What can we learn from 25-years of PUS research? Liberating and widening the agenda

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Abstract

The term ‘public understanding of science’ (PUS) considers the relationship of science and society with a double focus. On the one hand it refers to a variety of activities that engage the public with science. This takes, at times, the character of a social movement, involving actors, resources, and a growing repertoire of activities. It is on the other hand a growing field of empirical social research. This paper summarises the key issues of public understanding of science research over the last quarter of a century.[i] We show how the discussion has changed during that period, particularly in relation to surveys of public perceptions. We review past research agendas, incorporate criticisms, and attempt to take things further to elaborate and contextualise survey-based investigations. We trace developments in PUS research through three paradigms: **science literacy, public understanding of science** and **science and society**. Naming matters here like elsewhere. Each period is associated with a particular framing of the problems in the relationship between science and society, particular research questions and preferred intervention strategies; and each period displays a rhetoric of ‘progress’ over the previous one. Comparing the three paradigms, we ask the questions: Is there any progress in this field of research? How can we take it forward?

Introduction

Two semantic issues complicate any review of research in public understanding of science. Firstly, the term ‘public understanding of science’ (PUS) is an ambiguous phrase. On the one hand it refers to a wide range of activities that aim at bringing science closer to the people and to increase public understanding of science. On the other side it refers to research that investigates what the public’s understanding of science might be. We will say very few words about the former, and focus mainly on the latter concentrating on survey research.

Secondly, discussions in PUS research are often entangled in a polemic over the ‘deficit concept’. This polemic is reminiscent of Lazarsfeld’s (1941) dichotomy of ‘administrative’ and ‘critical’ research, but with a methodological fixation that was absent in the original discussion.[ii] As the polemic has it, the administrative PUS researcher is conducting survey research entirely from the point of view of its sponsoring government, business or scientific institution; by definition, such a researcher considers the public ‘deficient’ of knowledge, attitude or trust. Hence survey research serves existing powers, and aims to increase the efficiency of communication and the effectiveness of messages; it focuses only on means-to-given-ends. To use a military analogy, this administrative research is akin to intelligence gathering for an artillery guidance system: it focuses on issues such as target definition, required ammunition, timing of the projectile, and observation of the target area for impact and collateral damage. By contrast, as the polemic has it, the critical researcher will research the ends, as well as the means and the context, of the research, and will exclusively use qualitative protocols, shunning quantitative methods as normative. This critical research is thus supposed to introduce reflexivity and to open up the sponsor to change of mind. In Habermas’s terms, ‘critical’ means to conduct research that emancipates the lay public from the grip of scientific authority. Where *doxa* reigns there shall be *logos*. In military terms, the critical intelligence officer will question not only the particular shelling but also the strategy of shelling. Or that is how the story goes.

The problem with this PUS controversy is not the distinction of research interests, but the identification of particular agendas with particular methodological protocols: survey research is administrative, qualitative research is critical, we are told. Lazarsfeld, however, intended an ideal-typical distinction to promote the convergence of orientations, not the stigmatisation of method protocols. Furthermore, in practice it is difficult to see how the one orientation can be sustained without the other. After all, the critical researcher is dialectically bound up with the administrative researcher for his critique, and only the most cynical administrative researcher can sustain their efforts without reflecting on the ends at some point.

Thus, our paper starts with a programmatic note: too much of the discussion on PUS has stigmatised survey research by identifying it in essence with a purely administrative agenda, while case studies and qualitative enquiries have been suggested as the *sine qua non* of critical undertakings. (Ironically, critical discourses and qualitative research are being increasingly incorporated by powerful sponsors, a process which somewhat blunts their critical edge.) We, however, consider the linkage between method protocol and knowledge interest a logical fallacy and also empirically wrong (Bauer, Gaskell & Allum, 2000). The identification of method protocol and knowledge interest is 'behaviouristic' and ignores the functional autonomy of motives. An interest motive can move between different behaviours, and a particular behaviour can express different interests. While lower animals are blessed with relatively fixed linkages between motive and behaviour, *homo sapiens* is unfortunate in that respect, and pays for it with anxieties and mutual misunderstandings. Motive and method are flexibly linked, and this is true for knowledge, interest and methodological protocol - and not only in PUS research. We consider that it is crucial to break this stigma of survey research in order to open the agenda for future PUS research. For us, the only constraints are the criteria of rigour of any established research protocol, be that quantitative or qualitative. Knowledge interests is a different matter. That is our ethos.

