed to the spotlight faded into the background (Schiele 2005). Ill at ease with a TV

[4] Of course, there were journalists covering science as early as the 19th century, but we had to wait until the 1930s for science journalism to become a specialist area. England, for example, had only three science journalists in 1930 (Calder 1964).

[5] For an idea about the evolution of the relations between media professionals and researchers in television programs on the question of legitimacy, see Babou (2004).

culture that redefined the rules of media discourse and demanded new skills, scientists made their own retreat. Second, science journalists began criticizing scientific development that wrought negative impacts and noted the risks associated with major technological changes that affected social organization, the environment and health. Third, the investigative journalism they advocated took hold in the early 1980s when environmental issues became important social concerns. Henceforth, the media were suspicious of science.[6]

Spurred by the OECD, governments sought to reverse the trend by adopting policies promoting science. Public ignorance was identified as the culprit. Measures were implemented to boost the visibility of science and inform the public, since a better-informed public would embrace science more favourably and more young people would choose scientific careers. This was the premise for programmes developed from the 1980s to the early 21st century and aimed at highlighting science.

That era also marked the beginnings of changes in the press and other media that would transform the journalism profession and with it science communication. Along with, and part of, the economic changes of the time, government's role in science was also evolving. The printed press, which until then had set the tone, now had to contend with TV and was increasingly beset by rapid changes in cultural habits as new communication technologies relentlessly entered daily life. This was accentuated by the increasing convergence of the various media. Daily newspapers were going out of business, and those that remained were restructuring by cutting the number of permanent staff in the newsroom. Science journalists were among the first to go, and many ended up as freelancers (Göpfert 2003). Observing the effects of this developing cyberculture, Brian Trench (2007: 133) pointed out that 'it is plausible to claim that journalists have been more thoroughly affected by technological change in recent decades than any other occupational group. In the cross-connection of these processes science journalism is being redefined'. Newcomers from different horizons were entering the field of science communication, which increased the number of sources of information but also served to 'challenge the established mode of science journalism' (Trench 2007: 133). In other words, the frontiers between different professions were vanishing, and it became harder to distinguish between scientific and quasi-scientific news or to affirm the validity of the scientific stance. The multiple viewpoints about science added to this shift, while the internet became the hot spot where different discourses confronted each other.

[6] Note that from the 1970s onward, these trends went hand-in-hand with an intense critical reflection on the technosciences, which accompanied and often linked up with movements of intense social and political protest (the struggle against military intervention in Vietnam in the United States, protests against energy policy choices in France, the beginnings of the environmental movement following the Club of Rome declarations).

12.4 More power to PR

The fields of science and journalism, particularly investigative science journalism, share a common objective—the search for truth. Their approach is based on 'methodical doubt' (a form of scepticism, etymologically speaking), precision, objectivity and, of course, actual demonstration. But their search also requires open-mindedness and transparency. The term *openness* covers both intentions: to pursue all avenues of inquiry, and to keep an open mind. Scientists therefore demand the right to debate questions freely and without constraint, to advance their goal by finding and signalling mistakes and misconceptions. The famous Lysenko case illustrates a distorted use of science bent on bypassing its own rules (Salomon 2006: 145–164). Science journalism, and the media in general, share as an ideal principle the pursuit of truth and seek to apply it to society as a whole. Questions, debates, issues and facts must be brought to public attention as a necessary condition for democracy. And science, like everything of public interest, must be open to debate.

A classic case is the outcry by journalists in France at Minister Emmanuel Macron's announcement[7] that he would include an amendment[8] to the law (the so-called Macron Law) that would protect business secrets and would make journalists who disclosed 'sensitive' information or 'business secrets' liable to fines and imprisonment.[9] The proposed law was roundly denounced by journalists as 'a weapon of mass dissuasion'. This issue pointed up the importance of freedom of expression as crucial to the democratic ideal, and the extent to which it is under constant threat. Several days before the amendment was withdrawn after an overwhelming and unanimous reaction from journalists who declared 'information is not a criminal offence', they wrote:

> Under the Macron Law, you would never have heard of the Mediator scandal or the asbestos scandal, or of Luxleaks, UBS, and HSBC concerning tax evasion, of the hidden strategy of tobacco giants, or again of the Elf, Karachi, Tapie-Crédit Lyonnais scandals, or of the Amésys affair, named after the French company which helped a dictator to spy on his people. And there's more … (*Le Monde*, 28 January 2015)
>
> After the dramatic 'Charlie Hebdo' events, and the massive demonstration in Paris by two million people to defend freedom of the press and freedom of expression, such a cynical amendment is equalled only by last year's discreetly shelved law, 'a law aimed at

[7] *Le Monde*, 30 January 2015.

