|c|h|e|p|s|
Center for
Higher Education
Policy Studies

The challenges for 21st century science
A review of the evidence base surrounding the value of public engagement by scientists

Working paper prepared for the Science for All Expert Group

Paul Benneworth
Center for Higher Education Policy Studies (CHEPS)
Universiteit Twente
Postbus 217
7500 AE Enschede
Tel : 053 – 4893809 / 4893263
Fax : 053 – 4340392
E-mail : p.benneworth@utwente.nl

CHEPS, 11th December 2009

0 Executive Summary

0.1 Introduction and overview

The scientific world is profoundly affected by the changes taking place in the wider society of which it forms an essential part. Such is the scope and pace of the changes to contemporary society – driven by globalisation, the rise of new communications technologies, new economic competitors, and the collapse of traditional social structures – that science appears to face a crisis. The pace of change appears to have encouraged society to respond by blocking potential avenues for scientific developments, in a range of famous cases including BSE, nuclear power and GM food. Science and scientists depend on social approval for the freedom to carry out their experiments – their so-called licence to practice. Rising societal resistance to scientific developments has led to increasing calls for scientists to engage more with diverse public actors earlier in their discovery process, to create a fertile and welcoming environment for science inventions.

This problem has been slowly emerging in recent decades. In the 1980s, a movement known as 'Public Understanding of Science' emerged, the idea being that the public would be more supportive of scientists if they better understood the issues behind the science. A series of deep-seated crises gave lie to the idea that the problem was a deficit in 'public' understanding: sometimes the public understood but chose to reject scientists' interpretations. In the late 1990s, the idea of public engagement emerged, based on the idea that science's progressive potential requires broad public acceptance, which can no longer be assumed to be automatic. Instead, engagement allows the public to take a sense of ownership of science, to engage with issues, and ultimately, and collectively, to influence the direction of travel of scientific inquiry and progress.

In this working paper, we define public engagement by scientists as the activities where scientists meet with publics and have discussions which shape the practice of science. In part, public engagement differs from public understanding in that in engagement, there is two-way communication between scientists and publics. In some cases, publics even might evaluate or judge what those scientists have to say to some wider public end, such as in ethical debates around what is permissible in life science research. This working paper asks the question whether the increasing amount of activity makes a difference to improving the environment for science, and what certainty we might have whether further increasing engagement would further improve the UK's scientific environment. This paper reviews the evidence underlying this idea of public engagement, to better model the relationships between scientists and publics shaping science's special societal function.

0.2 The four external pressures on public engagement with the sciences

The review highlights four main societal changes which have affected the environment within which science operates, and which have increased the importance of engagement by scientists with a variety of publics.

- The loss of expertise and authority of scientists, alongside a series of rejection of expert advice by suspicious publics e.g. Bovine Somatotrophin, GM Food,
- A change in the nature of knowledge production, with increasing interaction and networking between partners within potentially closed 'innovation networks',
- Improved communications and a proliferation of sources of information, meaning scientists are in an increasingly competitive global 'marketplace of ideas', and
- The democratic deficit: the challenge to the mass-party system, with the emergence of single issue pressure groups and closed, populist movements.

The first driver has been that scientists have certainly in recent years seen the amount of deference they receive from the public eroded in a series of crises which have highlighted growing public scepticism towards the impartiality and fairness of scientific pronouncements. Despite this, scientists remain broadly trusted as the best placed to interpret and explain the impacts of their discoveries on society, and are certainly far more trusted than journalists, civil servants or politicians. There is strong concern in two areas: on the one hand, scientists exercise discretion in the scientific process, and there are public concerns that scientists are taking ethical decisions without due consideration of prevailing moral codes. On the other, there is a resigned disenchantment amongst publics that their engagement with scientists appears to have little tangible impact on the decisions affecting science policy which frame science's societal impacts. The first problem for science is how to allow the public to exercise some manner of accountability over scientific decision-taking, without science and scientists becoming a lightening rod for public dissatisfaction given a failure to take consultations seriously and with political disenchantment more generally.

The second pressure on scientists has come through an increasing recognition of the interactive nature of knowledge production process. Knowledge creation was long regarded as a linear pipeline, where governments funded universities to undertake basic science, which was applied through research laboratories and institutes, and implemented into innovative products in firms. This model creates a neat division of labour, between the impartial scientist, the ingenious engineer and the innovative entrepreneur yet fails to recognise that knowledge creation almost never follows a simple or straightforward route. In attempting to solve a corporate or public problem, the problem-solver will draw on a range of knowledges from a range of sources. What firms, laboratories and universities are all concerned with is ensuring that they have the right knowledges in the right forms so that it can be accessed and productively applied at the most effective point in the problem-solving process. But at the same time, this risks creating closed cliques between scientists, engineers and entrepreneurs which exclude wider publics, and which create very little public accountability around decisions which can profoundly change national ethical and moral landscapes.

The third pressure on scientists has come through the fact that they are increasingly competing with all manner of outlets offering their own versions of knowledge, facts, opinions and interpretations. Given that scientists have lost some of their public deference, and that other types of knowledge producer are increasingly accepted as equally or equivalently having legitimate voices, this means that debates about science often generate 'more heat than light'. Scientists may be forced to compromise their basic principles to be able to sell their knowledge in the global market-place of ideas, meeting media outlets demand for certain, quick answers at odds with the slow back-and-forth of the contemporary scientific process. Yet, failing to make these compromises raises the spectre of increasing funding and legitimacy being passed to bodies such as lobbyists and pressure groups who lack a commitment to science's steady and step-wise creation of knowledge.

The final pressure on scientists arises from the consequences of a crisis in the legitimacy of political institutions more generally. Contemporary societal problems are increasingly complex, and producing effective solutions requires mobilising coalitions of partners who between them have the knowledge, the resources and the legitimacy to deliver effective and well-thought through solutions. Politicians are therefore increasingly responsive to groups which participate in these coalitions, and correspondingly less so to traditional power structures such as unions and political parties. Legitimacy is increasingly dependent on the possession of knowledge or financial resources to contribute to solutions, which places science in something of a quandary. Should scientists exploit their knowledge through participation in elite decision-making structures, or should they instead try to inculcate wider society with the scientific norms and behaviours that underpin progressive societies more generally?

0.3 Making sense of the mess: five stylised facts about public engagement.

Public engagement is an important means to resolve these various tensions. But the fact that there are so many pressures and tensions simultaneously means that there needs to be a degree of caution in proposing more engagement between scientists and publics. The review highlights a number of stylised facts[1] emerging from the literature which both shape the way engagement should be understood, but also frame what it can be expected to achieve in practice.

Firstly, there is no reasonable prospect of encouraging engagement which significantly impinges on scientists' autonomy to pursue interesting avenues. Some writers have evoked a mirage of a kind of plebiscitary control over science, where every proposal is voted on by 'the public'. What has currently been achieved with public engagement is a set of interesting experiments that suggest (but do not conclusively prove) that a little more engagement, of the sort already being undertaken, but more effectively organised, can help to secure science's 'licence to practice' in these increasingly sceptical times.

Secondly, there is a limit to the amount of engagement which scientists can sensibly undertake, because of the trade-off for scientists between engaging with the public thereby securing long-term autonomy, as against the need to undertake science and immediately answer pressing questions. In some – but not all – cases it may be possible to develop more engaged research methodologies. But different types of engagement are appropriate to different kinds of situation, and there is no simple one-sized fits all solution to the engagement issue.

Thirdly, and paradoxically, new types of free-standing engagement institution (such as consultations) are seldom the best response to this putative engagement deficit. The purpose of engagement is to equip the public to form an informed opinion over science and potentially to use that informed opinion to influence the societal guidance of science. This means that effective engagement must also be influential, and the risk of with new, free-standing bodies is that they are not connected to the institutions which actually take those decisions, nor are those institutions skilled in knowing how to take forward the results of engagement in practice.

Fourthly, although there is no ideal type of engagement arena[2], some features of engagement arenas are unambiguously beneficial and increase the effectiveness of engagement. Clarity around the definition of who can participate, what are the rules of participation, and the expected influences and learning outcomes, all improve the quality of engagement institutions. Engagement arenas have a dual role – they allow publics and scientists to discuss scientific issues, but they also help publics and scientists to become better at discussing those issues. The most effective engagement arenas are the ones which emphasise and accentuate that learning process.

Finally, engagement only really works if the outcomes of engagement have an influence. And is it not the publics or scientists who will usually be able to determine that, rather it is public policy-makers. In the UK, there is a rather centralised governance structure in which national government decisions have a primacy. Scientific engagement therefore needs to feed into the public policy process. But the problem is that politicians usually only consult with publics around scientifically contentious areas, where there is little opportunity for rational deliberative processes. Mainstreaming public engagement means creating far more engagement arenas (they certainly exist, for example around Alzheimer's care) that can routinely influence public policy away from the pressures of urgency, conflict and crisis, where consultation and engagement usually occurs.

0.4 Towards a model of the public engagement system

To make sense of this complexity, the review develops a model of how public engagement contributes to securing scientific autonomy through increasing public accountability. Scientists and publics interact in various different ways, which can be distinguished between the differing levels of intensity

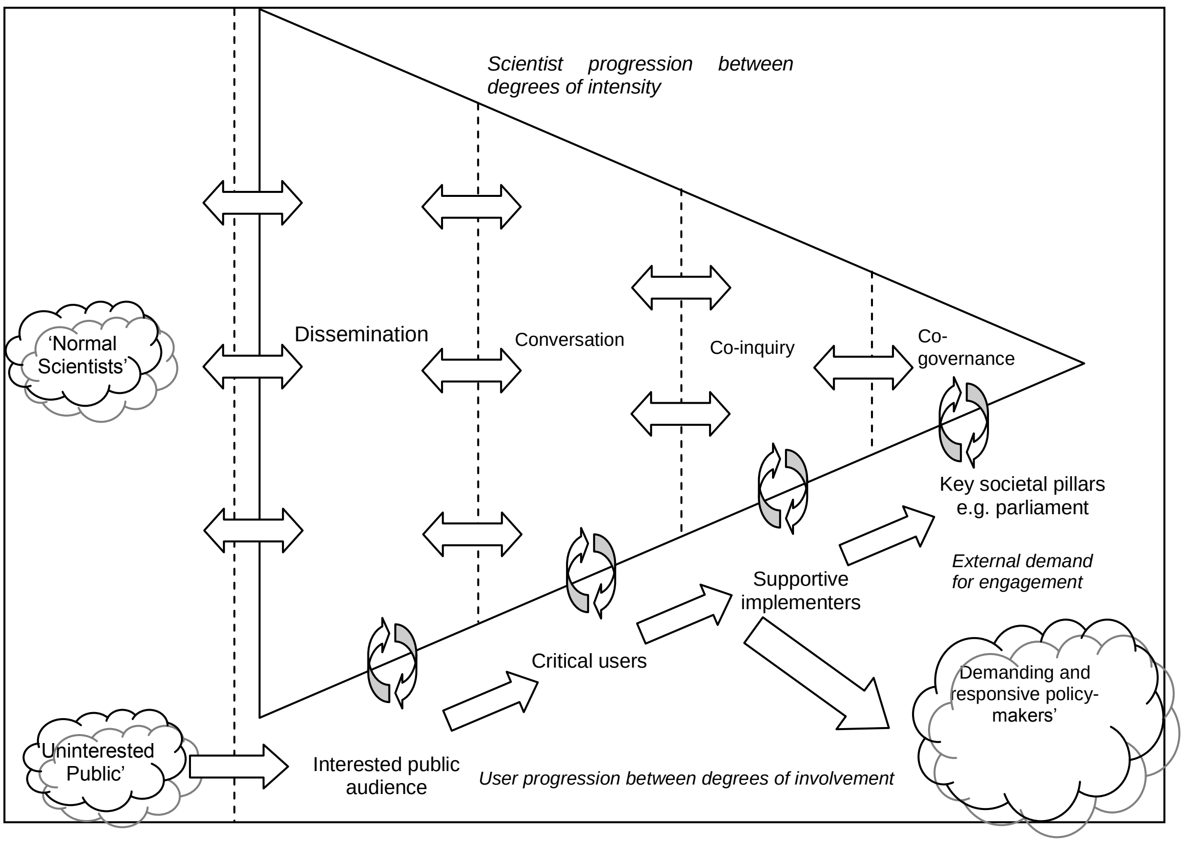
[1] A stylised fact is a simplified presentation of an empirical finding. They are used in the social sciences as a means of generalising very specialised findings and allowing findings from different disciplines to contribute to the development of a more sophisticated argument.

[2] We here use the idea of an engagement arena as a generic definition for any place where scientists and publics meet and exchange ideas about scientific knowledge. This might be a real place such as a science café, it might be virtual (e.g. a consultative web-site) or it might even be where publics judge proposals or submissions from scientists for funding grants.

of that interaction, ranging from traditional dissemination activities (least interaction/ intensity) to innovative co-governance of research programmes and priorities by publics and users (most intense). The model notes that engagement is burdensome, but experiencing successful interaction makes more intense interaction less burdensome. Thus, generally speaking, good engagement breeds more engagement, by making more-intensive engagement more appropriate, all other things being equal.

The model distinguishes four archetypes of engagement intensity, and highlights the importance of 'demand pull' for increasing engagement activity. The presence of activity engages the unengaged public, whilst effective engagement producing outcomes encourages more intensive interactions. Lower overall levels of public engagement can therefore be understood as the engagement system being in a lower-engagement equilibrium rather than the fault of one particular group within that overall system.

Figure 1 The scientist engagement system: multi-level science-society relationships



Taking a systems approach to understand engagement also helps to clarify what makes a 'good' policy intervention. The best interventions are those which **develop** the engagement system rather than merely **generating activity**. Developing the system involves creating and improving linkages between elements of this system to improve uptake of – and interest in – engagement in scientists, publics and policy-makers. From this perspective, it is possible to articulate a number of principles to which effective interventions will demonstrably conform.

Good interventions…

… increase both the numbers of arenas, as well as supporting experiments in novel kinds of engagement.

… build on existing well-functioning relationships and use them as the basis for developing novel engagement capacities.

… recruit people to activities by giving them an inspirational vision of where engagement might lead (them).

… create demand for the output of engagement, posing taxing problems and questions which engagement can answer.

… support local engagements whilst connecting it up to external peer support and bringing wider recognition.

… support the social lives of the communities who engage, valuing those communities as well as the engagement outcomes they bring.

Table of Contents

1 The challenges for 21st Century Science

1.1 Introduction and overview

What value does science bring to society? On the one hand, that questions lies in the same class as "what have the Romans ever done for us?" , because science, technology and innovation are profoundly fundamental to contemporary society in a way that even one century ago was not true. But on the other hand, it is a question that is increasingly being asked, and in an age of global credit crisis, it comes also with the coda, "and why should we pay for it?". To those who work in the science sphere, the question needs no answer: science is the bedrock of progress, based on the cumulative accretion of facts over the course of generations providing better understandings of the world (Ravetz, 1999). But to others, science and scientific progress raises new kinds of fears, from atomic destruction in the 1950s, 'mad cow disease' in the 1980s, or the 'Frankenstein Foods' of the 1990s.

Just as science is vital to contemporary society, so is societal support vital for the successful pursuit of science. In the absence of societal support, an environment of fear may emerge, in which societies restrict and burden science to deal with their uncertainties and worries. Societal support cannot be taken for granted, because science does raise ethical and moral dilemmas. Scientists are compelled in their daily lives to continually and incrementally resolve ethical tensions and to take moral standpoints. Societal support is contingent on society in some way being able to influence, control or regulate the way scientists make their ethical judgements. The challenge is therefore in allowing society to have its 'say' over science's ethical dimensions, without unnecessarily burdening scientists and reducing their capacity to make positive impacts.

Since the 1970s, there has been an appreciation amongst scientists of the importance of building a dialogue with public groups to ensure a supportive public environment. Initially, the emphasis lay on promoting public understanding of science, the idea being that if publics better understood science discoveries, then they would become more supportive of science as a whole. More recently, the emphasis has shifted to the idea of 'engagement', allowing the public the opportunity to interact with science, and potentially to bring their own perspectives into the way that scientific discoveries flow into and shape our contemporary world. How then to ensure that the public can retain their connections to, interest in and influence over science in a world where science is becoming apparently increasingly esoteric, specialist and obscure?

Alongside this, there are a set of "grand challenges", such as energy security, better healthcare and access to water for all, to which society is looking to science to provide effective solutions. A failure to address these wider socio-economic problems may undermine the scientific approach's claims to be the guarantor of progress, allowing long-standing scepticisms over sciences ideas' values to re-emerge (*cf.* 2.2.2). A second key challenge for 21st century science is thus to exploit its practical opportunities – and demonstrate the continuing value of progress and dispassionate inquiry – without compromising on the qualities which make it the basis for developing generalised solutions and a brighter future:-

> "how to combine commitment with neutrality, scientific objectivity with involvement in society problems and hence in social conflicts, and in the final analysis, independence with participation" (CERI, 1982, p.44).

It is impossible to dissociate the increasing phenomenon of public engagement in science from these dual pressures, being democratically accountable and demonstrating utility. This literature review explores how these two pressures have become intertwined, changing societal pressures on science, and increasing engagement of science with publics. On the one hand, engagement embodies an idealist commitment to a particular set of democratic values in science, but on the other hand engagement forms part of a pragmatic approach to secure acquiescence by the public to contemporary scientific inquiry. This tension provides our backdrop in this working paper in seeking to illuminate wider changes to the science system in the UK in recent years, and provide the basis for understanding how to renew the public covenant, thereby ensuring the most propitious conditions for science and scientists.