A field of activity and its agendas

For many people working at the boundaries between science and the public from the mid-1980s onwards, the 'public understanding of science' became a rallying cry, a banner or flag around which to gather and to do better work. The new cry superseded the earlier 19th century one for 'popularising science', which nowadays sounds rather condescending in tone.

Those who engage in bringing science closer to the people can be considered as a social movement that comprises actors, resources and a repertoire of activities and justificatory arguments and motives. Among the actors we find, traditionally, the scientists who communicate to a wider audience; these have been called the visible scientists (Werskey, 1978). But there are also the professional science writers who write in newspapers, magazines, radio and television or popular science books. Then there are the staffs of science museums and science centres, the activists in societies such as the British Association for the Advancement of Science or its sister institutions in many countries. Increasingly there are the press officers of scientific laboratories, professional scientific bodies and universities who prepare news events, press releases or annual reports to create a better public profile for their institution.

All these actors draw on resources. Their funding may come from public or private sponsorship, from members, or from selling stories or expert advice on how to deal with the public. Resources are not only money, but also ideals and motives which support the notion that science and the public need to be ever closer. Ideals of public education compete with self-interest, public entertainment, national pride in international competition, or more managerial notions such as public relations for the purpose of creating a favourable image for science or a particular institution. A public profile and favourable images are important to sustain public goodwill that may ultimately translate into funding for future research (e.g. Gregory & Miller, 1998; Gregory & Bauer, 2003).

The range of activities include exhibitions, science festivals and events, press releases, science reportage in the press, radio and television, popular science books and cinema, public hearings, meetings and internet websites, consensus conferences, deliberative opinion polls, citizen juries etc. This repertoire of activities grows with every new communication technology that becomes available. Alongside these actors auxillary efforts in "science communication" training and education have proliferated – an industry feeding on an industry, and becoming part of the available resources.

A full inventory of actors, activities, and material and symbolic resources of public understanding of science is still needed. Such was attempted by Schiele (1994) covering Europe, North America, Africa, Australia, and Japan, and a more recently for Brazil by Massarani, Moreira and Brito (2002). For Europe a preliminary collection of *information* (rather than strictly comparable *data*) has been undertaken by Miller et al. (2002).

The PUS movement has its ups and downs. In the short term, this may reflect party political priorities, as in the Portuguese Ciencia Viva programme, which flourished under the socialists for seven years, was pushed to the "back burner" under the conservative government that succeeded them, and is now back in favour along with the socialist party (Miller et al., 2002). But there are less easily characterised, longer term fluctuations. Preliminary evidence over the last 150 years (e.g. Bauer, 1998b) shows several periods when the popularisation of science was high on the agenda: in the years between 1870-1885, in the 1920s, again between 1955 and 1965, and more recently since the mid 1980s. This very paper surfs the latest wave. Equally, the membership of organisations such as the BA (British Association) or the AAAS (American Association of Science) and similar organisations is not constant (see Kohlstedt, Sokal & Lewenstein, 1999).

However, the demarcation of such waves of PUS activity is one thing, their explanation and implications quite another. Might it be that whenever science faces a crisis of public confidence, PUS comes into focus? Or could it be that PUS contributes to a crisis of confidence? For example the British House of Lords officially diagnosed a 'crisis of confidence' of society towards science (House of Lords, 2000) at a time when PUS activities were at an all-time historical high. While this ambitious historical account of PUS remains a desideratum, in what follows we propose a preliminary characterisation of the field and its associated research agendas.

'Paradigms' for understanding the public understanding of science

If the PUS movement has generated diverse engagement activities, it can also claim diversity of social scientific research. Over the last 20 years the public understanding of science has spawned a field of enquiry that engages, to a greater or lesser degree, sociology, psychology, history, communication studies, and science policy analysis. It remains somewhat marginal but vigorous in its output. The field displays a naïve dialectic between supposedly administrative and critical attitudes that echo the polemic that accompanied the foundation of communication research in the 1940s, as mentioned in our introduction.