[8] 'With this amendment', explained *Le Figaro* on 28 January 2015, 'a judge could be referred to by the company targeted by a journalistic inquiry. The judge would then, like an editor-in-chief, assess the interest or lack of interest of the information in question. If the article or the reporting infringed on a company's industrial secrets, the courts could then stop the publication of an inquiry. Thus it becomes more difficult for the investigating journalists to bring affairs to light. Companies would immediately deploy their new censorship weapon, permitted by the Macron Law, to protect themselves from scandals. Furthermore, journalists who have revealed sensitive information without the authorisation of a judge and the targeted company would incur a 3-year prison sentence and a fine of 375,000 euros.'.

[9] '"Business secrets" covers "non-public information, subjected to reasonable measures of protection" and which has "economic value".' (*Le Monde*, 29 January 2015).

> reinforcing the protection of journalists' sources'. (*Le Monde*, 30 January 2015)

Note, however, that this is but one skirmish in the battle to control and limit access to information sources and to regulate the circulation of information, all under the guise of economic security!

The weakening of the press, accompanied, as mentioned, by an increasingly concentrated media controlled by large and fiercely competing national and transnational groups, also coincided with an upstart internet, once seen as the spur to an ever-expanding public space. Both the press and the internet were subject to a realignment of science communication practices fomented by an economic discourse that put business at the core of the social project, while at the same time reducing the role of the state, as advocated by the neoliberal doctrine that has increasingly characterized the social model since the 1980s (Harvey 2005). This explains how:

> after the crisis in the mid-seventies, public representation of science underwent a total reconstruction: this representation is now an industry in itself. Modes of reporting and ways of structuring public attention are now closer to professional public relations than to the journalistic principles, admittedly less modern, of inquiry, education and the dissemination of knowledge. (Gregory & Bauer 2003: 56).

In a nutshell, the 'public understanding of science' now tended to merge with its 'promotion'. Enter the Macron amendment with its twofold aim: first, to restrict access to sources of information (that is, to control the information allowed to circulate in the social sphere by putting limits on the right to speak, from the science journalist to the whistleblowing blogger) and, second, to let companies and their agents be the sole arbiters of the nature and content of the information they wish to circulate—in short, to put a tight lid on what is said and who says it.

At the turn of the 21st century, Germany had 50,000 journalists and 16,000 relationists.[10] Seven years later, there were 70,000 journalists and 50,000 relationists. By comparison, in the United States in the early 1990s, there were 122,000 journalists and 162,000 relationists, while 10 years later the number of relationists had reached 200,000 (Göpfert 2007: 291). A similar upward trend is evident in England (Bauer & Gregory: 2007). The now-fewer newspapers and their downsized newsrooms (a situation equally affecting television), besides resorting to free sources of information, have often eliminated speciality pages and programmes (health, environment, science, and so on), and increasingly engaged temporary staff or freelancers as contributors. What's more, the new working conditions oblige journalists to 'deliver in real-time' to tight daily deadlines (Hansen 1994), without the time and resources to check information, and have encouraged the use of public relations sources. Television journalism has been affected in the same way.

By contrast, relationists can take the time to conceive, plan and orchestrate information campaigns. They have that advantage over science journalists, while for obvious reasons they maintain complex networks of connections by methods that range from providing free entry to conferences, to making exclusive material available, to covering fees and travel costs (Bauer & Gregory 2007: 44–48, *passim*).

[10] The term 'relationist' is used above all in North America, referring to positions such as communications manager, communications officer and press attaché.

Nor is job instability peculiar to science journalism. It is a result of the profound restructuring of employment under the 'new' capitalism (Sennett 2006, Boltanski & Chiapello 1999), which forces them to more readily accept such complimentary benefits when they are not holding down several jobs, including that of relationist! No wonder the public raises questions about the credibility of science communications (Bauer & Gregory 2007). Some 20 years ago, Dorothy Nelkin (1995: 160), analysing journalists' sense of betrayal by NASA following the *Challenger* space-shuttle explosion (28 January 1986), wrote:

> Fascinated with space technology, reporters had simply accepted what NASA fed them, reproducing the agency's assertions, promoting prepackaged information they received, and rarely questioning the premises of the program, the competence of the scientists or the safety of the operation.