Against this tense background, we firstly explore in some more detail the boundary conditions and drivers within wider society as a whole which frame these changes towards ‘post-normal science’. The review then turns to produce some key stylised facts about the nature of these changes, with a greater degree of nuance than high-level, broad-brush narratives of change often provide . The report then turns to consider a systematic framework for understanding these changes, and offers a model for understanding the key issue of why – despite a huge amount of engagement work undertaken by scientists - there remains relatively little of the more intense forms of engagement which might serve to fulfil public demands for appropriate influence over scientific trajectories.

1.2 Licence to practice and the science-society covenant

A starting point for this review is the fact that continued political and public support for the funding of science is likely to be primarily dependent on the extent to which ‘science’ is able to gain credit for contributing to solutions to societal problems, rather than society valuing sciences contribution to democracy in the abstract. This tension lies at the heart of the business of science, because science attempts to say authoritatively “what happens” generally on the basis of “what has happened” on particular occasions. Scientific method struggles to reconcile the practical and the particular (experimental data) with the abstract and the universal (scientific theory) (Latour, 1987). Scientists use their imagination and metaphorical thinking to construct, test, and refine or reject their theories. There are difficulties in translating knowledge from controlled ‘laboratories’ into the messy and chaotic ‘real world’ and in being able to talk decisively about outcomes in particular situations (Ravetz, 1999; Gregory, 2001). To facilitate this, scientists have developed sets of rules, norms and processes which dictate how scientists can use their scientific imagination to produce reasonable theories (Hulme & Ravetz, 2009), with which publics are not always acquainted.

Under such circumstances, the public might question scientists unable to authoritatively answer their questions concerning how particular novel developments might affect them personally or society at large. In the UK in particular, it is clear there are long memories in Government and Parliament of the debacle surrounding the BSE crisis and the attempted introduction of GM foods in the late 1990s (*cf.* S&TC, 1999; Wilsdon *et al.*, 2006), whilst at the European scale, conflicts around Bovine Somatotrophin, which also had a trade dimension, remain salient in considering scientific regulation. The post-mortem into the GM debacle concluded a need for greater public inclusion in scientific decision-making to address resistance to new technologies and sciences (STSC 1999). In its wake, the UK government has placed much emphasis on using science in government policy-making, funding both scientists and umbrella organisations to communicate more effectively with the public (SCST 2000; STSC 2002).

What is at issue here is what Jackson *et al.* (2005) term science’s societal “licence to practice”. As well as governments’ direct financial contributions in science, the regulatory and accountability environments also influence what science can achieve. Direct regulatory environments are restrictions which governments may place **blocking** particular technological developments, for example around fertility treatments, embryo research, cloning or the release of organisms into the environment. Indirect accountability requirements are reporting requirements which governments impose on scientists such as ethics committees, impact statements, and assessment returns. This burdening of scientists gives reassurance that they responsibly exercise their privileges.

The challenge for 21st century science can be conceived of as a revocation of its “licence to practice”. If science-society conflicts are not amicably resolved, this may slow down social and economic progress (Wilsdon *et al.*, 2006). Contentious scientific areas may be blocked, or scientists burdened with all kinds of accountability regulations, slowly throttling the creativity and autonomy necessary to knowledge creation (Elam & Bertilsson, 2003). Renewing the societal covenant is vital to ensure that propitious conditions for science – both actively in terms of adequate funding but passively through streamlined regulation – allow science to realise its societal contributions.

But the challenge is not merely to better explain increasingly complicated technological fixes to an increasingly distant group of societal actors, the so-called 'deficit model' of public understanding (Wilsdon *et al.*, 2006). Societal actors themselves question science's role in society, partly driven by broader societal changes as well as changes intrinsic to science (such as its increasing complexity). These external changes occur in political culture from mass, consensus-seeking parties towards smaller, more confrontational, single issue groups. The changing nature of knowledge production has created a proliferation of specialists and experts who question scientists' approaches and findings, creating a challenging, frightening and demoralising environment for scientists (Durodié, 2003).

> "Scientific communication: circa 1600: discussions with the public, according to one prominent researcher, are little better than listening to the "maunderings of a babbling hag". So said William Gilbert, a pioneer of research into electricity and magnetism." (Nature, 2004, p. 883).

One key issue for this review is the definition of scientist to be used here. As the surrounding documentation for this report makes clear, a significant proportion of the UK population have employment making use of science. In this working paper, we – for reasons that will become clear – limit our definition of 'scientists' to those involved in 'normal science' – knowledge production using demonstrably impartial methods rooted in an accepted theoretical paradigm, open to external blind review and responsive to critique. The question lies of where are the boundaries to the 'set of all scientists'. With academic scientists, the issue is clearer: we stress that we take here a Germanic perspective of scientists to include all those disciplines following a cognate method, including the arts and social sciences[3]. Even around universities and academic scientists, there are those involved in advocacy, policy development/ advice and administration as opposed to knowledge creation.

The issue becomes more unclear within business, particularly in small and medium sized enterprises where their small size may necessitate a blurring of roles. In a large business, R&D activities may be distinctive, located in laboratories . Nevertheless, given the importance of public regulation for the business of science, many firms also employ scientists with a strong understanding of the issues in advocacy or lobbying roles. Recognising these shades of involvement in 'normal science', we therefore restrict scientists as those principally involved in creating new knowledge rather than its advocacy in the public policy process (which we will later see can be a very important role)[4].

We therefore exclude those involved in activities which <u>use</u> science, including teachers, data gatherers, technicians, evaluators, patent administrators and routine software development, except where they are involved in research, development and innovation projects (OECD, 2003, Elam & Bertilsson, 2003). However, this group (teachers etc.) are science-users, and have critical roles to play in public engagement, and can be considered as the 'cognate public' or 'citizen scientists' (*cf.* 2.3.3). This distinction is activity- rather than individual-based. A science schoolteacher undertaking a M.Ed. will temporarily become in this definition – in the field of pedagogical research – a scientist. Unless otherwise specified (a distinction of primary importance in 2.1), all references to scientists here include all those involved in the production of new knowledge in the public, private and not-for-profit sectors conforming to norms of openness, review and critique.

---

[3] A justification for which can be developed as follows: philosophy of science and technology is clearly an 'arts' subject, but few would dispute that it has played a substantive role in developing understanding of scientific approaches and helping the reflective process of the definition of what is science. A similar argument can be developed for science and technology studies – which unlike philosophy has no cognate theoretical links via logic with mathematics (although may draw on numerical approaches such as bibliometrics) – and which is strongly rooted in sociology. From that point, it is unreasonable to exclude other humanities and social science disciplines from being included as sciences in terms of the production of knowledge.

[4] The Organisation for Economic Co-operation and Development, a think-tank of 30 advanced economies, has placed a great deal of effort into developing standardised methodologies for classifying and counting inputs and activities in science, technology and innovation. These are codified in a handbook called the Frascati Manual (OECD, 2003). What we are primarily concerned with is basic research, applied research and knowledge development. Our exclusions are drawn from tasks excluded from research and experimental development (*cf.* OECD, 2003, p. 31-32).

1.3 About this review

This review seeks to better understand the new environment for science, and in particular to understand what role – if any – science communication can play in re-affirming science's licence to practice, creating the most conducive environment for the pursuit of science which supports societal development. Nevertheless, this is a *critical review* of public engagement, and we would bridle at being described as Durodié (2003) might, as self-elevating new experts, or as Wellcome (2002) term it, part of a 'public engagement industry'. We begin from Healey (2005), that there have been some impressive and exciting experiments in public engagement, but talk of a new paradigm of engaged science can lead to a bald narrative which lacks an understanding of degrees of change. In this working paper, we attempt to nuance this debate by linking the rise of public engagement to four external societal changes which have changed the terms of the debates which influence science.

The preceding paragraph sets out precisely the challenge of any such review of public engagement, which is a mismatch between the levels of the debate. On the one hand, some micro-scale experiments in public engagement have – as Durodié rightly points out (2003) – been carried out by researchers as much interested in understanding how engagement can succeed as its wider merit. This is not to say engagement does not warrant scientific study, yet it is impossible to prove on the basis of those small-scale experiments more generalised benefits from public engagement by science. In this report, therefore, we develop an argument, based on a set of stylised facts at a range of different scales of aggregation, which are suggestive, rather than demonstrative or convincing, of the net merits of scientific engagement.

In a small review, it is impossible to do justice to all the literature covering a plethora of small experiments. To date, there has been nothing as systematic as a Cochrane review of public engagement: where possible, we have tried to draw upon aggregated analyses and reviews, but some of the most interesting and wide-ranging of these have been political in nature, in a number of Inquiries from the UK Parliamentary House of Lords Science and Technology Committee, and the Commons Science and Technology Committee, supported by the Parliamentary Office for Science and Technology. Alongside this, there have been final reports from two EU research projects, OPUS and STAGE, each of which integrated around six national case studies of public engagement in deriving their findings, and are more general than the scientific papers.

We have also reviewed findings from the 'scientific' literature, and in this context, we use scientist in its German derivation as academic sense (*cf.* 1.2, footnote 1). Arguably more interesting than the findings themselves is the finding that it is a highly disputed terrain. We have found two 'correspondences' – Durodié/ Jackson *et al.*, and Collins & Evans/ Win, Rip & Jasanoff, in the *Critical review of international social and political philosophy* (2003/5) and *Social studies of science* respectively (2005) (*cf.* Durant, 2008) – which clarify the key contours of the disputes between various perspectives and the main dividing lines in the arguments. There have also been a number of quantitative reviews of public attitudes to science and technology, and in this report we have used the National Science Foundation (2002), Eurobarometer (2005), Office for Science and Technology (2005) and People Science & Policy/ TNS (2008) as indicative of societal attitudes. Finally, we have used a number of grey documents from Medical Charities (Wellcome) and think-tanks (Demos) which report primarily at the level of argument and anecdote rather than presenting novel original experiments and analysis.

Given the partial, fragmented and diverse nature of the evidence used in this report, it is impossible to prove with any scientific degree of certainty the value to public science of engagement. Nevertheless, from the review, and from the remaining debates and controversies, it becomes possible to see a pathway forward. Given that the evidence is persuasive of the potential value of more engagement, but sceptical about the idea of comprehensive engagement, this suggests that what is necessary is progress along the spectrum from 'normal' to 'engaged' science. These arguments are drawn together in the chapters three and four, to set out a group of inferences which can be drawn for practical use with a fair degree of certainty, rather than intrinsic truths about engagement and science.

2 Four external pressures on public engagement with the sciences

The first chapter noted how that in recent years, thinking around scientific communications had moved beyond the deficit model towards conceptualising how society could interact with, and potentially even influence, science. Effective engagement beyond the deficit model needs therefore to take account of both these extrinsic changes in society, as well as intrinsic changes in science, and it is to that task that this literature review is addressed. The intrinsic changes are well-understood around the need to communicate increasingly complicated technology developments towards lay communities (SCST, 2000). We highlight four broad societal changes which have had particular impacts on the willingness of the public to engage with science. These require further examination to understand what is necessary to renew the science-society covenant, securing an effective and productive environment for scientists:-

- The loss of expertise and authority of scientists, alongside a series of rejection of expert advice by suspicious publics e.g. Bovine Somatotrophin, GM Food.
- A change in the nature of knowledge production, with increasing interaction and networking between partners within potentially closed 'innovation networks'
- Improved communications and a proliferation of sources of information, placing scientists in an increasingly competitive global 'marketplace of ideas'
- The democratic deficit and the challenge to the mass-party system, with the emergence of single issue pressure groups and closed, populist movements.

2.1 A crisis in authority and expertise in a number of scientific crises

2.1.1 The loss of expertise and authority

The first main external driver is a significant shift in public trust, and in particular public willingness to defer to expertise. This is by no means exclusive to science: governments have also experienced the democratic deficit (*cf.* 2.4). Stein (2003) places this problem in the UK in the context of a society with a strong degree of secularisation, and a rising trend towards scepticism rooted in a naïve post-modern relativism. Durodié (2003) argues that post-modern scepticism led publics to reject the idea of facts and truth, and to consider scientific findings similar to opinions, prejudices, beliefs and intuition. Elam and Bertilsson (2003) argue that the Enlightenment Model, whereby only the scientist could truly be a citizen, is being replaced with a post-modern model where everyone has rights to comment on and to shape scientific practise and activity.

This is often framed as a "crisis of trust" for science, the passing of an age where the "man in a white coat" was uncritically respected, affording them a special societal position (SCST, 2001). Despite this special position, science and scientists have repeatedly disappointed when asked to meet public desires for self-assured answers to complex problems which might deviate significantly from the laboratory conditions from where knowledges were created. The public apparently feel excluded from participation and dialogue processes around the implications of science for society (POST, 2002). When they do participate, they are disappointed when their participation lacks impact either shaping science or policy (POST, 2009).

However, this bold narrative hides a more nuanced picture. The number of people who are actively engaged with scientific issues is relatively low, US data from 2002 described 10% as actively attentive, 45% as passively interested and 45% uninterested in science issues. Likewise, the OST and Wellcome Trust (2000) clustered their respondents into six groups in terms of their attitudes (receptiveness) towards science communications. The report distinguished 'confident believers' (17%), 'supporters' (20%), 'technophiles' (17%), 'concerned' (17%), 'not sure' (13%), and 'not for me'

(15%). The relatively small sample size does not undermine the significance of the fact that – together with National Science Foundation survey (200) – publics are very heterogeneous in terms of their interest in and support for science as a driver of societal change. People Science & Policy/ TNS (2008) offered five clusters, 'confident' (21%), 'sceptical believers' (14%), 'less confident' (25%), 'distrustful' (17%)[5] and 'indifferent' (22%). With one-in-six of this sample distrustful, it is therefore perhaps not reasonable to claim a general crisis of trust.

2.1.2 Evidence on public trust of science and scientists

Indifference and a lack of confidence is not the same as saying that the public do not trust scientists or there has been a loss of deference and trust to scientists. Eurobarometer undertook a special survey in 2005[6] to gauge public receptiveness to science, and the results – both from the UK and EU as a whole – did not bear this general story. There was unanimity that the class of person which the public found best qualified to talk about societal impacts of science and technology was "scientists working in government laboratories and the university". 52% of respondents found that group trustworthy, in comparison to 32% for TV journalists, 28% for industrial scientists and 25% for newspaper journalists (see table 1 below). In the UK, 43% of those interviewed felt that public scientists were the best placed to talk about the impacts of science and technology on society. There is clearly a difference in the way that industrial scientists are understood in terms of their qualifications and legitimacy to explain societal impacts of science and technology.

Table 1- Public attitudes on legitimacy to explain S&T societal impacts (selected, EU)

Response	% Yes
Scientists in university or government laboratory	52%
TV journalists	32%
Scientists working in industrial laboratory	28%
Newspaper journalists	25%
Medical doctors	23%
Environmental protection associations	21%
Writers and intellectuals	10%
Industries	6%
Politicians	5%

Source: Eurobarometer, 2005

This is the one area in the evidence surveyed which highlights any differences between corporate and public scientists in terms of public engagement. The first, and Eurobarometer is quite explicit about this, is that the public tends to be more sceptical about the capacity of business scientists to explain their research in comparison to the public sector (regardless of whether that scepticism is well founded). Twice as many people found public scientists were well-qualified to explain the societal impacts of science and technology in comparison with four 'private sector' groups, namely medical doctors, TV & print journalists, and industrial scientists. This suggests that that the image of the public scientist as an independent authority figure remains untarnished in comparison to other groups.

The second issue was that respondents did make a clear distinction between different scientist roles within firms. The distinction between industrial scientists and the voice of industry is made quite

[5] "The group was defined by their lack of trust in Government and authority generally. They were considerably younger than the general population but were defined most strongly by the high proportion of women who fall into this group. The group was not really interested in science and science issues and did not think that science was particularly beneficial. They also expressed a high level of worry about some areas of scientific research, including the use of animals in medical research." (People Science & Policy/ TNS, 2008, p. 7).

[6] Eurobarometer is a survey activity that measures European opinions across the European Union area as a whole. This survey covered the European Economic Area, the 25 (then-)EU member states (i.e. neither Romania nor Bulgaria) plus across the European Economic Area, plus Norway, Iceland, and Switzerland.

clearly here, with a very low percentage of respondents feeling that firms were the best positioned to explain the impacts of science and technology on society. This tallies broadly with research that has shown that attempts by – for example GM foods companies – to engage with the public has been unsuccessful (e.g. The Mellman Group/ Public Opinion Strategies, 2005; OST, 2005).

> "The Government was seen by some people as benefiting financially from science and open to influence from lobbying. The example of tax on cigarettes was given ("Why don't they just make cigarettes illegal?"). Monsanto was mentioned in two groups as exerting undue influence on the Government." (OST, 2005, p. 90).

Likewise, this survey, along with others, found that there was a broadly positive inclination towards the capacity of science to improve society, and that scientific values were not felt to conflict too closely with personal values. The OST/ Wellcome Survey (2000) found that three-quarters of respondents were 'amazed by the achievements of science' (p.5). The Eurobarometer Survey asked a number of questions which went directly to the root of whether there was (broadly speaking) a clash between public values and what might be considered as scientific values (*qv*), and whilst a majority of EU respondents felt that science made life change too fast, that majority of regret was not replicated in the UK. Likewise, for the three other questions regarding personal values, the UK scored strongly oriented towards science in comparison with other countries surveyed.

Table 2 European and UK attitudes indicating fit between personal and scientific values

Question	EU 25	UK
Science makes our ways of life change too fast	60%	45%
We depend too much on science and not enough on faith	40%	35%
In my daily life, it is not important to know about science	37%	39%
Some numbers are especially lucky for some people	37%	29%

Source: Eurobarometer, 2005

Inter alia the House of Lords Science and Technology Committee (STSC, 2001) noted a problem in terms of the general culture of public openness of scientific decision-making. The real problem appeared to lie not in quotidian grant-making decisions, but in the way that scientific information was translated into policy-making. Stein (2003) highlighted substantive problems in the UK in specific cases where public consultation had been subordinated to expert scientific advice. Despite the consultation taking place, it in fact modified very little the way the government took that advice. This fits with findings in the UK and Europe that (Eurobarometer, 2005; Rayner, 2006) it is often politicians who are the least trusted to speak authoritatively. In the Eurobarometer survey, 6% feel that politicians and 5% the government are well equipped to talk about the impacts of science and technology on society, ahead of only the military (2%) and religious leaders (2%). STSC noted a particular culture of secrecy in the UK, not found in countries such as Denmark, creating a presumption against public policy process involvement. Nevertheless, high-profile failures of secrecy drove a policy-maker's desire to increase public involvement to improve acceptance for particular policy interventions. Rayner characterised this not as a crisis of trust, but rather a **crisis of governance** (Wilsdon *et al.*, 2006).