Table 1 above one gives a schematic overview of three 'paradigms' of research into public understanding of science. The table implies a model of the relationship between science and the public based on the attribution of deficits. Each paradigm has its prime time, more or less precisely defined, and is characterised by a diagnosis of the problem that science faces in its relationship with the public. A key feature of each paradigm is the **attribution of a deficit** either to the public or to science. Each paradigm suggests particular research questions and solutions to the problem.

Table 1: Different paradigms, problems and solutions

Period	**Attribution** **Diagnosis**	**Strategy** **Research**
Science Literacy 1960s – 1980s	Public deficit Knowledge	Measurement of literacy Education
Public Understanding 1985 – 1990s	Public deficit Attitudes	Know x attitude Attitude change Education Public Relations
Science & Society 1990s - present	Trust deficit Expert deficit Notions of public Crisis of confidence	Participation Deliberation 'Angels' mediators Impact evaluation

Scientific Literacy (1960s – mid 1980s)

The idea of 'scientific literacy' builds on a double analogy. Science is part of the cultural stock of knowledge with which everybody ought to be familiar. Scientific education ties in with the quest for 'basic literacy' in reading, writing and numeracy. The second analogy is 'political literacy'. Here the idea is that in a democracy people take part in political decisions, directly in referenda or indirectly via elections or as voices of public opinion. However, voice can only be effective if people command knowledge of the political process and its institution (Althaus, 1998). The assumption is that scientific like political ignorance breeds alienation, demagogy and extremism.

The literacy idea attributes a knowledge deficit to the public, who, for whatever reasons, is ignorant or not literate enough. This **deficit model of the public** serves the education agenda demanding increased efforts in science education at all stages of the life cycle. However, it also plays into the hands of technocratic attitudes among decision makers: the public is de-facto ignorant and therefore disqualified from partaking in science policy decisions.

An influential concept of 'science literacy' was proposed by Jon D Miller (1983, 1987 and 1992). Miller's definition included four elements: (a) knowledge of basic textbook **facts** of science, (b) an understanding of scientific **methods** such as probability reasoning and experimental design, (c) an appreciation of the ***positive*** **outcomes** of science and technology for science, and (d) the **rejection of superstitious** beliefs such as astrology or numerology. Miller constructed survey based indicators for literacy, based on earlier work (Withey, 1959; see also the review of Etzioni & Nunn, 1976), which became the basis of the bi-annual science indicator surveys of the US National Science Foundation (NSF) from the late 1970s onwards. A regular audit of the nation's scientific literacy was undertaken using representative surveys of the adult population.

The research agenda

The psychometrics of factual knowledge is a key problem of this paradigm. Knowledge is measured by quiz-like items (see table 2). Respondents are asked to decide whether a statement of a scientific fact is true, false or that they don't know. Some of these items are notorious, have travelled far across the globe, and hit the news headlines.

Table 2: Examples of knowledge and attitude items in literacy research

Knowledge items

Item 1. 'Does the earth go around the sun or does the sun go around the earth? (**the earth goes around the sun**; the sun goes around the earth; dk).
Item 2. 'The centre of the earth is very hot' (**true**, false, dk)
Item 3. 'Electrons are smaller than atoms' (**true**, false, dk)
Item 4. 'Antibiotics kill viruses as well as bacteria' (true, **false**, dk)

Attitude items (Likert scales)

Item 5: 'Science and technology are making our lives healthier, easier and more comfortable' **(agree = positive)**
Item 6: 'The benefits of science are greater than any harmful effects' **(agree = positive)**
Item 7: 'We depend too much on science and not enough on faith' **(disagree = positive)**

1 strongly agree;
2 agree to some extent;
3 neither/nor;
4 disagree to some extent;
5 strongly disagree;
9 don't know (DK).

Source: Eurobarometer 31 of 1989.