The disaster reminded them of their responsibilities, which they had deferred to NASA's public relations department—responsibilities that are all the more important because science journalists are often the only source of information about science for the vast majority of the public.

But the transformations in the media world do not in themselves adequately explain the ascent of public relations. That rise is part of a broader movement involving both the privatization of research and a reorientation of its aims. Research now became driven by the potential to capitalize on its results. Innovation took precedence over fundamental research or, more precisely, fundamental research was henceforth geared to innovation. The distinction between applied research and fundamental research became fuzzy. In this new environment, preferment is given to research leading to commercial applications. And funding is granted with a view to creating conditions that push economic development (Etzkowitz 1983, 1989) to the detriment of other considerations. Nor are universities immune. Indeed, where science is concerned, they naturally adopt a logic of communication, advertising and public relations (Bauer & Gregory 2007: 44). Edward Bernays, famously the double nephew of Freud and dubbed the 'Father of Spin', stated right off in 1928 that:

> [The] conscious and intelligent manipulation of the organized habits and opinions of the masses is an important element in democratic society. Those who manipulate this unseen mechanism of society constitute an invisible government which is the true ruling power of our country. (Bernays [1928] 2004: 1)

Bernays is credited with being the first to hit on the idea of turning a potentially disastrous controversy to advantage; that is, turning an obstacle into an opportunity by changing public perceptions. He completely invented 'an apparently disinterested third party, which would serve as a credible intermediary between the public and the subject of controversy and modify how it was perceived' (Baillargeon 2005: v). In 1917, to support a theatre play that was tackling taboo subjects by speaking openly about syphilis, he set up a scientific committee composed of well-known personalities whose role was to present the theme as educational. He was to use this strategy again in 1917, when it was a case of convincing the Americans of the need to go to war when the majority of the population was opposed. The tobacco industry solicited him in 1929 when seeking to boost sales at a time when women who smoked were frowned upon. Arranged by Bernays, women hired to play militant suffragettes during a demonstration explained to journalists, also set up by Bernays, that their cigarettes were 'torches of freedom' (Brandt 2007)! The fantastic media impact induced women to start smoking cigarettes as a way to assert their freedom. The tobacco industry was to recall the expedience of 'third party' and other stalling tactics to distract public attention when researchers established the carcinogenic effects of cigarettes (see Oreskes & Conway 2010).

Today, the third-party strategy has gone a step further with 'astroturfing', which is a big hit on Web 2.0. This practice intentionally creates fake groups to serve hidden interests. They use the web to present themselves as spontaneous citizens' groups defending particular interests (see Boulay 2015). But what happens when, despite the odds, the scientific community mobilizes and successfully communicates in 'precise' and 'easily accessible' terms the social implications of collected knowledge on the environment and climate (Mann 2012: 253)?

12.5 Suppressing the production of new knowledge

Stephen Harper has been elected Prime Minister of Canada three times since 2006. Using the pretext of a need to achieve a balanced budget, he has in nine years completely reversed Canada's environmental policy, systematically undermined research in this field, and gagged scientists working for the government and government agencies.

In 1962, Rachel Carson published her groundbreaking book, *Silent spring.*[11] In denouncing the indiscriminate use of pesticides and the threat to wildlife and human health, the book helped bring about a global awareness of environmental issues, and the environmental movement emerging at the time was galvanized around a controversy never before experienced. *The limits to growth* (Meadows et al. 1972), published 10 years later, questioned models of economic development based on consumption and the untrammelled exploitation of natural resources. In 1987, the World Commission on Environment and Development, which advocated a radical change in modes of production and consumption, promoted 'sustainable development', taking into account the environment's capacity to support life and the lifestyle changes needed (CMED 1988). Public opinion was being mobilized during these years and Canada, a country whose sheer immensity bespeaks unspoilt nature, took an active environmentalist role in talks resulting in the Kyoto Protocol (1997). It developed policies and supported research aimed at protecting the environment.