Despite Healey (2005) noting a risk in polarising 'science' and 'the public', thereby downplaying the extremely good connections and overlaps between these two groups, Collins & Evans (2003) argue that despite some dissolution of the qualifying criteria for what is an expert, on a practical level there is still a need for boundaries to be drawn in the interests of manageability of scientific governance. Durant (2008) argued that there had been an overstating of the power of publics to engage with science out of a desire to portray academics as inflexible and unwilling to engage. One area where there is public disquiet by the public is in being excluded from situations where scientists take value-laden decisions in the application of their research into real world situations (SCST, 2001).

2.1.3 More transparency at the science-society interface

Scientists do have a great deal of interpretative freedom in pursuing science: within the parameters of rationality, scientists choose to frame and present their work in differing and subjective ways. There is clearly a demand from the public to be allowed to influence that subjective process, expressed in a belief that scientists had a set of ethical responsibilities that came with their rights as scientists.

> Science is conducted and applied by individuals; as individuals and as a collection of professions, scientists must have morality and values, and must be allowed and indeed expected to apply them to their work and its applications. By declaring openly the values which underpin their work, and by engaging with the values and attitudes of the public, they are far more likely to command public support. (SCST, 2000 para 2.65),

In Eurobarometer (2005), for example:-

- 79% believed that scientists should be formally obliged to respect ethical standards
- 75% believed that scientists' knowledge gave them power which made them dangerous.
- 73% believed that scientists should be free to carry out work freely provided they met ethical standards.

There are therefore strong grounds for scepticism regarding claims for a grand "end of authority" narrative. There is certainly a degree of suspicion that some engagement is being mismanaged to ensure the public agree with pre-determined policy decisions. Felt (2003) and Collins & Evans (2003) both argue that public capacity for an interest in engagement is clearly restricted in a way that limits its possibilities to create a burdensome imposition on the activities of scientists that writers like Durodié (2003) clearly fear. The public expect scientists to be open and accountable to societal ethical norms, but do not demand that they directly hold them accountable. The demand is instead for accountability systems representing public interests with consultations more than exercises in opinion management (Nature, 2004; Wilsdon & Wills, 2005).

The key challenge therefore is Rayner's, of a crisis of governance rather than a crisis of trust, ensuring the public feel scientists are held to account for the impacts of their decision on the public realm, and that authorities listen better to both scientists and the public. The examples of catastrophic communications exercises already highlighted – including BSE, nuclear power GM organisms – can be regarded as egregious examples of governance failures. These are failures to incorporate and act on profound public values, and not as Durodie (2005) can be read to suggest, a failure to pander to the whims of the anti-scientific and superstitious. This underlines a need to consider the governance system for science more widely and in particular, to ensure that there are better opportunities for scientific communications and dialogue both to achieve more real influence, as well as to assuage the public that science is held adequately to account.

2.2 The changing nature of knowledge production and diffusion

2.2.1 Who takes ethical responsibility in team-based knowledge production?

A second major challenge for the privileged position of science and scientists in the knowledge society is that there has been a widely acknowledged shift in the way that the business of knowledge production is undertaken and organised. A commonly-used characterisation is of Gibbons *et al.* (1994), who describe these changes as from 'Mode 1' of knowledge production, linear and staged in nature, to Mode 2, where knowledge production is far more free-flowing, multi-directional and evolutionary. Their argument is more nuanced than claiming a complete shift from one to the other. Rather, their argument is that there has been a tendency away from the linear organisation of knowledge production towards a more interactive set of connections in the way knowledge is produced and flows into society. Ackoff (1999) refers to these new problems as 'multi-disciplinary messes' (p. 99-101, in Harding *et al.*, 2007).

> "These are complex, dynamic, multi-disciplinary problems that have scientific, technical, social scientific and humanistic dimensions … these are precisely the kinds of problems that

graduates of universities will face in their work lives, and that local, regional and national governments consider to be urgent" (Greenwood, 2007, p. 109).

This fits with the findings from *inter alia* Kline & Rosenberg (1986) that in trying to turn abstract ideas into workable new products, difficult problems will be encountered whose solution necessitates drawing on a range of experiments, knowledges and innovations. Potentially promising avenues may become dead-ends, and so innovators may have to back-track, giving feedback loops and U-turns, in an iterative and interactive process. In this novel model, the role of science is no longer simply providing inputs flowing into business, but instead making a variety of knowledges available for innovators at the appropriate moments. Scientists must undertake a range of knowledge operations, including creating new knowledge (the traditional role), storing and sustaining knowledge until required (e.g. libraries and repositories), transferring knowledge through teaching and consultancy, challenging existing knowledges and helping to eliminate out-dated knowledges[7].

In part, these shifts can also be regarded as related to shifts in the nature of authority relations for scientists, from an elitist towards a relativist expert model with many new groups making claims in the scientific domain (Jasanoff, 2003). Bryson (2000) traces how new groups have challenged the expert functions traditionally exclusively fulfilled by scientists, including special interest and lobbyists, consultants, public intellectuals and lay communities (Benneworth, 2004). The nature of this new model of knowledge production is relatively well understood, often described using network or innovation system models. To exchange knowledge efficiently, at the most valuable point in time, people build up relationships based upon trust and proximity (Boschma, 2006), which can become solidified into more formal institutions (Lundvall, 1988). These institutions can create strong connections between actors helping to circulate knowledge, giving rise to innovation systems (OECD, 1997). These systems facilitate interaction, knowledge exchange and regulation between a range of partners (Cooke & Picalluga, 2005). This raises the question of the extent to which this systematisation excludes non-professional and non-professionalised actors.

2.2.2 The risks of inadvertently excluding publics from translational 'cliques'

This apparent democratisation of science brings both new actors into the business of knowledge production and application, but risks systematically excluding publics in cosy user-producer cliques (Wilsdon *et al.*, 2006). Elam & Bertilsson (2003) see this as resultant from a need to deal with the fundamental problem of applied science, namely the tensions between universal knowledge and its contextual application. Intense and urgent interactions can exclude potential deliberate and prevent outside stakeholders, bringing their values and societal visions into discussions dominated by a set of technocratic needs to implement solutions in particular locations. A failure to respond to public stakeholders, increasing dissatisfaction with the governance of science, can lead to restrictions hindering both the pursuit of science and its capacity to deliver wider societal benefits.

In a sense, the problems which can emerge from cosy, exclusive science-industrial cliques are neither entirely novel nor restricted to mode 2 science. Western Euroepan post-war reconstruction involved substantial public investment in science-based industrial sectors as drivers of economic wealth. Vanavar Bush described in *Science: the endless frontier* what Etzkowitz (2008) was later to stylise as the 'scientific-industrial complex'. Investing in strategic science in both universities and large industries became a means of driving national economic development. Although premised on a linear innovation model, mass programmes such as the expansion of nuclear power in France, the UK and Sweden, or water management in the Netherlands and Belgium, actually required incredibly complex relationships between universities, government laboratories and industry.

[7] The Frascati manual explicitly excludes teaching from science unless it contributes directly to research. Likewise, the Oslo Manual, which defines innovation, excludes eliminating outdated technologies as a kind of innovation. To be explicit, these various activities will rarely be distinct (except where weeding out library collections) but rather come in the evolving thinking and practices of scientists.

Sustaining these relationships encouraged these actors to ignore public stakeholders. This became problematic as these 'cosy cliques' began to take decisions reflecting very self-interested perspectives around wider societal controversies. Dissatisfaction with these cosy relations led in 1968 to a general out-bursting of civil unrest across North America and Western Europe. As Daalder & Shils (1982) point out, across the 17 countries surveyed, one general response was making universities more democratic through introducing more elected management positions (*cf.* Delanty, 2002). This exemplifies the dangers of a growing science-society disconnect based on neglect of societal stakeholders. There are clear corollaries for the kinds of societal demands that may restrict the pursuit of science in the future if broader public interest is not pursued despite the need for close connections between those most intimately involved in science.

This is not purely a macro-scale (society-level) problem: more generally, publics can be excluded from key decision-taking forums, with even well-intentioned consultations becoming opinion-forming rather than opinion-seeking. Wilsdon & Wills (2005) argue the presentation of expert evidence is often "performed", by particular experts invited to arenas such as committee hearings on the basis that that committee is already aware that they have something interesting to say. There is therefore a huge amount of preparation necessary for those without institutional support for their case to be able to perform in engagement. Hagendijk & Kallerund, on the basis of a survey of 6 European Countries (within the FPVI STAGE project) note that:-

> "Scientists and professionals often engage in debates in their own specialised media to discuss policy issues" (p. 166)

'Pre-debates' can frame consultations, restricting public freedom to influence outcomes Healey (2005). Felt (2003) notes a tendency for the creation of mediating institutions to 'encourage' these debates, whilst noting that they can play a precisely opposite role, excluding publics from the arenas where the 'real' debates are taking place. Their criterion for effective public engagement is that the interactions are a foundation for "further development, namely to build a scientist's understanding of the public, alongside a public understanding of science" (p. 674). An editorial in *Nature* in 2004 came out firmly in favour of increasing public engagement with science, with the twin caveats that that engagement had to be meaningful, in terms of being long-term and properly funded, and that it must be taken seriously, with a clear set of mechanisms for implementing results.

2.2.3 Restoring a sense of openness to scientific decision-taking

The lesson of the late 1960s was that this perception of exclusion can override any sense that current arrangements contribute to rising welfare standards generally. This again points to the need for a degree of accountability and openness by science, ensuring effective scrutiny of the claims made for the wider benefits of particular discoveries and inventions, which may nevertheless also have a more limited set of losers (Elam & Bertilsson, 2003)[8]. On the other hand, there is a need for an active citizenship of engagement, involving 'outsiders' who nevertheless share sympathy for science's 'messy practices'. Wilsdon *et al.* (2006) argue for a shift away from the Enlightenment idea of the 'science as citizen' to the idea that of the 'citizen scientist'. These are defined by Elam & Bertilsson (2003) as people outside knowledge creation who nevertheless share science's primary values, such as teachers, museum workers, local authority researchers and health workers. These groups already have their own voices and forums to debate and challenge science, such as practice and policy conferences, trade journals and newsletters and collective representative organisations which commission their own research and bring it independently to media outlets (Wilsdon *et al.*, 2006).

[8] This "many winners, few losers" argument raises an issue of societal solidarity, a notion which was politically discredited in the UK as part of the liberalisation of the 1980s, but which retains contemporary salience. It is socially better if the introduction of a new technology – which has net societal benefits – is accompanied by some compensation for those who directly lose out. In part it reduces their direct resistance to the technology, but indirectly, it reduces worries amongst people that the next technological innovation will penalise them.

There are two consequences in terms of what is necessary for effective engagement to encourage light-touch accountability and societal flexibility and responsiveness. The first is what Wilsdon *et al.* (2006) regard as "a greater appreciation of the 'software' – the codes, values and norms that govern scientific practice but which are far harder to access and change" (p. 19). Participation involves understanding of these scientific norms and codes, and this must be learned, either through professional training or through participation in the community. Effective participation requires opportunities and mechanisms to ensure that individuals can learn these codes, values and norms, to be able to make their own voice heard and thereby make a contribution.

The second is increasing participation and consultation that happens ahead of science, what Wilsdon *et al.* (2006) call "upstream participation". The technique of Constructive Technology Analysis was developed in the Netherlands (Rip *et al.*, 1995) to facilitate the introduction of potentially controversial new technologies into society, demonstrating the efficacy of upstream involvement in the domain of technological development (*cf.* Sørensen & William, 2002). Given the close inter-relations between science and technology, this in turn suggests that there may be added scientific value from greater upstream participation of users and the public in the production of scientific knowledge.

2.3 Proliferation of competing sources of knowledge

The third main pressure in recent years is the proliferation of sources of knowledge and information. Part of this is the issue that scientists are no longer seen as a privileged source of 'expert' knowledge (Collins & Evans, 2002): there has been a blurring, dissolution, or redrawing of the line between 'expert' and 'lay' involvement, to the point where the distinction is not easily made. But the issue is far wider, with clearly a distinct issue concerning the ubiquity of information both affecting the ease with which publics can be engaged, and impacting on how scientists are able to communicate, and the degree of control they hold over their communications. When Bucchi published his study of science communications and the 'cold fusion' scandal in 1998, the growth of the internet was starting to hint that this might have been the last of the 'old'-style scandals. With a proliferation of channels and forums for the public to make their voices heard, it is likely that such a scandal today would have followed an entirely different – and far higher profile – course.

2.3.1 Much information available, reliance on the press

With so many sources of information available, and scientists no longer occupying a privileged position, there are decreasing opportunities for their voices to be heard in an increasingly vocal marketplace. This is particularly significant given the importance of the media as the place where people acquire their understanding of science and technology issues. The press (including on-line) appears to be a particularly source of scientific information for UK residents. The 2005 Eurobarometer survey highlighted that a relatively high proportion of UK respondents regularly access science articles in the press, alongside relatively low participation levels in public debates and campaigning activity around scientific issues.

The 2005 survey offered respondents four choices for engagement with science and technology issues[9]. The results for the EU and UK are given in the table below, and the two tables show that there are a slightly higher proportion of UK respondents that regularly read scientific articles in the press (including on-line), whilst there was a much lower propensity towards attending public meetings or debates, with only 3% occasionally attending, as against 8% at the EU average, and with 78% rather than 71% never attending a public meeting or debate about science. This relatively high dependence on the 'scientific' press for information (both at the EU and UK levels) has impacts on the way that that knowledge flows.

[9] Reading articles on science in the media, talking with friends, attending public meetings/ debates, and becoming involved with campaigning (petitions or demonstrations

Table 3 Active involvement of public in science and technology, EU-25, 2005

	Reg	Occ	Rare	Never
Read articles in newspapers, magazines, internet	19%	40%	20%	20%
Talk with friends about science and technology	10%	37%	26%	27%
Attend public meetings or debates	2%	8%	19%	71%
Actively campaigning – petitions or demonstrations	2%	11%	14%	73%

Source: Eurobarometer, 2005

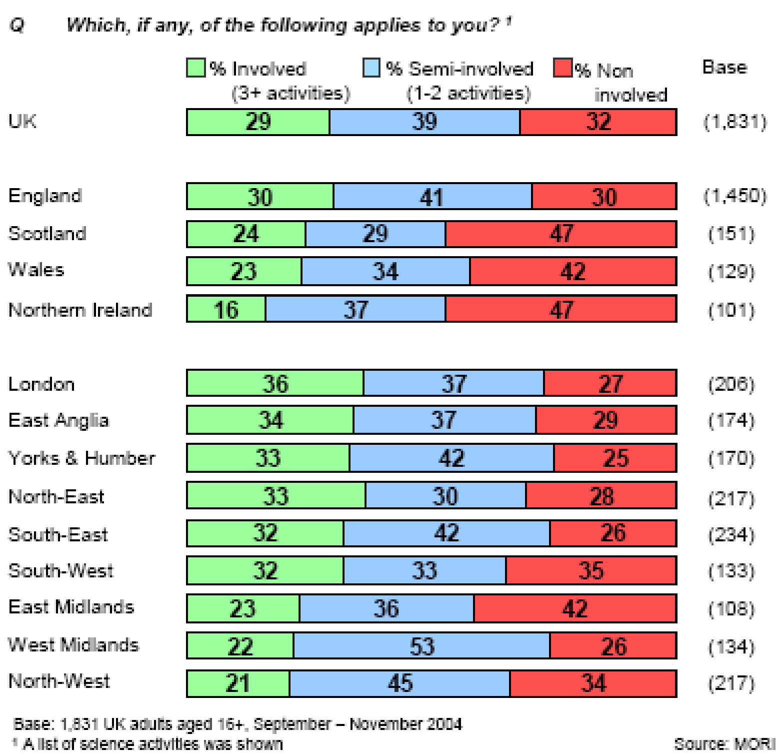
Table 4 Active involvement of public in science and technology, UK respondents, 2005

	Reg	Occ	Rare	Never
Read articles in newspapers, magazines, internet	**22%**	**36%**	22%	20%
Talk with friends about science and technology	11%	36%	26%	26%
Attend public meetings or debates	2%	**3%**	17%	**78%**
Actively campaigning – petitions or demonstrations	2%	10%	13%	75%

Source: Eurobarometer, 2005

A 2005 survey from the Office of Science and Technology highlighted that across the UK, there are significant numbers of people who are multiply involved in science. This survey defined involvement in science as covering "being a member of a science organisation, buying or subscribing to a science magazine, working as a scientist or engineer, having educational qualifications in science or engineering, having met or being friends with scientists or engineers frequently, or looking up scientific information on the internet" (OST, 2005, p. 50). The responses along with a regional breakdown are shown in Figure 2 below.

Figure 2- Public involvement in 'science', by UK region, 2004.



Source: OST-DTI 2005

One of the consequences of the ubiquity of information is the proliferation of comment and interpretative forums in which science facts, conjectures, opinions and prejudices are blurred together and circulated in ways that hinders objective evaluation. There has been a downgrading of the barrier in terms of who gets to make 'public' statements about science (Gregory, 2001), with an increase of the framing of science in the creation of 'stories' both by journalists but also lobbyists and pressure groups. Dr Ben Goldacre has spent a great deal of effort in demonstrating how science reporting implies 'conclusions' diametrically opposite from the findings argued for by the researchers, in pursuit of a story (2008). There has been a divergence of behaviour away from passive reception (in a public understanding mode) towards two different kinds of information using behaviour.