Respondents score a point for every correct answer (as highlighted in table 2). It is an empirical research problem to formulate short and unambiguous statements for which the correct authoritative answer can be determined without too much controversy, and to get a balance of easy and difficult items from different fields of science. Many of the responses to these items, often between 10 or 20, are correlated and act as indicators that can be combined to form a scale of scientific knowledge. Such variables can then be used in further analysis. Much research is involved the testing of such items and their scalar value. Recently item response theory (IRT) is brought into the discussion for this purpose (Miller & Pardo, 2000). As literacy indicators these items are fundamentally of value only in combination; any single item has little significance. However, public speakers and the mass media repeatedly pick out stand-alone items as indicators of public ignorance and reasons for public alarm. In particular the item about the sun and the earth (item 1 above in table 2) has seen alarmist citations out of context.

What counts as scientific knowledge? Miller suggested two dimensions: facts and methods. This stimulated efforts to operationalise 'methods' such as probability reasoning, experimental design, the importance of theory and hypothesis testing. To formulate items to cover scientific methodology poses a far greater challenge than textbook facts. Scales of methodological knowledge are based on three or four items, and therefore less reliable than factual knowledge indicators. Useful in this context is an open question initially suggested by Withey (1959): *'Tell me in your own words, what does it mean to study something scientifically'*. Respondents' answers are recorded verbatim and coded for an index of methodological and institutional awareness. However the coding the responses remains controversial: normative or descriptive (see Bauer & Schoon, 1993).

Critics have argued that the essence of science is its process and not its facts (e.g. Collins & Pinch, 1993). Therefore awareness of issues like uncertainty, peer reviewing, the settling of scientific controversies, and replication of experiments should be reflected in the assessment of literacy. Furthermore, relevant knowledge includes that of the scientific institution and its politics, what Prewitt (1983) called 'scientific savvy' and Wynne has called the 'body language' of science (Wynne, 1996). The latter dimension has to date received the least empirical attention (although see Bauer, Petkova & Boyadjiewa, 2000; Sturgis and Allum 2004).

The appreciation of 'positive outcomes' of science is measured by attitude scales. Respondents agree or disagree to value statements, and thereby express their positive or negative attitude towards science. Some statements, in order to assess a positive attitude, require the respondent to disagree, others to agree depending on the formulation. This tactic attempts to avoid so-called acquiescence response bias. A related issue is the inclusion and separation of neither/nor and 'don't know' options. Not offering a 'neither/nor' may increase the variance in the data, but forces people into positions which they might not actually hold and leaves them no space to express genuine ambivalence or, equally, to admit to genuine ignorance.

Is literacy a continuum or a threshold measure? Miller's original was a threshold measure. To qualify as a member of the 'attentive public for science' one needed to command 'some' minimal level of literacy, be interested and feel informed about science and technology, appreciate their positive outcomes, and renounce superstitions. However, the definition of this ‘minimal level of literacy’ changed from audit to audit, and it is unclear whether the NSF reported changes, or for that matter lack of changes, reflects modifications in definition or in substance (see e.g. Beveridge & Rudell, 1998).

Since the 1970s many countries have undertaken similar audits of *adult scientific literacy*, data exists in the USA, Canada, China, Brazil, India, Korea, Japan, Bulgaria, Switzerland, Britain, Germany and France and many other EU countries, but the access to at least some of these data for the purpose of analysis remains problematic. The US NSF has presented comparative analyses and offered ‘horse race’ type ranking of different countries’ literacy and answered the question: and where do *we*, the US, stand? A possible problem of such comparisons remains the fairness of the indicator. A particular set of knowledge items may be biased towards certain countries. Countries have a different science base, and literacy is likely to reflect the country’s science base (e.g. Raza et al, 1996). The issue of culturally unbiased literacy measures deserves more attention than it has thus far received.

What is to be done?

The literacy paradigm is concerned with the public deficit of scientific knowledge. It focuses on the operationalisation of knowledge, and the NSF opened the space for international comparisons of adult science literacy indicators during the 1980s. Interventions are mainly in the area of public **education**. A deficit in adult scientific literacy is a matter of continued education, and requires increased attention in school curricula and in publicly responsible mass media reportage (e.g. Royal Society, 1985).