One example of such action was the Experimental Lakes Area (ELA) programme set up in 1968. Experiments were conducted on the lacustrine ecosystems of 58 small lakes in northern Ontario. The results of the work on eutrophication spurred the government to enact legislation on detergent composition in 1973. Research into acid rain convinced Canada and the United States to conclude a 1991 treaty on air quality. Research on mercury led the United States to tighten standards in 2011

[11] The book was first published in serialized form in *The New Yorker* earlier that year.

and led to a global treaty in 2013. Further research efforts examined the effects of flooding, toxic contaminants and other concerns. The ELA programme's results have affected environmental policies worldwide (see Smith 2013). Yet, in 2012, Stephen Harper's government cut off this programme's funding.[12]

It would be naive to think that Harper's decision was motivated by the simple wish to balance the budget. The dire announcement of the end[13] of the ELA programme and of other environmental research programmes included the injunction not to communicate with the media or the public (Smith 2013, Turner 2014: 37). It was all to happen very discreetly. But the news got out. There were international protests by people appalled that a research centre that cost so little and achieved so much should be closed. It's 'what you might expect from the Taliban in Afghanistan', declared Swedish researcher Ragnar Elmgren (Smith 2013). Another researcher, preferring to remain anonymous, noted that '[t]he bulk of the cuts to scientific research programs come in the Prairie and Arctic regions, which have the most industrial development; the new Ring of Fire, the oil sands, huge industrial projects, it doesn't quite add up' (Smith 2013). So that's the upshot: sooner or later, environmental research leads to a fateful duel between public and private interests.

This closure is part of a deliberate strategy to control the production of knowledge, its impact, the statements of scientists and science communication. The government intends 'to make Canada the most globally attractive country for investment in natural resources' (Turner 2014). To reach that goal, it needs to minimize the risk of mobilized public opinion. It must snuff out information sources that foment public debate. So it abandons 'responsible management of the environment':

- 'by reducing' its capacity 'to gather fundamental data […] particularly in areas where a lucrative exploitation of resources is expected'
- by 'downsizing or eliminating offices and organisations'—both governmental and non-government—that 'survey and analyze this data and respond to risk'
- by attempting to 'seize control of the channels that all these organizations use to communicate their conclusions to Canadian public opinion (Turner 2014).

Scientific programmes were eliminated by the reassignment or outright dismissal of some 5,332 scientists or other professionals (Nelson 2013). While those cuts were purportedly justified by the need to reduce costs, this same government allocated a budget of $8 million to the Canada Revenue Agency to audit the accounts of environmental NGOs, claiming that they spent more on political activities than their charitable status permitted. A year and some 900 inspections later, only one miscreant had been found: 'a group campaigning in favour of nuclear disarmament' (Turner 2014). In effect, the government has been muzzling potential sources of dissent while simultaneously abolishing or severely limiting the scope of laws aimed at constraining the excesses of private economic interests.[14] 'The Harper Cabinet',

[12] To ensure its survival, in 2013 the provinces of Ontario and Manitoba took over the funding of this unique laboratory.

[13] It really was a closure, as the government terminated the researchers' contracts.

[14] The list of measures adopted by the Canadian Government can be consulted in *The Canadian war on science: A long unexaggerated, devastating chronological indictment*. See http://scienceblogs.com/confessions/2013/05/20/the-canadian-war-on-science-a-long-unexaggerated-

concludes journalist Joyce Nelson (2013), 'looks like nothing less than the New Inquisition dressed in a cowboy hat.'

This 'New Inquisition', which looks suspiciously like a new obscurantism emanating from a government blind to the effects of its own policies, is essentially an ideology that wants only an expedient science, a science subservient to the quest for innovation, whose sole goal is to maintain the 'process of industrial change that relentlessly revolutionizes the economic structure from within, relentlessly destroying the old one, and creating a new one. This process of Creative Destruction is the essential fact of capitalism' (Schumpeter 2008). This ideology disparages 'citizen science'—that is, a science 'aware of its social responsibilities', one that contributes to the 'knowledge capital and capacity for evaluation that every ordinary citizen can draw on in the domain of political debate and decision-making' (Salomon 2006: 393). The restrictions imposed on scientists, forbidding them to talk directly to media or speak in public without prior authorization, are part of this desire to control public debate.