The two emergent behaviours greatly facilitated by news communications technologies are **hostile interference** and **active acquisition**. Hostile interference is that public users ignore scientific information when it clashes with their other sources of information, which may come presented through an alternative lens. Active acqusition is exhibited by those that pro-actively seek out and apply scientific information unmediated by scientific communicators (Wilsdon *et al.*, 2006). Both these trends have consequences for the optimisation of contemporary public engagement.

2.3.2 Open access, peer review and sampling & selection of information

Part of the problem is caused by the fact that scientific information moves into the public domain in a step-wise process, rather than all at once. This happens because that allows the generalisability of that knowledge and its conformance to scientific norms, and in commercial cases, allows the discoverers and disseminators of that knowledge to profit from their findings. But this is a problem for public engagement, meaning that claims may be made for results without the 'working' being visible. This can be extremely frustrating for publics, allowing opponents to challenge scientists for failing to provide full disclosure. An unwillingness by scientists to fully disclose when 'stories' emerge can leave those stories in the hands of 'science commentators', or encourage premature disclosure of findings which have not been through peer review. These commercial, scientific and public interest issues come together in a complex way which requires sensitive handling.

One issue for increasing access to information is the continued practice of peer review, a process by which scientific material which appears as 'authoritative' and ubiquitous is sceptically tested by reviewers to ensure that it conforms sufficiently to academic norms (POST, 2002b). Peer review is habitually carried out by scientific publishers (STSC, 2004) who use the status of peer review to justify charging for that content. Publics may be able to afford journal articles, and resort to non peer-reviewed research, or to the reporting of peer-reviewed evidence in the scientific press, potentially filtered through either pressure groups or the need to create a 'story', to make their judgements. As the Commons Science and Technology Committee noted,

> "We understand that many journal articles are esoteric and, by their very nature, inaccessible to large swathes of the public. Nonetheless, we cannot see what damage could be done by allowing the public to examine the articles for themselves … We are convinced that it is better that the public should be informed by peer–reviewed research than by pressure groups or research as it is reported in the media." (STSC, 2004, p. 25)

The Science and Technology Committee noted a growing movement of open access publishers which conform to Peer Review norms, also making their findings open to a wider public. Despite these moves[10], peer review is not in itself an indicator of the quality of the findings, only that the paper has conformed to a minimum norm of logical and methodological adequacy. There are implicit evidential hierarchies influencing findings' generalisability, which publics may not appreciate in seeking to make sense of their own situation. The nature of public debate should reflect that public comparative valuations of evidence may deviate profoundly from those common within science.

[10] These make peer-reviewed material available either free-at-the point of access (open access) or in pre-typeset form (institutional repositories).

The third issue, also raised by STSC (2001) was the increasing mismatch between the speed of peer review science and the demands of both public and media. The peer review process is typically a long process (POST, 2002b), integral in improving the quality and the replicability of the findings. The growth of the internet has seen a corresponding acceleration of the speed at which people expect stories to develop. An impact in the field of science communications has come through the dissemination of conference papers and pre-publication articles into the press. In part this is because of a demand for timely information, and if scientists have lost their authority as experts, scientific publications with a lower level of peer review (e.g. the review of abstracts) have gained authority from their capacity to fill this need for timeliness.

2.3.3 Greater learning in scientific communications.

The claim can clearly be made that greater engagement will allow the public to form their own judgements about science, apart from commentators, pressure groups and lobbyists with their own partial agendas. Yet, there is a parallel tendency to draw absolutes, and to claim an absolute paradigm shift in science communications methods, from Public Understanding to Public Engagement. Many writers have questioned the extent to which such a paradigm shift can be demonstrated, and how far these changes have created competitors for scientists in the public domain. Healey (2005) noted that whilst there has been a partial turn to engagement, it is both partial and place-specific.

> "Our argument is **not** that a new paradigm of engagement has swept across Europe, pushing aside the old emphasis on innovation and economic competition. Although interesting social experiments in engagement have taken place, it is not plausible to suggest that these have replaced more familiar modes of governance and institutional action. In any case, significant debate still surrounds the form and effectiveness of such experiments."

Much discourse arguing that alternative modes of communications are replacing science communications is very deterministic, and assumes a radical future of which current trends are merely the first signs of a wider, totalising change. Although there are a proliferation of information sources on the internet, the extent to which they genuinely influence public values have almost certainly been overstated, because of the relatively low levels of exposure to information about science from whatever source (*cf.* 2.3.1) and with low levels of active interest in scientific questions.

POST (2001), Healey (2005) and Elam & Bertilsson (2003) agree that scientific communications remains important to present information to the public. Given the relatively low proportion of the population actively interested in science issues, scientists need to be proactive in making material involved. However, these authors also agree that scientists and the public need also to be engaged in a co-learning process about the potential of and limits to scientific communications. This chimes with Wilsdon *et al.* (2006), that there must be "a greater appreciation of the 'software' – the codes, values and norms that govern scientific practice but which are far harder to access" (p. 19).

Given clear limits to engagement and involvement, including capacity of scientists and publics, the issue of public engagement remains at a relatively experimental stage (STSC, 2001; Elam & Bertilsson, 2003). Activities are being developed by academics as much for their interest in scientific engagement as a topic as in the substantive nature of the science they communicate. Thus far, it has been driven forward by enthusiasts (Wellcome, 2002), and Durodié (2003, 2005) clearly articulates a worry that these enthusiasts have lost sight of the bigger picture. The limits to upscaling are not clear: there are interesting experiments in a wide range of areas, unchanged in form since the 2001 POST Report *Open Channels*, which makes the point that learning at all levels is necessary for effective public interaction and knowledge exchange. The 2001 POST report listed a set of methods common in government-society engagement which could be applicable to public engagement by scientists, and since that publication, these techniques have been explored in a public engagement context. In the last decade, there have been serious and detailed experiments with all these activities, which represent a different level of intensity of activity, in terms of the investments of time and effort by scientists and publics.

Box 1: Accepted methods in public dialogue

Deliberative polling

In a deliberative poll, a large, demographically representative group of perhaps several hundred people conducts a debate on an issue, usually including the opportunity to cross-examine key players. The group is polled on the issue before and after the debate. Typical costs around £200,000.

Standing panels

The United Kingdom was the first country in the world where the government has created a standing panel at national level, the People's Panel consisted of 5,000 members of the public, selected at random from across the United Kingdom, available as a market research instrument for quantitative and qualitative research and consultation. It was set up in 1998 by MORI and Birmingham University for the Cabinet Office, and disbanded in 2002

Focus groups

A focus group is a qualitative method used widely in commercial market research and increasingly in academic social research. Typically, a group of around broadly representative 10 people, are invited to discuss the issue of concern, usually guided by a trained facilitator working to a designed discussion protocol, typically for up to two hours. The group is not required to reach any conclusions, but discussion contents are studied for what they may reveal about shared understandings, attitudes and values with respect to an issue. Typical cost £1-2,000 each.

Citizens' juries/panels

A citizens' jury (or panel) involves a small group of lay participants (maybe 12-20) receiving, questioning, discussing and evaluating presentations by experts on a particular issue, usually over 3-4 days. At the end, the group is invited to make recommendations. Typical cost £15-£25,000.

Consensus conferences

By convention, a group of c. 16 lay volunteers is selected for a consensus conference according to socio-economic and demographic characteristics without purporting to be representative of the public at large. They meet first in private, to discuss an issue and to decide the key questions they wish to raise. There is then a public phase, lasting perhaps three days, where the group hears and interrogates expert witnesses, and draws up a report. A consensus conference does . The costs are around £85, 000.

Stakeholder dialogues

A ‘stakeholder dialogue’ is a generic term applied to processes that bring together affected and interested parties (‘stakeholders’) to deliberate and negotiate on a particular issue (or set of issues).

Internet dialogues

An Internet dialogue is a generic name for any form of interactive discussion that takes place through the medium of the internet. They may be restricted to a selected list of participants, or open to anyone with internet access.

Source: POST, 2001, p. 6 (also reproduced in SCST, 2002) authors’ own edits

Durodié’s argument – that science does not need to engage with its wider communities – is widely accepted to be – if not untrue then slightly disingenuous (e.g. Jasanoff, 2003; Felt, 2003). In a longer historical perspective, where science has attempted to divorce itself from its host societies, then societies have responded by creating new institutions. Phillipson (1976) argues that Scotland is so well-endowed with Learned Societies (such as the Royal Society for Edinburgh) precisely because in the late 18th century, its four ancient universities were not up to the job of providing knowledge for the industrial revolution. In the 19th century, the Universities of London and Durham were set up in the early decades of that century out of a feeling that the other-worldliness of Oxford and Cambridge were leading to foregone opportunities for innovation in the UK industrial revolution (Bender, 1988). What these organisations acquired, just as have the new Leading Technological and Social Research institutes recently emerging across OECD member states, is an impetus and dynamism, leaving the older institutions in the doldrums. Given the pressing imperative of harnessing scientific knowledge, a recurrence of this process – the establishment of new scientific institutions to address emerging societal needs – would appear to represent a huge repetition of effort with significant opportunity costs, requiring better engagement by existing institutions.

2.4 The democratic deficit in contemporary political societies

2.4.1 A shift from politics to post-politics.

The final issue facing scientists is part of a widely acknowledged change in the nature of the way decisions are taken within society, and the relation between the individual and wider power structures, most notably political parties. In response to the increasing complexity of societal problems (*cf.* Ackoff, 1999), and the range of competing potential policy measures, governments involve wide numbers of stakeholders in developing policy solutions (Kickert *et al.*, 1997). Rhodes (1997) characterises this as a shift from government in hierarchies towards governance in networks, away from top-down edicts towards more collective, negotiated and discussed solutions. In 2.2, we have already explored the impacts that this has had on the nature of the 'expert scientist', shifting from being the expert to holding one of many views which must be considered.

Under the former model of governments in hierarchies, democratic governments were distinguished by their technological and political capacity to deliver policy solutions. Where this did not happen (for example in the French Fourth republic), it produced political crises which in turn led to both political and technological modernisation (Allum, 1995). Leach (2002) notes that the crisis in government – and its response in a shift to governance – threatened traditional societal structures which bridge between periodic voting and quotidian political decisions, namely membership associations which may be corporatist, party political, or trade union. Actors within these structures gain powers concomitant both with their respective constituency or membership size, but also in negotiation as actors attempt to solve societal problems.

Difficulties associated with solving these societal problems have seen an increasing turn to actors who bring particular resources, namely knowledge, resources and legitimacy, to the policy-networks within which these problems are solved (Andersen, 1992). On the one hand, universities' roles as expert and unchallenged knowledge has been replaced by more relativist models of 'self-appointed' experts (Jasanoff, 2003). The corollary of the conjunction of these two issues (the need for resources and for a self-appointment requirement for expertise) is that in principal, legitimacy can be conferred on very self-interested, partial groups that bring either significant resources or the appearance of legitimacy to policy discussions. This closes off policy networks from less well-organised groups, and in particular, as traditional structures such as unions or political parties have evolved, publics have withdrawn from these structures.

The effect has been described by as a shift to post-politics, the recognition by publics that they increasingly need to self-organise and form groups with independent power and resources separate from the franchise to achieve political influence within policy networks. The effect is also polarising: for those that do not self-organise, the gulf between themselves and the political classes appears too great to bridge, and traditional democratic representation mechanisms (voting, party membership, demonstration) appear ineffective. For those that do organise, what is critical is their capacity to mobilise knowledge and resources around a (the) single issue: the wider context of knowledge production, or its inter-relation with other societal issues, is not considered by those mobilising.

The role of the scientist as independent expert fitted well when the political party was a mechanism of natural compromise, where like-minded people could cluster and agree a platform most representative of their interests. Inclusion of scientific evidence therefore was capable of influencing this compromise process, making explicit the difference between 'expert science' and 'legitimate politics'. In the current situation, science has lost its expertise except insofar as it endows legitimacy, and can be incorporated into single-issue interest groups seeking to maximise their members' benefits from particular policy decisions. At the same time, users are less interested in long-term idea development, and correspondingly more interested in its short-term exploitation for advantage within the policy network. It is naïve therefore to expect that engagement by science can expect to find a welcoming political realm which will bend its processes to accommodate deliberative discussion of scientific knowledge[11], and indeed may drive scientists towards political activities to secure their own positions (Massy, 1996).

2.4.2 From democratic science to 'more democratic' science

Of course, the preceding narrative about the rise of the post-political society is partial, and it is striking that many of the most authoritative claims for its occurrence are also the most vernacular and journalistic (e.g. Oborne, 2007). The reality is more complicated, and a range of experiments with more deliberative approach to decision-making have been successfully implemented, such as citizens' juries (e.g. Wakeford, 2002). Likewise, instrumental treatment of scientists by politicians pursuing politically expedient but scientifically indefensible outcomes have also drawn both popular and scientific criticism (*cf.* Jasanoff, 2003). There have been several severe crises in the legitimacy of the UK Government which have derived from their politicised treatment of science alongside a failure to read public values (SCST, 2002). Rip *et al.* (1995) are able to point to a range of cases where judicious public involvement greatly facilitated the societal introduction of a new technology or innovation by addressing societal concerns.

There remains scope on some level for an idea of deliberative democratic science, that citizenship requires understanding of science underlying key contemporary philosophical, ethical and political debates (Healey, 2005). Janasoff argues that given public investment in science, democratic society must have some kind of control mechanism. The question is what is that control process, and how can this process meaningfully function[12]. In the UK, this general issue is sometimes overlooked through the veneration of the Haldane principle, that whilst governments set funding envelopes, scientists allocate funding, although with Haldane, the cliché is certainly true that it is observed more in its breach than its observance (IUSC, 2008)

In short, governments do invest in science to achieve strategic aims, but cannot not fully understand how science produces its benefits, because science is advancing so fast that administrators lose their understanding of the science (Caswill, 2001, Siune & Helm-Petersen, 2001). Governments fund intermediaries (science and research councils) and direct them to produce benefits, as well as having the power to regulate research actors. What is actually achieved is therefore highly dependent both on the capacity of these intermediaries as well as how those intermediaries choose to frame their understanding of the problem. Intermediaries are in turn reliant on scientists for peer review, and this means that it is in fact extremely difficult for government to strategically manage science as separate from the interests of the scientists it is funding.

[11] If, as argued in the introduction, democracy is an integral part of scientific ideals, then the ideal-type scientific democracy would be one where scientific ideas were discussed, exploited and developed through a process of deep reflection both on the implications of the science, and also the desires of the society. This kind of democratic ideal, advanced by sociologists such as Jürgen Habermas, is never completely present, and any kind of engagement activity which assumes that society will use its knowledge in that way fails to anticipate the problems which science faces in interacting in complex power situations.

[12] There has long been acknowledged a problem in science policy of a version of the principal-agent problem (*cf.* Van der Meulen, 1998), a particular version of the Weberian bureaucracy problem. Governments want to invest in science to achieve particular aims, but they do not have the expertise to determine what science should be carried out to achieve those aims, because scientists are very creative and not easily controlled. There is a risk that increasing investment in science by governments comes at the price of an increasing control infrastructure so there is less investment in science, and more in trying to force scientists to comply with government intentions.

The previously identified shift to post-politics and increasing detachment between the state and its citizens highlighted the need for political structures to exercise control over science to ensure its wider autonomy, through exerting some kind of influence over its evolution. Durodié (2003) sets out the *reductio ad absurdum* of this position, of uninformed citizens vetoing or voting down scientifically-excellent proposals and choosing to squander the money instead on fleeting fancies. However, Elam & Bertilsson (2003) point out that the vote is only one of the key pillars of a democratic society, and they highlight that as far as science is concerned there are two more that are arguably more important, namely the right to a hearing, and a right to fair (consistent) treatment.

Durodié's criticism in this light can be presented as an argument against jury trial based on the fact that guilty people might be able to persuade their fellow citizens to pronounce them not guilty. The strength of jury trial is that people participate seriously and follow a set of rules, and those rules are designed to ensure that people do have a right to be heard, and that their treatment is reasonable and consistent. This in turn ensures that widespread public support for the system of law and order, even if only a very few people are directly involved in its application through jury participation. The democratic challenge then for science engagement is to better embody these democratic ideals, providing publics a "right to a hearing" (Elam & Bertilsson, 2003) and ensuring a reasonable and 'fair' process whereby citizen contributions can be judged.

The one problem that remains in this arrangement is that the naïve deliberative approach to democracy assumed here smoothes away the conflicts which characterise all societies (Wilsdon & Wills, 2005). Political parties were successful in the age of mass participation because they offered a 'cultural' or tribal structure allowing vicious disagreement resulting in compromise solutions. In the post-political age, an overly deliberative version of science contributing to consensus solutions may seek to create deliberation where it simply cannot exist. Effective public engagement must also be robust enough to deal with disagreements and to progress from solutions, even those not necessarily chosen by the scientists (Elam & Bertilsson, 2003; Healey, 2005).

2.4.3 The issue of education and participation in engagement

Healey's (2005) idea of a culture of scientific citizenship seems to offer a helpful distinction here. Contrary to the Enlightenment model where only the scientist could be a true citizen, in this the argument is inverted that the scientist is only complete if their work is truly grounded in the societies from which it originates. Wilsdon *et al.* evoke the concept of 'everyday democracy', where citizens' ordinary interactions are embodiments of and shaped by democratic values such as the right to a hearing and right to fair treatment. As Elam & Bertilsson note (2003),

> "Processes of deliberative democracy can be seen as contexts where citizens simultaneously gain new rights of scientific citizenship, while receiving the political education allowing them to exercise these rights. Designed in the hope of producing a new rational consensus, PES [public engagement in science] initiatives inspired by deliberative democracy resemble political laboratories for carrying out controlled experiments in scientific democracy" (p.241).