Critique

The critique of the literacy paradigm focuses on conceptual as well as empirical issues. Why should science knowledge quality for special attention to audit its public’s profile? What about historical, accountancy or legal literacy? Arguments abound for the societal significance of any of these forms of specialised knowledge. The case for ‘science literacy’ needs to be made in competition to other types of literacy.

Secondly, critics argued that these large scale survey measures produce at best irrelevant indicators of ‘textbook knowledge’, at worst empirical artefacts. Of real importance is knowledge-in-context that emerges from local controversies and people’s life concerns (Ziman, 1991; Irwin & Wynne, 1996). However, what accounts for the consistent correlations between measures of literacy and attitudinal and socio-demographic variables? The failure to engage in this debate perhaps goes some way in explaining why the British ESRC research programme on Public Understanding of Science between 1986 and 1991 became hopelessly entrenched in methodological conflicts over how to study the public understanding of science.[iii]

Thirdly, there is the question of superstitions. Does belief in astrology disqualify a respondent from being scientifically literate, as Miller (1983 and 1987) suggested. This issue might be culturally sensitive in some countries, particularly the US. The co-existence of superstition and scientific literacy is an empirical matter. Astrology and scientific practice serve different functions in life. To make ‘belief in astrology’ an exclusion criterion for literacy bars us from understanding the interesting contexts of tolerance and intolerance between science and ‘superstitions’ as cultural variables (see Boy & Michelat, 1986; Bauer & Durant, 1997).

Finally, it is suggested that the concern for literacy arises in parallel with the crisis of legitimacy of ‘big science’. To beat this crisis with literacy assumes a fundamental gap in the cognitive operations of literate scientists and an illiterate public, for which there is little evidence. Furthermore, if the Baconian notion of ‘knowledge = power’ holds, any attempt to share knowledge without public empowerment might only create further alienation rather than rapprochement. Literacy is therefore the wrong answer to the crisis problem (Roqueplo, 1974; Fuller, 2000).

Public Understanding of Science (1985 – mid 1990s)

In the second half of the 1980s, new concerns emerge under the title public understanding of science (PUS).[iv] In the UK this transition is clearly marked by an influential report (Royal Society, 1985). PUS shares with the previous literacy phase the diagnosis of a **public deficit**. However this time round it is public attitudes that are foregrounded (Bodmer, 1987). The public is not positive enough about science and technology; in fact it is negative or outright anti-science, and this must be of concern to scientific institutions. Old and new reasons for the promotion of science in public are put forward: understanding is important for making informed consumer choices; it enhances the competitiveness of industry and commerce; and it is part of our tradition and culture (see Thomas & Durant, 1987; Gregory & Miller 1998). The Royal Society of London assumed that more public understanding activity will ‘cause’ more positive attitudes. The **axiom** of PUS is ‘the more you know, the more you love it’.

Research agenda

The research agenda moves away from the measurement only of knowledge to that of public attitudes. The measurement of attitudes has a long tradition in social psychology (see Eagly & Cheiken, 1993). Thus research on science attitudes became concerned with ‘acquiescence response bias’, the construction of reliable scales, the multi-dimensional structure of attitudes (e.g. Pardo & Calvo, 2002), the relationship between general attitudes and specific attitudes (Daamen & vanderLans, 1995), context effects of questions (e.g. Gaskell, Wright & O’Muircheartеigh, 1993) and, most importantly, with the relationship between knowledge and attitudes.

Conceptually attitudes can be conceived within the framework of social representations of science. Representations arise when common sense encounters novelty; they allow us to familiarise the unfamiliar (Farr, 1993). The research focus shifts from rank ordering people along some continuum to characterising the diversity of representations (e.g. Boy, 1989; Bauer & Schoon, 1992; Durant, Evans & Thomas, 1992). Studying representations rather than simply measuring attitudes opens the door wide for qualitative enquiry (Bauer & Gaskell, 1999).