As for accessing information sources, the same logic applies to the media. Since 2007, the Media Relations Headquarters, the government's public relations agency, coordinates all media requests. So, for example, after David Tarasick, a researcher who had detected an abnormally large ozone hole and reported the fact in *Nature* (Manney et al. 2011), was asked by a journalist for an interview, he replied: 'I am available when Media Relations says I'm available' (Davidson 2012). Similarly, during the International Polar Year 2012 Conference, Environment Canada sent a memo to its specialists, stipulating that:

- If you are approached by a journalist, just ask him for his card.
- Tell him someone from Media Relations will get back to him to set up an interview.
- A Media Relations rep will likely be with them during the interview to assist and record it (Munro 2012).

* * *

Ever since the Enlightenment, it has been felt that science, and thus today's science communication, must contribute to the public good, and that, in a democracy, it is the duty of government to defend it against all private interests, but now some wish to reduce science simply to a productive role: they want it to relinquish its autonomy and gear knowledge to practicality alone. Similarly, in their view, science communication should refrain from taking a critical stance and be content with fascinating people and promoting scientific vocations. Heaven forbid that it should try to inform citizens!

'Without a science-literate and politically aware populace,' wrote Michael E. Mann, 'there can be no match against well-funded, well-organized groups that place little value on honesty or integrity, that cleverly masquerade denialism as scepticism, and that are more than willing to state their own positions in the most absolute terms, while exploiting and indeed misrepresenting the frank admission of uncertainty by those they view as their opponents' (Mann 2012: 256).

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devastating-chronological-indictment/.

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Abbreviations and acronyms

4S	Society for Social Studies of Science
AHIIST	Hassan II Academy of Science and Technology (Morocco)
CAST	China Association for Science and Technology
CDSTM	China Digital Science and Technology Museum
CNRST	National Centre for Scientific and Technical Research (Morocco)
CRISP	China Research Institute for Science Popularization
EASST	European Association for Social Studies of Science and Technology
ECLAC	Economic Commission for Latin America and the Caribbean (UN)
ELA	Experimental Lakes Area (Canada)
ENSCOT	European Network of Science Communication Teachers
ESOCITE	Latin American Society for Social Studies of Science and Technology
ETP	economics of technoscientific promises
FRIPON	Fireball Recovery and Inter-Planetary Observation Network (France)
GDP	gross domestic product
GM	genetic modification
GMO	genetically modified organism
ICT	information and communications technology
IKS	indigenous knowledge system
KOFAC	Korea Foundation for the Advancement of Science and Creativity
KSF	Korea Science Foundation
MNE	Ministry of National Education (Morocco)
NGO	non-government organization
OCIM	Office of Museum Cooperation and Information (University of Bourgogne, France)
OECD	Organisation for Economic Co-operation and Development
PCST	public communication of science and technology
Picri	Partnerships between Institutions and Citizens for Science and Innovation (France)
PR	public relations
PSL	public scientific literacy
PUS	public understanding of science
R&D	research and development
RNA	ribonucleic acid
RNCST	National Network for the Promotion and Dissemination of Scientific and Technical Culture (Morocco)
S&T	science and technology
SCR	science communications research
SDGs	Sustainable Development Goals
SSS	social studies of science
STC	science and technical culture
STEM	science, technology, engineering and mathematics
STS	science and technology studies / science, technology and society
UCAM	Marrakech Cadi Ayyad University (Morocco)

Edited by Bernard Schiele, Joëlle Le Marec and Patrick Baranger

Science Communication Today - 2015

Current strategies and means of action

This book reports on the work of the fifth *Journées Hubert Curien*, which took place in Nancy, France, from 3 to 5 June 2015, in a meeting organized as part of the Science & You project. The theme of the conference was 'Current strategies and means of action'.

The fifth *Journées Hubert Curien* had four main objectives:

- Confront science communication research with science mediation practices.
- Reflect on and debate about science communication issues in different national contexts.
- Explore the citizen dimension of science communication actions.
- Analyse new science in society practices.

The papers presented in this book cover recent renewed interest in science communication and the reasons why policymakers want to communicate science. They describe how national contexts frame science communication actions and policies. They explore the public's demand not to be treated as passive consumers of information anymore, but as actors in their own right—not only in debates about the rightful place of science and technology within society, but also in those about research processes that affect or concern them. In this way, the authority and legitimacy of scientific knowledge are being questioned as new types of relations to knowledge are emerging.

This book brings together the 11 keynote addresses from the conference.

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ISBN : 978-28143-0236-5 PRIX : 12 €