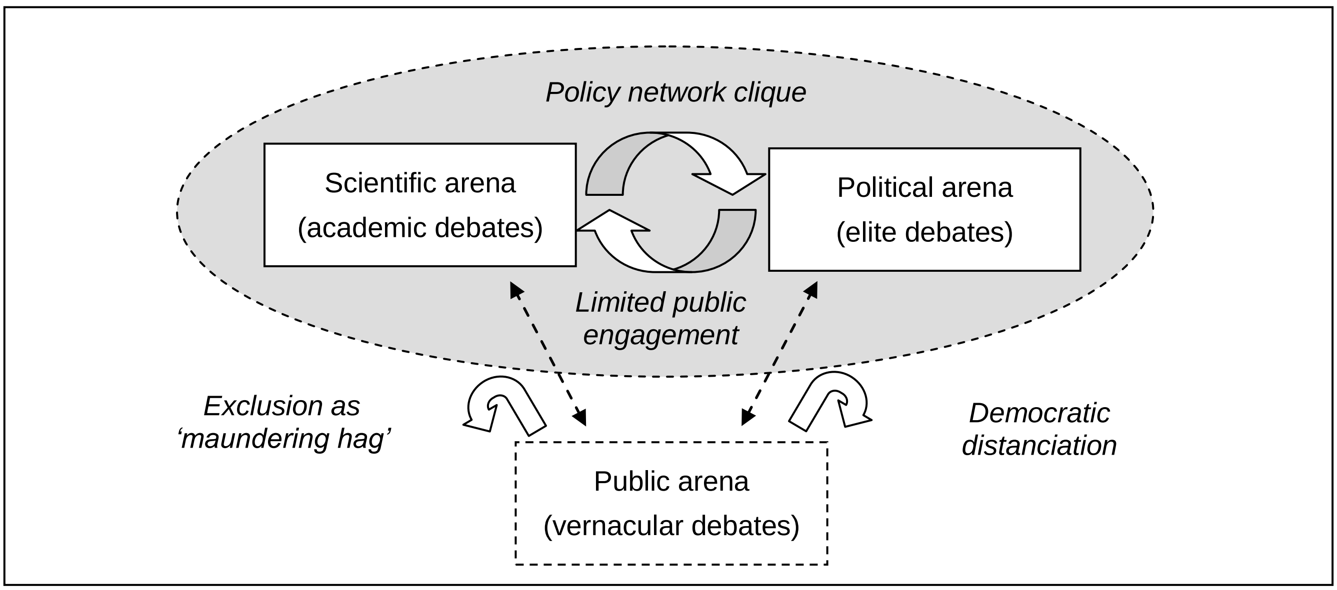
Elam & Bertilsson use scientific democracy here not in Durodie's sense of plebiscites over particular research projects or programmes, but in the sense of having a right to be heard. Durant elucidates this point further, pointing out that there are natural limits to public involvement – there are some 'publics' with good knowledge and capacity to make sensible input, but for others, their participation and the hearings they will receive from science and science dialogues will be less constructive.

> "For Collins and Evans, Wynne misreads routine aspects of culture as islands of specialist knowledge. Such islands of specialist knowledge do exist in lay public culture, but Wynne posits too many islands according to Collins and Evans. The resulting over-population poses a theoretical problem, for it makes it difficult to solve the problem of extension: "how far should participation in technical decision-making extend?" (Collins and Evans, 2002: 237). If participation is to be decided upon on the basis of expertise, and expertise was everywhere, then there is no limit to participation" (Durant, 2008, p. 15).

Likewise, Collins and Evans (2002) call for a need for a clearer separation of the democratic rights to participation and the technical capacity to participate. There are clearly two arguments here pulling in two different directions. At the top level of society as a whole, public involvement in science can discharge a critical democratic function, and help embed science more firmly within society by giving society authority over science[13]. At the lower level, of interacting individuals, there is a capacity shortfall greatly restricting active participation in discharging that democratic function, including what Wilsdon *et al.* describe as a "lack of a shared framework for describing, debating and organising the contribution of science and technology towards wider societal goals" (p.25).

This recognises Hagendijk & Kallerud's (2005) observation of a tendency for (a) the scientific and political arenas to interact very closely, and (b) to collectively exclude the public arena. How can the public become more involved in the public arena given the rising democratic deficit (SCST, 2002)? However, the responsibility is not exclusively on the political domain, and there is a need to consider how science can encourage people to engage within this large political-scientific decision-making process, enlarging what Collins & Evans term "islands of specialist knowledge", and increasing public contributions. In figure 3 below, we stylise this problem of democratic exclusion as publics being excluded both by a political system increasingly influenced by interest groups and not individuals, and by a scientific system dismissive of lay knowledges despite good evidence they can make a different (e.g. SCST, 2002).

Figure 3 The exclusion of public from the political-scientific decision-making arena



Source: authors' own construction after the literatures reviewed

Wilsdon *et al.* (2006) set out what they argue are the bases for scientific participation, arguing that six norms form the basis for public engagement with science. In the terms of figure 3 above, they allow the public to be seen as more than a 'maundering hag' and to contribute effective. The six norms Wilsdon *et al.* highlight are (capitalisation in authors' original) Communalism, Universalism, Disinterest, Originality, Scepticism and an adherence to 'Science Values'. Although these are value-laden terms, they at least begin to sketch out the kind of dimensions along which public learning must proceed in order to allow the public to contribute effectively. These are likely to be currently

[13] The idea of society having authority over science is an abstract one, and is clearly not the same as there being a body or institution which bosses scientists about in the name of society. Society having authority over science is likely to be a far more diffuse and grass-roots process, coming through scientists understanding their societal obligations in terms of societal norms, and reflecting them in the way that they take forward science.

demonstrated in the citizen scientists and cognate supporters, and one question is how these values can be more widely inculcated across the citizenry. One answer can be seen in Wilsdon & Wills (2005) argument that expertise is performative, and it depends as much on the presence of a venue at which that expertise can be performed, and those performance skills learned. Part of the problem can be seen that there are relatively few venues where the public can perform expertise, and learn these six norms.

3 The stylised facts of contemporary public engagement by science and scientists

In chapter 2, we have traced some contemporary contours of the public environment within which science is undertaken, exploring how changes in the wider public realm and society have profound influenced how science is done. Central to these is an increasing imperative for the value of public engagement in science. From a functionalist perspective, engagement ensures that a public sense of accountability is felt, reducing unnecessary over-regulation of the scientific domain, and the value of the benefits which science brings to society is appreciated. From an idealist perspective, engagement helps both scientists and publics to realise their potential to benefit from 'progress', and to provide societal solidarity in taking big decisions which shape societal evolution.

But in the preceding chapter, it has been made clear that the idea of engagement is not a simplistic or straightforward domain, and therefore needs handling in an extremely nuanced manner if it is to deliver these benefits. Public engagement in science remains an extremely contested domain. The past paradigm of 'public understanding of science' has not been entirely supplanted by a public engagement model, and at the same time, some are claiming new paradigms of publically democratic science are replacing engagement. In this chapter, therefore, we attempt to provide clarity from the preceding discussion, by creating a set of stylised facts which describe the current state-of-the-art in public engagement, both generally as reflected in scientific debates, as well as practically through current behaviours and practices. These fall under three main categories:-

- The shift towards public engagement is partial, and within the many modes of possible engagement, the optimal balance is very context-dependent.
- Successful public engagement requires that it is a core task which scientists take seriously as part of their work, and
- The way external partners value and demand engagement strongly influences both the way scientists choose to engage, and how that engagement creates benefits for its host society.

The clear message from this chapter, and this report, is that a simplistic notion of a move to an anything-goes, plebiscitary public engagement is neither being advocated nor acceptable. An understanding of engagement is needed reflecting a *diversity* of activity, a diversity of intensity of engagement, a diversity of pathways and arenas, which hang together in an "engagement ecology" that ensures the benefits of science for the publics which invest in, permit and fund it. This chapter provides a synthetic narrative on the current engagement situation as the basis for developing of a more interconnected engagement ecosystem model highlighting where potential interventions can best be made to maximise the system's fertility and sustainability.

3.1 The partiality of the shift towards an era of engaged science

The first key message from Chapter 2 is that there is no consensus over the extent to which engagement represents a new paradigm of science. Clearly, there has been an issue that science communication has been hampered by a deficit model which has regarded clearer dissemination to the public as its key goal. In an attempt to break this paradigm, and following the rules of paradigm shift as set out by Kuhn (1968), those involved in engagement have postulated that what is currently observable as small experiments in fact presage a future in which public engagement will become much more significant to science. This is used to explain why these experiments are small scale, and embodies a **prediction** that engagement will become increasingly important in the future. This raises the risk that a future model of 'ultra-engagement', which so terrifies Durodié, has been used to explain relatively small-scale and potentially unimpressive experiments in engagement.

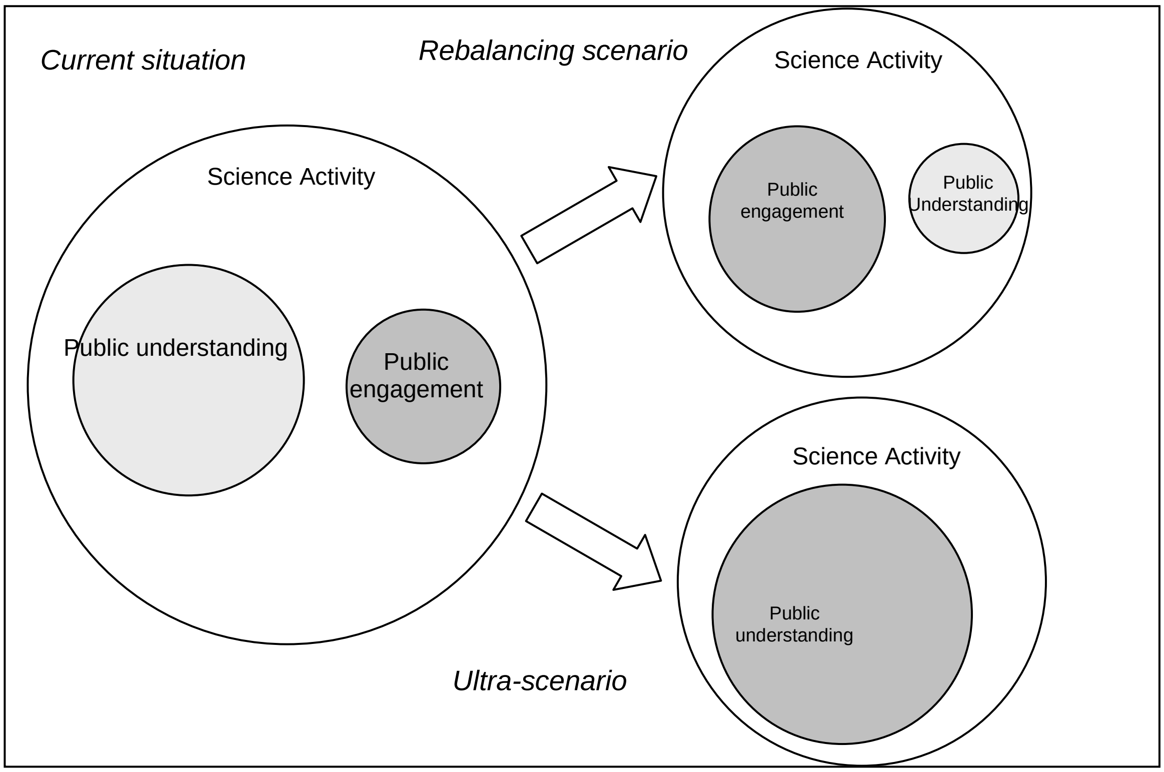
This potentially falls foul of a trap of arguing that public engagement is necessary for all scientists/ science, rather than making the much more justifiable points

(a) more public activity should be engagement rather than understanding, and

(b) there should probably be some more engagement

The criticism here is not of the idea of "more engagement is required", rather that in order to try and validate "more engagement is required" within a dominant (hostile-sceptical) paradigm of public understanding, engagement theorists have invoked a future mirage, which could be regarded as "ultra-engagement". This then allowed engagement sceptics to dismiss this ultra-engagement perspective and at the same time to argue that the invalidity of the ultra-engagement model also means that the current 'more engagement (rather than understanding) is required' model is invalid.

Figure 4 Visualisation of competing perspectives on the value of engagement



More explicit recognition is therefore needed of the fact that engagement is a differentiated process, and the end-point, whilst also uncertain, is also clearly likely to not be hugely different from what is currently undertaken. This issue of appropriateness is an important part of the diversity of engagement activity, given the findings that intense engagement by scientists is extremely time-consuming, and that organising meaningful engagement events across policy-making is extremely expensive. This suggests a natural limit to what engagement can achieve, and following the argumentation of figure 4, increasing the communications effort devoted to engagement, without substantially raising the overall communications effort.

The first substantive consequence for the 'engagement ecology' is that engagement activity can be regarded as being on a continuum based on the level of intensity of the interaction. But rather than viewing high intensity as objectively good (or better than less intense engagement), high intensity of interaction brings with it substantive opportunity costs. Appropriateness of intensity of engagement therefore depends very strongly on contextual conditions. The circumstances in which more intense engagement is required are where there is a compelling case for the benefits of engagement.

Appropriate engagement is one that matches the costs of the activity with the benefits it brings given the particular context (e.g. an outbreak of public scepticism). An example is when there is public scepticism about some new technology which may create a blockage to further progress (such as a ban on public funding on stem cell research). A public debate (very resource intensive) in that circumstance may be necessary to resolve that blockage before science can recommence. Ideally, effective engagement would have prevented that from happening in the first place. But under less controversial circumstances, less intensive interactive may indeed be the most appropriate given the need not to waste resources. This is not to say that public engagement is a waste of resources, merely to say that understanding the engagement ecology means understanding the costs and benefits of different types of intensity of engagement.

3.2 Engagement as a core task for scientists – in varying measures

The second issue relates to the fact that if engagement is to be meaningful, and to have impacts beyond the realm of science, then it needs to be a core task of scientists[14]. This may sound tautological, but there are many pressures which may lead to a 'sham' engagement process. On the one hand, strong affirmation of the importance of engagement is necessary to address the resistance of many to encroachment in their scientific practice. On the other, there is a tendency for engagement to be framed in terms of consultations around risk, which reduce the meaningful public input and can often lead to engagement managing public opinion, of which the public are sceptical. The key to both of these issues is a need for realism in what engagement can achieve, how engagement relates to scientific norms and institutions, and the extent to which scientists are themselves already engaged with a variety of publics.

3.2.1 The reality of the engaged scientist in contemporary practice

It is certainly true to say that there is resistance amongst some scientists to the idea of public engagement. Durodie (2005) classifies four issues which engagement raises for scientists. Firstly, he argues that a compulsion to engage is demoralising for many scientists, whose training has not equipped them for engaging with unruly and sometimes chaotic publics. Secondly, engagement is patronising to the public, because of the need to use demotic descriptions of technologies which undercut their ability to meaningfully contribute to technical debates. The third is that it has created a new set of agents, the public engagement industry, who use engagement as a means to acquire power. Fourthly, engagement becomes a means used by policy makers for deflecting blame for difficult decisions away from them to a supposedly impartial arbiter.

Together, these facts do not add up to a compelling case against public engagement, rather a compelling case against a <u>particular kind</u> of engagement, of the kind evident in the GM foods or nuclear waste cases in the 1990s (*qv*). These factors come into play in particular situations, and effective engagement needs to avoid these four particular problems. Given that more engagement with the public is necessary (Nature, 2004), these factors provide a set of guiding principles for the kinds of engagement which should be avoided. Moreover, they stress that anyone seeking to increase engagement has to ensure that scientists understand the benefits – and feel the rewards – of engagement efforts. An artificial distinction between excellent and engaged science can reduce the sense that it is something which potentially all scientists might wish to undertake – under the correct prevailing conditions.

There is a sense that public engagement is now unavoidable in science, and so the issue becomes in ensuring that the engagement which emerges and is promoted creates benefits for the scientists involved. This clearly requires being mindful of the cost-benefit calculus for engagement (*cf.* 3.1) and avoiding demanding unrealistic ultra-engagement models. But as an important benefit for scientists relates to this 'licence to practice', and discharging the accountability function, there is a need to ensure that engagement satisfies external stakeholders desires and demands for scientists to be more transparent about their activities. At some moments in the scientific process, scientists do take value, moral and ethical positions and judgements, and there is clearly scope for public engagement to

[14] This is not the same as saying that engagement has to be a core task for all scientist, rather that there should be an acceptance within and beyond scientific communities that engagement is important, expected and worth paying for.

meaningfully seek to influence those discretionary positions. But the challenge is for this to happen without reducing scientists' conceptual autonomy necessary to explore a range of potential pathways and to progressively generate knowledges.

There are no easy solutions to this particular issue, in part because scientists and publics are humans with competing desires and interests which are not necessarily reconcilable. What is necessary is a degree of 'soft coupling' between scientists and publics, effectively ongoing, discursive and evolving relationships between scientists and publics, related to concrete issues but also scientific concerns, which gives capacities to deal with and respond to conflicts as they arise. Depending on the situation - but mindful of fundamental values – through these soft coupling arrangements, the various parties interact and create settlements. These settlements fulfil public desires for accountability and accordance to fundamental norms and values, but at the same time preserve scientist autonomy as far as is possible.

3.2.2 Avoiding the pressures to make engagement peripheral

At the same time as the need to meaningfully address scientists' resistance to engagement, there is also the need to ensure that engagement activity provides genuine public scope to participate. There is some resistance amongst publics to engagement activities which raise expectations within and then fail to deliver these often ambitious agendas in the face of pressing political or commercial imperatives. These are driven by three pressures which come from a variety of directions, risking undermining engagement's value in providing accountability, and securing an autonomous and sustainable intellectual and public policy environment for science.