The concern for scientific literacy carried over into PUS. A knowledge measure is needed to test the expectation ‘the more you know, the more you love it’. However, the emphasis shifts from a threshold measure to that of a continuum. One is either literate or not, but more or less knowledgeable (Durant, Evans & Thomas, 1989). The correlation between knowledge and attitudes becomes a focus of research (Evans et al, 1989; Durant et al, 2000). The results remained inconclusive until recently (see Allum et al, under review): most large scale surveys show a small positive correlation between knowledge and positive attitudes, but they also show larger variance among the knowledgeable. With controversial issues, the correlation tends to be lower or zero. Thus not all informed citizens are also enthusiastic about science and technology; for some ‘familiarity breeds contempt’. It is surprising that anybody ever expected this to be different. Classical attitude theory considers knowledge not a factor of positive attitudes, but an indicator of attitudes that resist change (Eagly & Cheiken, 1993). What emerges, though, is clear evidence that knowledge and information matter. It is most unlikely that poorly and well informed citizens make up their minds in the same way.

Some research looked at ‘don’t know’ (DK) responses and reveals various meanings of self-attributed ignorance. Comparing incorrect responses and DK-responses suggest an index of confidence: women and some milieus consistently declare ignorance rather than guess as they are less confident to opine on science (Bauer, 1996; Mondak & Amdersen, 2003). Turner & Michael (1996) found four types of admitted ignorance: admittedly embarrassed; I am not very scientific; I know somebody who might know; I don’t care and don’t want to know. Sharp changes in the rates of DK-responses in any one context also indicate methodological issues, such as sudden changes in interviewer protocol. Such changes might reflect a change in fieldwork contractor, like in the case of Eurobarometer surveys from one cycle to another.

PUS research extended the range of concepts, methods and data. Understanding includes familiarity with the facts and the methods of science, but also with the workings of scientific institutions and politics at large. It emerged that attitudes to science and technology are related to general political sophistication as well as to a specific scientific literacy (Sturgis & Allum, 2004; Gaskell, Allum and Stares 2002). The polemic over the deficit concept stimulated discourse analysis of interview and textual materials during the 1990s. In the attempts to assess the salience and the framing of science in the mass media the twin ideas of social indicators and cultural indicators meet (e.g. Bauer, 2000). Mass media monitoring, in particular of newspapers, is cost effective and can be readily extended backward in time and updated into the present very easily. Such analyses reveal long-term trends such as the medicalisation of science news over the last 25 years in Britain (Bauer, 1998a).

What is to be done?

The intervention of the PUS paradigm might be divided into a rationalist and a realist agenda. Both agree with the diagnosis of an attitudinal deficit - the public is insufficiently in love with science and technology - but they disagree on what to do about it.

For the **rationalist,** attitudes are a product of information processing with a rational core. Hence, negative attitudes towards science - or unreasonable risk perceptions, the fashionable concept of the 1990s – are caused by insufficient information, or they are based on certain heuristics that bias the public's judgement of science and technology. It is the assumption that had people all the information and operated without certain heuristics, they would display more positive judgements of scientific developments. Without exaggerated perceptions of risks, they would agree with experts, who do not succumb to these biases as the public does. People need more information and training on how to avoid biased information processing. The battle for the public is a battle for rational minds with information and statistics training.

For the **realist,** attitudes are emotional relations with the world. How emotions may relate to rationality is a vexing question, one that is traditionally confused by a conflating cognition and emotion with rationality and irrationality. Realists understand emotions by thinking in terms of appealing to people, thus following the logic of advertising. The battle for the public becomes a battle for hearts of the public. How can we make an issue sexy? How can we attract attention to something many people find naturally boring? The public is a '**consumer'** that is seduced rather than rationally persuaded. There is little difference between science and washing powder, according to this logic of communication. The research required includes market segmentation, consumer profiling, and targeted campaigning taking into account the inclinations of different segments of the public. For example, British science consumers are divided into six groups with different socio-demographic profiles (OST, 2000): confident believers, technophiles, supporters, concerned, the 'not sure', and the 'not for me'. The same approach was taken in a Portuguese study (Costa, Avila & Mateus, 2002).