The first is that there is what can be considered as an engagement community, people who are actively involved with public engagement and are also actively trying to shape the scientific environment to be more conducive to public engagement by scientists. These are spoken derisively of by engagement sceptics who imply that there is a trade-off between good science and good engagement, insinuating that engagement is undertaken by those incapable of excellent research. This is a challenging environment: if one side criticises those who engage, then those engaging may turn inwards amongst themselves, to avoid and deflect criticisms from other scientists. Defensively segmenting engaged from 'normal' science risks excluding potentially interested scientists who see engagement as something undertaken by a self-interested and self-referential clique.

The second is that 'cosy cliques' emerge between well-configured expert scientific stakeholders. By this, we mean between scientists and the close end-users of their research. In areas of uncertainty, it is natural to interact closely, intensely and privately to resolve those uncertainties. Working closely and privately within self-defining elite networks risks excluding the public from meaningful engagement. If public engagement is only permitted after all uncertainties are resolved, this clearly limits the scope of public involvement. This in turn runs the risk of creating public dissatisfaction with scientists' responsibility and openness, and could lead to measures which substantially impinge on scientific autonomy.

The final risk of segmentation lies in the creation of new institutions for the promotion of engagement activity within science. Although there is a need for particular opportunities and incentives to ensure that additional direct costs incurred through engagement are covered, the issue here is avoiding the **compartmentalisation of engagement**. What is important is in dealing with what Rayner called the crisis of governance, providing publics with opportunities to influence decision-making around science (on the basis of informed participation). The creation of new engagement institutions runs a dual risk, firstly risk that these institutions will not be where the critical decisions are actually taken, and for a range of technical reasons may be unable to influence meaningfully those decisions. Secondly, and more profoundly, special engagement institutions may become a means of shaping, rather than reacting to, public opinion, and in fact engender greater public suspicion of scientists and science.

This stresses the imperative of the human dimension of engagement, and the need to offer opportunities for all to engage appropriate to their capacity, for the effective management and promotion of public engagement. Likewise, there is a need to recognise the costs and pressures which engagement bring for scientists. Engagement by scientists is often a voluntary activity and those who engage may require additional direct support for their activities to ensure that it fits with their core interests. But as important as direct support is indirect valuation of their efforts: if those engaging face resistance to their engagement from managers, this greatly discourages engagement, whilst reinforcing the sense amongst enthusiastic engagers that they need to isolate themselves from their corporate or institutional mainstreams in order to effectively engage. But resistance to engagement by managers is not always irrational, and in part relates to the relatively low value placed on engagement by its end-users. There is no realistic prospect of changing this situation by making statements about engagement activity: there needs to be a higher value placed on engagement by external groups, to which this chapter now turns.

3.3 Publics and policy makers: partners for engagement in the scientific enterprise

A final set of findings relate to the importance of the demand-side of public engagement, and how receptive external actors are to the idea of engagement. Engagement differs from public understanding approaches in being premised on a degree –albeit variable – of interaction with a range of publics rather than a ‘broadcast’ approach. Under such circumstances, the condition of the reception, and in some cases the intensity and value of the interaction, frames what can reasonably be achieved by the engagement. In practical terms, this means there is a broad correspondence between the thirst of the audience for engagement, and the ease with which scientists can meaningfully engage. Of course, public enthusiasm and thirst for engagement does not arise in a vacuum, and it is clear that public willingness for engagement is also shaped by publics’ expectations as to what that engagement will achieve.

This means that this demand is shaped by two extrinsic variables, namely, the institutional support and capacity which exists to allow publics to engage with scientists, and secondly, the channels by which engagement outcomes - expressed opinions on public norms and values - are able to influence public life (and the policy process). In practical terms, engagement is influenced both by the presence of effective arenas for engagement (with the requirement from 3.2.2 that these are not free-standing, but are themselves where key decisions are taken) and mechanisms for the public process to reflect engagement. In the context of the UK’s highly centralised version of democracy (Hailsham’s “elective dictatorship”), this can be interpreted as their capacity to influence the public policy and regulation process. As the 2002 Lords Committee noted,

> “It is that a meaningful response to the well-recognised need for more and better dialogue between the public and science in the United Kingdom requires us to go beyond event-based initiatives like consensus conferences or citizens' juries. The United Kingdom must change existing institutional terms of reference and procedures to open them up to more substantial influence and effective inputs from diverse groups. Consultation of interested groups is already widely practised in preparing legislation and regulations; but this falls well short of both the diversity and the substantive strength of formal agency granted to public representative groups to articulate values and views in legal and many other fora in the USA.” (SCST, 2002, para 5.46)

3.3.1 The importance of engagement arenas for encouraging effective engagement

One of the more apparently esoteric findings was the fact that engagement is often ‘performed’. This does not mean that it is either false or insubstantial – accountability is often performed: a group (e.g. a board of trustees) are given oversight powers, and have to demand that the body they hold accountable (e.g. a charity’s management) answer questions about what is or is not reasonable: if those answers are not satisfactory, this changes what that body does, and managers may be sacked. A supervisory board member may be mandated to express the collective will of an interest group or collective, such as the membership or the wider public. In doing that, a trustee must think beyond their immediate experience and suppress their personal interests, in favour of the interests of the group which they formally represent.

Given the importance of the 'licence to practice' for scientists, and in science reflecting wider societal norms and values, it is likewise possible to see how engagement can be regarded as a performance. A group of scientists and publics come together and play out particular roles, although those roles are not necessarily as precisely defined as in the accountability example set out above. This means there are consequences for effective engagement, in that there need to be arenas where engagement takes place, and the rules and expectations of engagement need to be set out in advance.

A second important consequence is the importance of partners learning to perform their 'engagement roles' which may be quite different from their usual experienced roles at a time when those involved are very closely and emotionally attached to the subject under discussion – whether science or the wider impacts of that science. The *Nature* article's reference to the "maundering hag" paints a worst-case scenario for engagement in which the performance of engagement is only a burden on the scientist and of little value to the publics. The key question is what can be done in practical terms to minimise that burden whilst at the same time ensuring that engagement meets wider public needs.

The first element is configuring engagement arenas to ensure that there is genuinely interaction. Different intensities of interaction require different power relations between actors – whilst 'experts on a podium; roving mic in the audience' is appropriate for dissemination, co-determination of a research programme requires scientists and publics given comparable status, both physically but also organisationally. As well as having an appropriate format for engagement events, there also needs to be a suitable number of them, and if the desire is to increase certain kinds of engagement, then the corollary of this is more engagement arenas. Finally, it is important that these arenas are not peripheral, stage-managed events, but constructed to allow engagement to have an appropriate level of influence.

The second element is a clear definition of the roles which actors are expected to play in particular engagement arenas, with suitable prior preparation and support for those roles. For activities which tend more towards dissemination, then roles may be apparently clear, with scientists playing experts and publics playing audience. But for contentious issues – whether stem cells or new airports – there may be those that wish to use dissemination events to make their own statements of public record. Thought needs be given to how organisers will react to that situation, to be fair both to that participant, but also to others who find their own learning disrupted by the deviation. For more intense interactions, effectively defining who holds whom accountable or exerts strategic influence with what mandate and representing whose interests are necessary if engagement is to succeed. This is not impossible, and there are good examples – for example from the health sector – where lay panels from health charities funding research are able to provide a steer in the reviewing process. But experience and clarity of those roles is critical.

The third issue, also related to the clear definition of roles in the performance of engagement, is the issue of learning by the participants in engagement. Good engagement performances require good performers, and the skills to be a good performer require learning. This issue relates not just to publics learning how science works, but to all concerned learning about how engagement works, and how to play their role in the process effectively to create societal added value from the scientific activity. Both scientists and publics learn progressively about engagement activity and thereby develop the capacity to engage more effectively. This is not purely an individual learning process – learning takes place in arenas, and participation in those arenas supports the learning process: experienced actors mentor those less experienced, building capacity in the system as a whole. This is an additional requirement of the arenas; that they are not closed to new membership, and host 'learning communities of practice' which both produce concrete engagement outcomes but also initiate new members and develop existing members.

It is worth at this point distinguishing between two kinds of impacts from engagement Firstly, there are direct engagement outcomes, which may be a rising general interest in science issues, or even as direct as involvement in deciding which research proposals may be funded by a research charity. Secondly, and arguably more importantly, there are **developmental outcomes**: performing engagement takes place within communities of engagers, groups of scientists and publics who work together and learn how to work together better, in turn creating the preconditions for a more engaged scientific environment. Designing engagement arenas therefore needs consideration of this developmental role played by engagement. Arenas therefore need to be open to the inexperienced, offer mentoring and support to novitiates helping them to participate more fully, and then signposting onwards to more intense engagement experiences.

This need not be a formal or mechanistic process – science cafés may be advertised at public lectures and then regular attendance and participation in those cafés may bring particular individuals to the attention of the organisers, who can then use those regular attendees for more ambitious engagement projects. What is critical is recognising that this developmental nature means there are relationships between arenas, and increasing engagement involves progression from less intense to more intense interactions, with the implications that this brings for the kind of roles which scientists and publics are expected to play.

3.3.2 Public interest and values in the engagement process

It is remarkable in attitudinal surveys that the greatest degree of scepticism was reserved not for the willingness of scientists to engage, but rather for chance that that engagement would make any difference, not just in scientific spheres, but within the wider public realm. The figures for trust in government and politicians was remarkably low, the OST finding that only 18% of those surveyed felt that the government acted in any significant way to public consultations around science. This is not just a problem for governance, suppressing problems temporarily and creating greater backlashes later, as was seen in the crises around BSE, GM foods and nuclear power. This also undermines the willingness of the public to engage with these consultations, and therefore reduces the demand on scientists to engage, undermining the arenas and communities within which public engagement takes place (*cf.* 3.3.1).

Part of the reason for the separation between consultations and the policy process is because the public policy process is often – in areas of uncertainty and controversy such as those found in the scientific realm - conflict-based and relies on a mix of sheer political power alongside messy compromises to achieve that power. Such contentious decisions are at the same time embedded in a wider political calculus by politicians seeking both the delivery of past promises whilst ensuring future electability. In such circumstances, tight, closed networks form between those with resources, knowledge and legitimacy to achieve a solution. Where publics can have greatest impact and influence in this controversial process is when a febrile public mood threatens the legitimacy of policy-makers. By contrast, by undertaking slow, rational and deliberative interaction, diffusing a sense of panic and conflict, publics almost connive at their exclusion from the urgency of practical policy-making.

One consequence of this espoused by some of the references was to reaffirm the importance of science in ‘speaking truth to power’, and in particular the obligation for scientists in allowing excluded voices to be heard in wider policy debates[15]. Some have argued for a recognition of the importance of ‘activist scientists’ and ‘scientific activism’ although there is far less consensus around its desirability. This is particularly the case with those that would conflate activism with subjectivity in a way incommensurate with the demands of scientific objectivity. Scientific activism also raises a host of important questions for those scientists who cannot claim some kind of academic freedom, particularly where they may found themselves drawn to raise interests counter to those of their employers, whether in the public or private sectors. There is more ambivalence around the idea of scientific

[15] This can be a tricky and contentious point, particularly around deviant or denialist scientific views, raising the question of whether science and scientists have the obligation to provide a platform to views outside the scientific mainstream.

freedom in terms of the capacity of scientists outside the academy to articulate ideas that are not formally those of their employer but which are not directly contrary to employer interests.

But the fundamental issue remains that there is a tendency in the public policy process – in the UK at least and exclusively in the case of controversial topics – to promote scientists who corroborate politicians' 'fixes' and to denigrate and exclude those that do not. It is unrealistic to attempt to change the UK's style of governance, but what can be done is to focus on encouraging engagement in those areas which are less controversial, and in which the public can expect to have a greater degree of input. Healey *et al.* (2005) read this across to mean there should be more deliberative governance of non-controversial science areas, to create a general norm of reflective public engagement which creates an infrastructure which can then hope to also exert influence in more imminent and urgent policy processes.

3.4 The boundary conditions for effective contemporary engagement

In the preceding discussion, some of the contours of the contemporary landscape for public engagement by scientists are becoming clearer. As the preceding chapter is a synthesis of a literature review which is at times equivocal, and by no means conclusive, it is important not to overplay the validity of these synthetic findings. What follows can primarily be regarded as suggestive rather than demonstrative, a foundation for accepting the model which Chapter 4 will suggest as one way of understanding what is admittedly a very complex situation. One of the less equivocal findings is that engagement is relatively novel, certainly experimental, with little certainty over the final end-point on the journey towards 'engaged science'. Nevertheless, the literature does suggest a number of important issues to be borne in mind in attempting to shift the current science system towards a greater level of engagement, even if the end point is uncertain. The five consequences emerging from this chapter are as follows:-

- The appropriateness of intensity of engagement depends strongly on contextual conditions. Appropriate engagement matches activity costs with the benefits it brings given the particular context (e.g. an outbreak of public scepticism).
- 'Soft coupling' between scientists and publics is important, giving a capacity to deal with and respond to conflicts as they arise, to interact and create settlements which fulfil public desires for accountability, whilst preserving scientist autonomy.
- The effective management and promotion of public engagement requires stressing the imperative of the human dimension of engagement, and the need to offer opportunities for all to engage appropriate to their capacity, whilst recognising the costs and pressures which engagement bring for scientists and publics.
- Engagement arenas need to be open to the inexperienced, offer mentoring and support, and signposting onwards to more intense engagement: there are relationships between arenas: increasing engagement involves stimulating progression from less intense to more intense interactions.
- There should be more deliberative governance of non-controversial science areas, to create a general norm of reflective public engagement which creates an infrastructure which can then hope to also exert influence in more imminent and urgent policy processes.

This helps to establish the boundary conditions for a model providing an insight into the functioning of contemporary public engagement in science. There are many activities taking place simultaneously: some of them are more intense and demanding than others, but there is no ideal type or best-practice. What is the most appropriate type of engagement activity varies according to contextual conditions, and in particular there is a strong trade-off between scope and intensity for a particular level of resourcing. A number of things can be said about what makes a particular type of intervention most appropriate for a situation.

Because context is driven by external as well as internal drivers which may change outwith the control of scientists and publics, flexibility in collaborative relations is important to ensure that particular engagement arenas remain meaningful for those engaged with them. All other things being equal, well-defined and transparent conditions for access to a particular arena, which are appropriate to the type of arena, improve the contribution made by a particular engagement arena. People matter: more engagement involves more people engaging, and more people appreciating that engagement is worthwhile for them. Also, as people learn and develop capacity for engagement, this can make more intensive engagement more attractive as experience makes it less demanding.

This background paper for the report suggests that there is insufficient engagement currently undertaken in the UK: a positive outcome is for more people to be involved in engagement activities. As the volume of engagement increases, this should be reflected across all types of engagement arena, from the passive-dissemination type through to involving publics in shaping research priorities and programmes – in an appropriate manner. Because engagement is done by people, and is a learning experience, it can be expected that as well as more people become involved in engagement, there will be progression of numbers involved (publics and scientists) from the less-intensive to the more-intensive types of engagement. There will be more contact with dissemination activity, more participation in science activities as defined by the Office of Science and Technology (*cf.* footnote 6), but also more people with the capacity to contribute effectively to more intense activities. This will also allow public policy to make more use of engagement as it becomes mainstreamed.

It is important not to present this as a virtuous cycle, as one reading of the preceding paragraph might suggest. Rather, these improvements are underpinned by a set of relationships between publics and scientists, between engagement arenas, and between engagement arenas and the policy process. The question is how to represent these relationships within a model, and in this report, we choose a systems approach, that is to say that relationships between people, arenas, and policy makers can be regarded as manifestations of systematic connections between these groups. Improving engagement outcomes then becomes a question of improving system performance, by improving input volumes, by improving system connections and connectivity, and identifying and removing blockages in the system.

4 Towards a model of the public engagement system

In this final chapter, we present a model of the science engagement system which links the various engagement arenas together to produce a set of engagement outputs. The basis for the model is that because of the necessity for learning for effective engagement, increasing system performance requires stimulating learning activities to increase numbers involved in engagement appropriate to their context. At the same time, it is important not to neglect the external stimuli which impact on the demand for engagement, and which encourage both publics and scientists to engage. Having elaborated this model in 4.1, the literature review concludes by drawing a limited number of implications for the development of effective interventions to improve the overall functioning of the science engagement system in the UK.

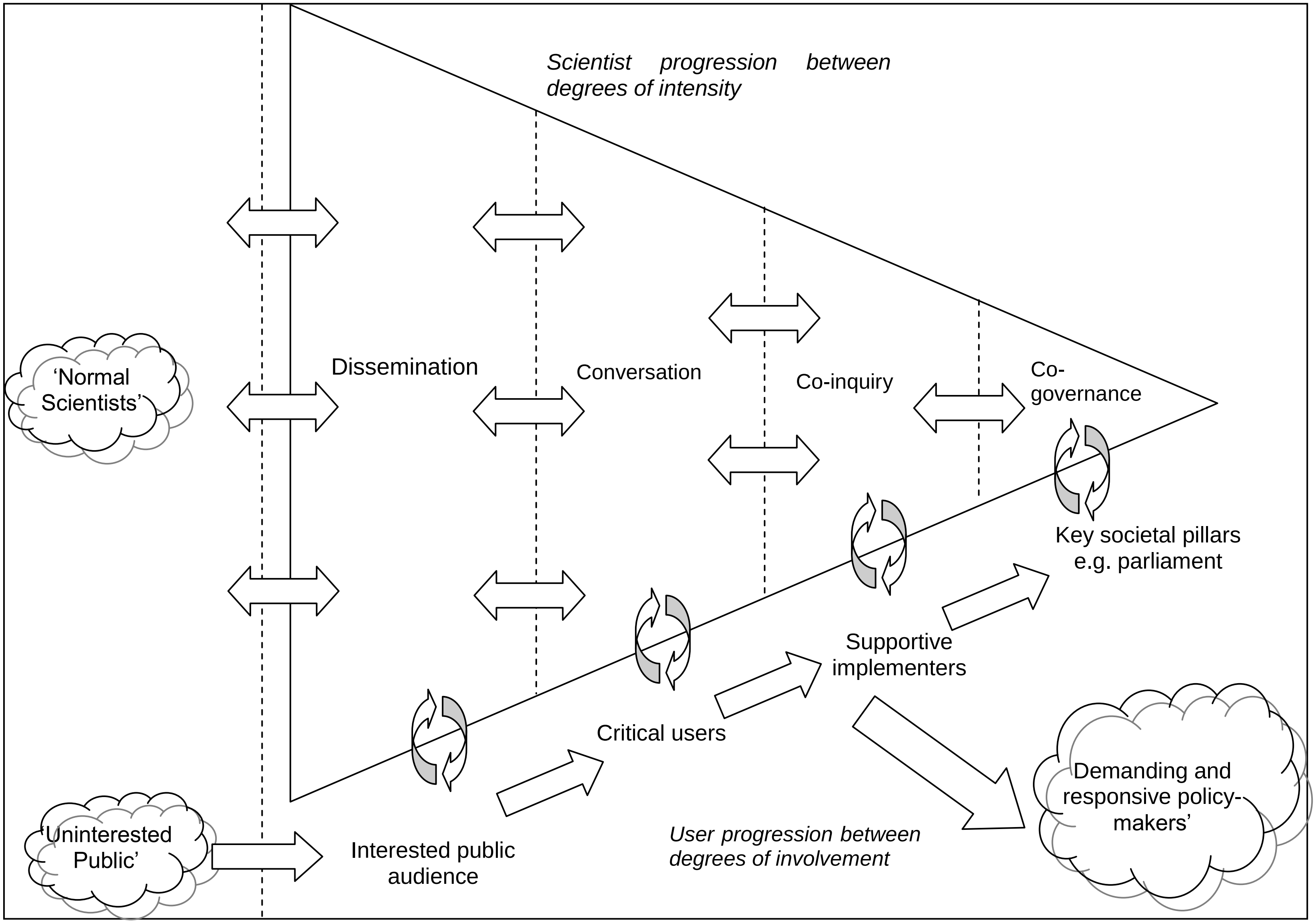
4.1 The public engagement system model

The basis for the model is that science engagement can be regarded as a system connecting science and publics through engagement arenas which produce engagement outcomes. In this model, we classify these engagement arenas at four distinct **intensities** (as experienced by the scientist, and the policy-maker involved with science) and **involvement** (as experienced by the public), covering both attitude to engagement as well as capacity for that contribution. The roles played by the publics in each of these circumstances differ, as do the prerequisite skills, knowledges and inclinations. These intensities correspond to the empirical evidence on the experience of the public of engagement. NSF (2002) classes publics into three levels, the 'uninterested', 'passively' and 'actively' interested. The former group correspond to the 'normal' public, the passively interested to an interested public audience, and the actively interested to more critical publics engaged in dialogues with scientists. Towards the higher levels of engagement, OST/ Wellcome (2002) distinguish (admittedly on a very small sample size, 6 classes in a sample population of 40) size classes. Their distinction is more around predilection towards science rather than activity levels, but again suggest a progressive scale from 'not for me', 'not' sure' and 'concerned' through 'supporters' and 'technophiles' towards 'confident believers'. People Science & Policy/ TNS (2008) produce five clusters, 'confident', 'sceptical believers', 'less confident', 'distrustful' and 'indifferent'. We therefore stylise public involvement as being comprised of four archetypes:-

- **Interested public audience**: active participation in scientific forums such as *cafés scientifique* or public scientific lectures.
- **Critical users**: sufficient experience of active participation and command of scientific issues to be able to provide insights to the pursuit of research alongside dissemination.
- **Supportive implementers**: a good working knowledge of scientific norms and behaviours able to improve and provide 'lay review' for the development of science.
- **Key societal pillars**: comprehensive understandings of scientific norms and societal interests and the interplay between the two, contributing to shaping the most supportive development for creative and autonomous fundamental science at the service of society.

The model is shown in Figure 5 below. Output from the system comes through the various engagement arenas: those outputs are not represented in the model. The level of outputs is dependent on both the intensity of the interactions but also the absolute numbers of scientists and publics involved in engagement. Because of the requirement of learning to develop capacity to engage in more intense ways, activity at higher intensities is also constrained by the volume of participants at lower levels of engagement. Increasing output can therefore involve greater levels of inputs, or improving the level of through- flow between lower and higher intensity levels.

Figure 5 The scientist engagement system as a set of multi-level relationships between science and society



This diagram attempts to capture the learning progression process for scientists and publics involved in public engagement (*cf.* Elam & Bertilsson, 2003; Healey, 2005), from what Ravetz (1999) calls normal science, towards the more intense levels of co-governance. The diagram also captures the challenge of Wilsdon *et al.* (2006) of moving engagement 'upstream', but attempts to break the link between upstream being earlier in the process, but to tie it more closely to active participation in the 'democracy of science' (in Elam & Bertilsson's perspective). The different levels to some extent reflect the intensity of engagement in the 'spaces of encounter between science and the publics' (*cf.* Felt 2003, POST, 2001), but also the propensity of publics to themselves engage. For this latter distinction, NSF (2002) and Wellcome & Office of Science and Technology (2000) make useful distinctions.

In the model, participants in both science and the public progress along a co-learning journey as both acquire knowledges, competencies and skills necessary for effective public engagement. At the same time, through making that progression, their engagement has a greater effect by embedding science more deeply within the public realm, as well as giving the public more 'control' (in the Elam & Bertilsson sense of authority) over the direction of science. As uninterested publics (NSF, 2002) and normal scientists (Ravetz, 1999) flow through this process, so increasing engagement and more significant engagement takes place. The effect of this is mutually beneficial – there is greater indirect public control over the science (of a desirable, steering kind) and there is increasing direct autonomy for the scientists in terms of the 'licence to practice' alluded to previously.

The basis for the model is as a pipeline, recognising the reality that with increasing intensity of engagement, there are limited numbers of scientists that also have the time and the capacity to undertake engagement of this intensity. The nature of what 'flows' is not purely knowledge – from the scientist into the public – but also the people involved in engagement. As scientists and publics learn about the engagement process, and learn how to effectively engage, they move through the system, and can develop the connections which allow them to exchange knowledge, the prerequisite for effective engagement. This progression increases the intensity of scientist engagement and the involvement of public engagement, and creates the necessary preconditions for better accountability and autonomy in science.

But the model also makes clear that this flow is interactive. On the one hand, effective engagement at higher intensities or involvements is dependent on higher levels of lower intensity engagement, producing scientists and publics who are sufficiently familiar with the requirements of scientific discourse to interact at with higher intensity (scientists) or involvement (actors). But the 'valves' controlling flow in this pipeline are not only internal to the model. The amount of flow through this system also depends on external connections, and in particular the demand for engagement by suitably sophisticated publics. The greater the demand for knowledge by publics, the greater the pressure on scientists to engage in increasingly intense ways, and the greater the outcomes in terms of creating both accountability (for the publics) and autonomy (for the scientists).

This model raises the prospect that ineffective and partial engagement outcomes (e.g. observed by Healey) are not merely the result of insufficient effort or inclination on the part of scientists, or a lack of insight or interest by publics (*cf.* Durodié, 2003). Rather, it suggests that there is not good progress from the lower level co-learning processes to higher levels. This has the effect of them stemming off the flow of scientists and lay participants into the higher levels, restricting what can be achieved at higher levels.

We now make a (contestable) assumption that there is less public engagement at higher intensities than would be desirable (that is demonstrated in other working papers in this series). Firstly, there are very high numbers of academics reporting public engagement work – 42% (Kitson, 2009), and relatively high numbers of passively interested societal actors (NSF 2002 estimating 45%), both relatively low intensity engagements. This means that any shortage in engagement activity must be found at the higher levels of the system. Lots of low level activity alongside an (assumed) shortage of high intensity engagement suggests one explanation is blockages at lower intensity levels of the system.

If these blockages were addressed, and there was more interaction between scientists and publics at lower intensities, allowing both groups to learn and develop through the process, then this would increase the overall scope, impact and sincerity of the science engagement system. This is shown figuratively in the two diagrams in Figure 6 below, which use the preceding figure's categorisation of four intensities of scientist learning, and four levels of public involvement capacity.

4.2 Implications for interventions to improve system performance

The Science for All group is concerned with increasing the amount of public engagement by scientists currently undertaken in the UK, out of a concern that it is mismatched with both the capacity within science to inspire the population as well as failing to create a sustainable future environment for the pursuit of science. This review does not have the capacity to test that assertion and evidence base, but if we assume that it is reasonable, then a number of inferences can be drawn from the model outlined above. Regarding science engagement as a system of interacting arenas linked by people allows the problem to be reframed with a greater degree of nuance.

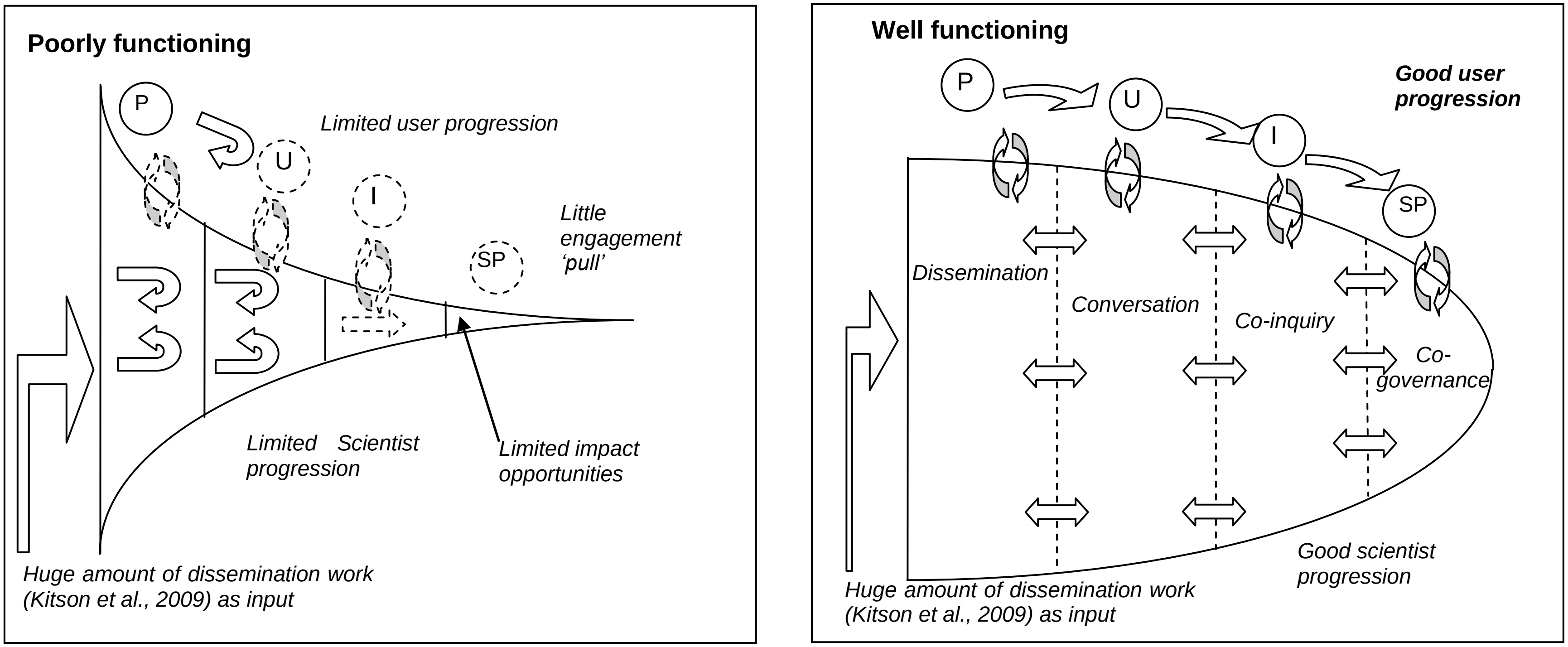
Rather than arguing that UK scientists, publics and policy-makers are deficient, the model suggests that the UK science system has settled in a relatively low-engagement equilibrium. There are a number of relatively small-scale changes which can be made which will shift this equilibrium position, and increase the volume and contribution of public engagement in science. In this final section, we draw out a set of implications for the guidance and evaluation of potential interventions to improve the working of this system.

The first is that central to engagement are engagement activities, the arenas where engagement takes place, so interventions should seek to increase the numbers of engagement arenas. Increasing engagement involves increasing the numbers of arenas, both numerically but also in terms of the development of new kinds of engagement activities. Because effective engagement is not peripheral or outside existing activities, it would be expected that public engagement would crop up in activities from where it had previously been absent. This growth process would by necessity not be driven by scientists but by 'publics' demanding that scientists engage in a dialogue with them. This would be driven by a sense that engagement was a useful contribution to the public needs and interests, but was also enjoyable rather than a burden for those concerned.

The second is that engagement is a set of relationships, and relationships are very tricky for public policy to encourage, so interventions should seek to foster the growth and development of existing working relationships. Partnerships – that is to say concordats and agreements between organisations - are at best a poor proxy for these relationships, and are only of value insomuch as they engender and promote the right kinds of relationships. Engagement relationships are both functional and cultural – they are functional in that parties wish to exchange knowledge, but they are also cultural in the sense that they rely on the existence of a particular social milieu, connections between people who can work together to achieve an outcome. Interventions should identify where there are good cultures of engagement, and challenge them to deliver more – thereby challenging the existing participants to improve the quality of their engagement and the functional outputs, whilst affirming the value of their personal relationships.

The third is that increasing engagement involves increasing the numbers of people involved in engagement, and this requires recruitment to activities. Participation in engagement requires a rationale – a rationale which need not be expressed purely in financial terms. Nevertheless, recruitment of individuals to engagement activity – both of scientists and publics – requires a clear articulation of why they should engage, and what they should expect from those activities. What is perhaps missing here is a Premiership or Wimbledon effect, world-class engagement activities to which people can eventually aspire. Public engagement in governance is (or at least was until very recently) often framed in terms of being a necessary a step on the road to become a Member of Parliament. Good interventions will help answer this question to where is one particular engagement activity a step on a journey.

Figure 6 Stylised versions of a poorly functioning and a well-functioning science-society engagement system



In a poorly functioning science engagement system, despite a significant amount of dissemination activity, this does not translate into more intense varieties of engagement, with limited involvement of publics. This means there is little user learning and progression, reinforcing a lack of 'pull' for engagement by scientists. The lack of opportunities for engagement undermines scientist learning approaches, and ensures that engagement remains constrained to very extensive and low impact approaches.

A well-functioning science engagement system is characterised by high levels of demand for engagement by public partners, and providing higher numbers of publics with which scientists can engage more intensely. At the same time, this increased amount of engagement increases the numbers engaging. This has the effect of increasing the public sense of accountability and control over the broad thrust of scientific development, which in turn has the effect of increasing scientific autonomy through a confirmation of science's licence to practice.

The fourth principle is that increasing the quality of engagement necessitates increasing its impacts in terms of its uptake in wider society, and good interventions are those which intervene at the demand side, and which create questions and problems which effective engagement can answer and solve. At the same time, this helps to bring publics into policy networks as more salient stakeholders because these engagement activities contribute to the (legitimacy of the) solution. Janssen (2009) describes an attempt by a Water Management organisation to bring river engineers and publics together to model the impact of climate change on the landscape of the Maas floodplain in the southern Netherlands. The engagement was necessary after the first technical modelling exercise by scientists failed to generate public legitimacy for a set of technical but also potentially arbitrary decisions. Given the huge amount of knowledges that are applied in attempting to solve societal problems at a range of scales, there is clearly in the UK a huge untapped potential for greater public involvement in exercises which meaningfully influence policy-development, and good interventions will further drive this process.

The fifth principle of good interventions is that they support local engagement and help place it in a wider context. Because the domain of contemporary science is so internationalised it is easy for scientists and policy-makers to forget that other participants in engagement may not have the opportunities and experiences to situate their work in its broader context. For scientists, this is not a top-down process, rather scientists have local laboratories and scientists participate in networks which validate and affirm that knowledge as a community outcome, through peer review, learned societies, Inquiries & Commissions, accolades and awards. It is important that engagement has the opportunity to be situated in this wider community – and to link local engagement activities to wider engagement networks – which do exist, such as Living Knowledge (the Science Shop network) or the virtual Science Café network. Good interventions help support linking between engagement activities, stimulating peer-learning, but also connect engagement better to where it can exert an influence.

The final principle is that engagement communities – and the cultures around them – use artefacts and infrastructures as a way of supporting and sustaining their communities. Good interventions recognise that it is not just engagement arenas that are necessary but also these supporting infrastructures and artefacts. These already exist at a variety of levels, from the national scientific communications associations to local Speakers' Clubs which arrange debates and use their membership to create an audience or participants in particular engagement activities. STSC (2002) concluded that "Public communication of science activities is funded by Government through a variety of channels, and in a piecemeal manner" (p. 5). Although STSC urged more consolidation and funding of efforts, there is the risk in concentrating funding into creating a body responsible for engagement that also runs the risk of removing that engagement from the contexts where it has the greatest opportunities for success.

So what might a good intervention look like in practice? To avoid casting aspersions on existing activities which this review has not considered with any degree of depth, we hypothetically consider the research networks which research councils fund on the basis of a light-touch application to bring scientists and users together at a series of meetings (typically six) to develop understanding and aid dissemination. A similar process could be oriented towards small non-university organisations (such as Speakers' Clubs) who could bring together groups of users and scientists. These activities could define a set of questions they were interested in exploring through a set of defined engagement activities over a fixed (e.g. multi-annual period) with a relatively short time-scale and with a small budget (Research networks are of the order of £10k). The table below sets out how this intervention meets with one single intervention the gamut of the necessary principles for effective engagement.

Table 5 how an engagement network intervention might improve the engagement system

Principle	Contribution
Creating engagement arenas	The meetings are themselves an engagement arena
Developing existing relationships	The application requires an existing network to exist but gives the network something to do, namely administer the award.
Effective recruitment to activities	The organisers use their existing membership to create a participant for events
Increasing uptake of findings	One purpose of the meetings is to clarify a set of understandings in a digestible way which can then be easily communicated at the appropriate time.
Linking local activities to wider networks	The award gives the group external imprimatur, and the Funder could run Award Holder sessions to stimulate learning between groups and about engagement in general.
Supporting a community	The award is both a recognition of the value of the activity, and gives the group something tangible to do and a sense of purpose.

This is not a plea for funding engagement networks, rather to make the argument that what is necessary in a time of budgetary stringency is to develop a suite of light-touch activities that build on what is already present. Critically, they also manage to avoid falling into the elephant trap of creating new over-arching structures which bypass existing activities and destroy enthusiasm, but which also sideline engagement as 'something else' or a desirable extra. An effective approach system management is one which:-

- maps existing activities against these six principles, the intensity of the interactions and the capacity of the participants,
- identifies potentially gaps in the overall ecology, and
- tailors its novel solutions to ensure that there is a balanced mix of activities at all levels,
- which in turn stimulates connections and developments between those levels.

5 Bibliography

Ackoff, J. (1999) *Ackoff's best: his classic writings on management*, New York, John Wylie.

Andersen, J. J. (1992) *The territorial imperative: pluralism, corporatism and economic crisis*, Cambridge, UK: Cambridge University Press.

Allen, M. (1988) *The Goals of Universities*, Milton Keynes: Society for Research into Higher Education/ Open University Press.

Allum, J. (1995) *State and Society in Western Europe*, London: John Wiley & Co.

Baumunt, Z. (1997) "Universities: old, new and different" in A. Smith & F. Webster (eds) (1997) *The post-modern university? Contested visions of higher education in society*, Milton Keynes: Open University Press.

Bender, T. (1988) 'Introduction', pp. 3-10 in: T. Bender (ed.), The University and the City. From Medieval Origins to the Present. New York/Oxford: Oxford University Press.

Benneworth, P. (2004) "Fire historier om klynggepolitikk" [four stories of cluster policies] in H. Gammelsæter & Peter Arbo "Teori og politikk i utviklingen av regionalt næringsliv" [Theory and policies for regional economic development], Tromso, Norway: Tapir.

Boschma, R.A. (2005), Proximity and innovation. A critical assessment, R*egional Studies*, 39 (1) , pp. 61-74.

British Academy (2008), Punching our Weight: the humanities and social sciences in public policy making, London: British Academy

Bryson, J. R. (2000), 'Spreading the message: management consultants and the shaping of economic geographies in time and space'. In Bryson, J. R., Daniels, P. W., Henry, N. and Pollard J (eds), *Knowledge, Space, Economy.* (Routledge, London).

Bryson, J. R., Henry, N. D., Pollard, J. S. & Daniels, P. W. (2000) (eds) *Knowledge, Space, Economy*, London: Routledge 2000

Bucchi, M. (1998) *Science and the media*, London and New York, Routledge.

Bush, V. (1945) *Science: the endless frontier*, Washington: United States Government Printing Office

Caswill, C. (2001) "Science Resource Decisions - Principals, Agents and Games" in K. Siune (ed.) "Science Policy Setting the Agenda for Research Proceedings from MUSCIPOLI Workshop One" *The Danish Institute for Studies in Research and Research Policy 2001/8*, Aarhus, DK: AFSK.

Centre for Educational research and innovation (1982) *The university and the community: the problems of changing relationships*, Paris: OECD.

CEC (2005)"Report on European Technology Platforms and Joint Technology Initiatives: Fostering Public-Private R&D Partnerships to Boost Europe's Industrial Competitiveness", *Commission Staff working document SEC(2005) 800*, Brussels, Commission of the European Communities.

ftp://ftp.cordis.europa.eu/pub/fp7/docs/report_jtis_en.pdf

Collins, H. M. & Evans, R. (2002) "The Third Wave of Science Studies: Studies in Expertise and Experience", *Social Studies of Science* 32(2): 235—96.

Collins, H. M. & Evans, R. (2003) King Canute meets the Beach Boys: Responses to the Third Wave, *Social Studies of Science* 33 (3) pp. 435-452.

Cooke, P. & Piccaluga, A. (Eds) (2004) Regional economies as knowledge laboratories. Cheltenham: Edward Elgar.

Daalder, H. (1982) The sudden revolution and the sluggish aftermath: a retrospective since 1968. In H. Daalder and E. Shils (Eds.), Universities, Politicians and Bureaucrats: Europe and the United States. Cambridge University Press, Cambridge

Delanty, G. (2002) “The University and Modernity: A History of the Present” Pp. 31-48. In: *The Virtual University? Information, Markets and Management* K. Robins & F. Webster (eds) Oxford: Oxford University Press.

Durant, D. (2008) “Accounting for expertise: Wynne and the autonomy of the lay public actor” *Public Understanding of Science*, 17 (5) pp. 5-20.

Durodié, B. (2002) “Why I think a dialogue with the public will undermine science” *Times Higher Education Supplement*, 12th April 2002.

http://www.timeshighereducation.co.uk/story.asp?sectioncode=26&storycode=168424

Durodié, B. (2003) Limitations of public dialogue in science and the rise of new ‘experts’, *Critical Review of International Social and Political Philosophy*, 6(4), pp. 82–92.

Durodie, B. (2005) “Inclusion versus Experimentation: A reply to Roland Jackson et al.” *Critical Review of International Social and Political Philosophy*, 8 (3) pp. 359-262.

Editorial (2004) “Going public: should scientists let the public help them decide how government research funds are spent?” *Nature* 341 (7011), p. 883, 21st October 2004.

http://www.nature.com/nature/journal/v431/n7011/full/431883a.html

Elam. M. & Bertilsson, M. (2003) “Consuming, engaging and confronting science” *European Journal of Social Theory*, 6 (2) pp. 233-251.

Etzkowitz, H. (2008) The Triple Helix: University-Industry-Government Innovation In Action, London: Routledge..

Eurobarometer (2005) “Europeans, science and technology” *Special Eurobarometer no. 224*, Luxembourg, OOPEC.

http://ec.europa.eu/public_opinion/archives/ebs/ebs_224_report_en.pdf

Felt, U. (2003) “Concluding remarks” in U. Felt (ed) *OPUS: Optimising public understanding of science and technology Final Report*, Vienna: Vienna University of Technology.

http://www.univie.ac.at/virusss/opus/mpapers.html

Felt, U. (2003) “Spaces where publics encounter ‘their’ sciences” in U. Felt (ed) *OPUS: Optimising public understanding of science and technology Final Report*, Vienna: Vienna University of Technology.

http://www.univie.ac.at/virusss/opus/mpapers.html

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. & Trow, M. (1994). *The new production of knowledge: the dynamics of science and research in contemporary societies*. London: Sage

Goldacre, B. (2008) *Bad science*, London: Harper Perennial.

Gregory, J. (2001) “Public understanding of science: lessons from the UK experience” *Science and Development Network*, 3rd December 2001.

http://www.scidev.net/en/features/public-understanding-of-science-lessons-from-the.html

Hagendijk, R. & Kallerud, E. “Changing Conceptions and Practices of Governance in Science and Technology in Europe: A Framework for Analysis” STAGE Discussion Paper 2, March 2003.

http://www.stage-research.net/STAGE/downloads/StageDiscussPaper2.pdf

Healey, P. (2005) “Science, technology and governance in Europe: challenges of public engagement” *Final report of project number HPSE-CT2001-5003*, Brussels, CORDIS.

http://www.stage-research.net/STAGE/documents/STAGE_Final_Report_final.pdf

Hulme, M. & Ravetz, J. (2009) “Show your working: what ‘ClimageGate’ means” *BBC News website page* <Accessed 2nd December 2009> <http://news.bbc.co.uk/2/hi/science/nature/8388485.stm>

Innovation, Universities & Skills Committee (2008) "Putting Science and Engineering at the Heart of Government Policy", *Eighth report of the Innovation, Universities and Skills Committee 2008-09*, HC168-i

www.publications.parliament.uk/pa/cm200809/cmselect/cmdius/168/168i.pdf

Irwin, A. & Healey, P. (1999) ESRC New Opportunities programme on the public understanding of science" *Project Final Report*, December 1999, London: Science Policy Support Group.

http://www.stage-research.net/SPSG/scisoc/pus/NewOppsprogwebreport.html

Jackson, R. Barbagallo, F. & Haste, Helen (2005) "Strengths of Public Dialogue on Science-related Issues" *Critical Review of International Social and Political Philosophy*, 8 (3), pp. 349-358.

Janssen, J. A. E. B. (2009) *Modelling qualitative knowledge for strategic river management: necessity, feasibility and utility*, Enschede, NL: University of Twente

Jasanoff, Sheila. (2003) "(No?) Accounting for Expertise." *Science & Public Policy* 30 (3) pp. 157-162.

Kellog Commission (1999) "Returning to Our Roots: The Engaged Institution" Third report of the Kellogg Commission, Washington DC: National Association of State Universities and Land-Grant Colleges, available online at:

http://www.nasulgc.org/NetCommunity/Document.Doc?id=183

Kickert, W. J. M., Klijn, E. H., & Koppenjan, J. F. M. (Eds.). (1997b). *Managing Complex Networks. Strategies for the Public Sector* (1st ed.). London: SAGE Publications Ltd.

King, R. (1999) *Genetically Modified Foods, Facts, Worries, Policies and Public Confidence*, London: Office for Science and Technology OST.

http://www.food.gov.uk/multimedia/pdfs/fsa-00-02-06.pdf

Kitson, M. (2009) "Knowledge Exchange Between Academics and the Business, Public and Third Sectors" *Making an Impact: Universities and the Regional Economy*, London, UK, 4th November 2009.

Kline S. J. & Rosenberg, N. (1986) "An overview of innovation" in R. Landau and N. Rosenberg (eds) *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, National Academy Press, Washington, D.C.

Kuhn, T.S. (1962) *The Structure of Scientific Revolutions*, Chicago: University of Chicago Press.

Latour, B. (1987) *Science in action: how to follow scientists and engineers through society*, Cambridge, MA: Harvard University Press.

Leach, R. (2002) *Political ideology in Britain*, Basingstoke: Palgrave

Lundvall, B. Å. (1988). Innovation as an interactive process – from user-producer interaction to the national system of innovation. In: G. Dosi et al. (Eds), *Technical Change and Economic Theory*. London: Pinter Publishers

Massy, W. (1996) *Resource allocation in higher education*, Michigan: University of Michigan Press.

Melody, W. (1997) "Universities and public policy" in A. Smith & F. Webster (eds) (1997) *The post-modern university? Contested visions of higher education in society*, Milton Keynes: Open University Press.

Meulen, B. van der (1998) 'Science Policies as Principal-Agent Games: Institutionalization and Path Dependency in the Relation Between Government and Science.' *Research Policy* 27(4):397-414.

National Science Foundation (2002) "Science and technology: public attitudes and public understanding" in *Science and engineering indicators 2002*, Washington DC: NSF.

http://www.nsf.gov/statistics/seind02/c7/c7s1.htm

Oborne, P. (2007) *The triumph of the political classes*, London: Simon & Schuster.

OECD (1997) *National innovation systems*, Office for Economic Co-operation and Development, Paris. Available online at:

http://www.oecd.org/dataoecd/35/56/2101733.pdf

OECD (2002) *Frascati manual: proposed standards for surveys on research and experimental data*, Paris, OECD.

http://www.oecdbookshop.org/oecd/display.asp?lang=EN&sf1=identifiers&st1=922002081p1

OECD (2003) *Governance of public research: towards better practices*, Paris: Organisation for Economic Co-operation and Development.

http://browse.oecdbookshop.org/oecd/pdfs/browseit/9203051E.PDF

OST (2005) Science in Society Findings from Qualitative and Quantitative Research: London: DTI-OST.

http://www.dius.gov.uk/~/media/publications/F/file14950

OST & Wellcome (2000) *Science and the public: a review of science communication and public attitudes to science in Britain*, London: Office for Science and Technology/ Wellcome Trust.

http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtd003419.pdf

Parliamentary Office of Science and Technology (2001) *Open Channels: public dialogue in science and technology*, Report No. 153, March 2001, London: POST.

http://www.parliament.uk/post/pr153.pdf

Parliamentary Office of Science and Technology (2002a) *Public dialogue on science and technology*, PostNote No. 189, November 2002, London: POST.

http://www.parliament.uk/post/pn189.pdf

Parliamentary Office of Science and Technology (2002b) *Peer Review*, PostNote No. 182, November 2002, London: POST.

http://www.parliament.uk/post/pn189.pdf

Parliamentary Office of Science and Technology (2006) *Debating science*, PostNote No. 260, March 2006, London: POST.

http://www.parliament.uk/documents/upload/postpn260.pdf

Parliamentary Office of Science and Technology (2009) *Futures and Foresight*, PostNote No. 332, May 2009, London: POST.

http://www.parliament.uk/documents/upload/postpn332.pdf

The Mellman Group/ Public Opinion Strategies (2005) *Public Sentiment About Genetically Modified Food*, Philadelphia, PA: Pew Initiative on Food and Biotechnology.

http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Public_Opinion/Food_and_Biotechnology/2005summary.pdf

People Science & Policy/ TNS (2008) *Public attitudes to science 2008: a survey*, Department for Innovation, Universities and Skills/ Research Councils UK

Phillipson, N. T. (1974) "Culture and society in the 18th century province: the case of Edinburgh and the Scottish Enlightenment" in L. Stone (eds) *The University in Society: Volume II – Europe, Scotland and the United States from the 16th to the 20th Century*, London: Oxford University Press pp. 407-448.

PPP (2008) *Engaging higher education in the societal challenges of the 21st century*, San Jose, CA: National Center for Public Policy and Higher Education

Ravetz, J. (1999) 'What is Post-Normal Science?', *Futures* 31 (5): 647–53.

Rayner, S. (2006) "Dimensions of trust in science, technology and society", Paper *presented to TSEC TRUST Conference*, Energy Research Centre, Oxford, 28th-29th June 2006.

Rhodes, R. A. W. (1997). *Understanding Governance. Policy networks, Governance, Reflexivity and Accountability*. Buckingham: Open University Press.

Rhodes, R. A. W. (2003). 'What is New About Governance and Why Does it Matter?' In *Governing Europe*, eds J. E. S. Hayward and A Menon. Oxford: Oxford University Press.

Rip, A. Schot, J.W. & Misa, T.J. (1995) *Managing Technology in Society. The Approach of Constructive Technology Assessment*. Pinter Publishers, London

Select Committee on Science and Technology (2000) "Science in Society" Third Report of the SCST 1999-2000, HL-38, London, HMSO.

http://www.publications.parliament.uk/pa/ld199900/ldselect/ldsctech/38/3801.htm

Science and Technology Select Committee (1999) "Scientific Advisory System: Genetically Modified Foods", *First Report of the Commons S&TC 19898-99*, HC 286-I, London: HMSO.

http://www.publications.parliament.uk/pa/cm199899/cmselect/cmsctech/286/28602.htm

Science and Technology Select Committee (2002) "Government Funding of the Scientific Learned Societies", *Fifth Report of the Commons S&TC 2001-02*, HC 774-I, London: HMSO.

http://www.publications.parliament.uk/pa/cm200102/cmselect/cmsctech/774/77402.htm

Science and Technology Select Committee (2004) Scientific Publications: Free for all? *Tenth Report of the Commons S&TC 2003-04*, HC 399-I, London: HMSO.

http://www.publications.parliament.uk/pa/cm200304/cmselect/cmsctech/399/399.pdf

Sørensen, K. H. & William, R. (2002) (eds) *Shaping technology, guiding policy: concepts, spaces and tools*, Cheltenham: Edward Elgar

Stein, J. A. (2003) "Public understanding of science and the policy context in the United Kingdom"

http://www.univie.ac.at/virusss/OPUSReport/Policy%20Chapters/POL_UK.HTM

Siune, K. (2001) (ed.) "Science Policy Setting the Agenda for Research Proceedings from MUSCIPOLI Workshop One" *The Danish Institute for Studies in Research and Research Policy 2001/8*, Aarhus, DK: AFSK.

http://www.afsk.au.dk/ftp/Muscipoli/2001_8.pdf

Siune, K. & Helm-Petersen, N. (2001) "Trends in science policy: Governments priority setting" in K. Siune (ed.) "Science Policy Setting the Agenda for Research Proceedings from MUSCIPOLI Workshop One" *The Danish Institute for Studies in Research and Research Policy 2001/8*, Aarhus, DK: AFSK.

Wakeford T. (2002) "Citizens juries: a radical alternative for social research" *Social Research Update* 37.

Wellcome Trust (2002) Going public: public attitudes to science and research, London: Wellcome Trust.

http://www.wellcome.ac.uk/News/2002/Features/WTD004707.htm

Wilsdon, J. & Wills, R. (2004) *See-through science: why public engagement needs to move upstream*, London: Demos.

http://www.demos.co.uk/files/Seethroughsciencefinal.pdf?1240939425

Wilsdon, J., Wynne, B & Stilgoe, J. (2006) *The public value of science: or how to ensure that science really matters*, London: Demos.

http://www.demos.co.uk/files/publicvalueofscience.pdf?1240939425

Wynne, B. (1989) "Sheepfarming after Chernobyl" *Environment*, 31(2), 10-39.