Critique

The conceptual critique of PUS successfully stigmatised large scale survey research with the deficit model (e.g. Irvin & Wynne, 1996; also Jasanoff, 2005). The critique focussed on the **deficit models** and highlighted the pitfalls of reifying 'knowledge' in the knowledge survey by insisting on knowledge-in-context (Ziman, 1991) and on how experts relate to the public. Literacy and PUS agendas assume or at least hypothesise a public state of deficiency, either lacking in the amount or the right kind of knowledge, or not displaying enough positive attitudes or 'reasonable' risk perception. Wynne (1993) used the term 'institutional neuroticism' to point at diffuse anxieties and to a lack of generosity of scientific actors vis-à-vis the public. The self-serving deficit model engendered self-fulfilling prophecy and a vicious circle: the public, a-priori deficient, cannot be trusted. Mistrust on the part of scientific actors will be paid back in kind by public mistrust. Negative public attitudes confirm the assumption among scientists: the public is not to be trusted. This circularity in the 'institutional unconscious' called for reflexivity and 'soul searching' among scientific actors, at times endorsing elements of a post-modern theory of knowledge with many centres.

An empirical critique of the PUS paradigm considers the relation of interest and knowledge. Many PUS surveys include a classical battery on the people's interest in science, thus comparing interest in science with other life interests. These items allow us to construct an index for interest-knowledge gap. Eurobarometer surveys suggest that self-reported interest is falling, while knowledge is increasing slowly over time (Miller et al, 2002). This trend, if continued and verified, would suggest that “familiarity breeds disinterest”, at least potentially, thus touching another hypothesis of the PUS paradigm: knowledge correlates with interest.

Science in-and-of Society (mid 1990s onwards)

The critique of the literacy and PUS paradigms as ‘deficit models’ ushered in a reversal of the attribution. It is proposed that the deficit is not with the public, but with the scientific institutions and their actors who have lost public trust. This opened the attribution process for other explanations of negative public attitudes. There may be several deficits: not only a public deficit of trust, but an expert deficit on the part of science and technology and its representatives. The focus of attention shifted to the **deficit of the technical expert**.

Diagnosis

Evidence of negative attitudes from large scale surveys and contextualised in focus group research and in quasi-ethnographic observations lead to an interpretation of the survey data as a ‘**crisis of confidence’** (House of Lords, 2000). Science and technology operate in society, are both expressions and resources of society, and therefore stand in a relationship with other sectors of society. A **crisis of trust** of the public vis-à-vis science indicates a breach of contract that needs patching up or renegotiation. The implicit and explicit views held by scientific experts of the public come under scrutiny. The trust problem is reversed. The **expert deficit** vis-à-vis the public explains part of the trust crisis. False conceptions of the public operate in policy making and misguide communication efforts which alienate the public still further.

What is to be done: mediation and ‘action research’ ?

In the writings on ‘Science and Society’ the distinction between research and intervention is blurred. Many critics are committed to action research and reject the separation of analysis and intervention. The aim of analysis is to intervene and to change science policy. This agenda, academically grounded as it may be, often ends up in political consultancy with a decidedly pragmatic outlook. Here the explicit and implicit notions of public, public opinion and public sphere are the focus of analysis as ‘theories espoused’ and ‘theories enacted’, not ‘theories tested’. As far as empirical research is concerned, there are few studies that document the conceptions of the public held by experts.

The bulk of activity under science and society arises from this fusion of research and consultancy. Advice is offered on how to rebuild **public trust**, and to address the paradoxes of trust. Once an issue, trust is already lost; trust cannot be engineered, it is granted to those that deserve it (Luhmann, 1968). Public deliberation and participation are presented as the new ‘royal road’ to **rebuild public trust**. The House of Lords Report (2000) lists numerous forms of deliberative activities such as citizen juries, deliberative opinion polling, consensus conferencing, national debates and hearings. As these activities have considerable financial and know-how implications they become the remit of private ‘angels’ rather than civil servants or academics. Angels are age-old go-betweens that mediate, but here not between heaven and earth but between a disenchanted public and the institutions of science, industry and policy making. Where hitherto social scientists were investigating literacy and attitudes, and critically diagnosing deficits, some social scientists seem satisfied with the role of angels ensuring that more people talk to each other more often. The writing on the governance of science promotes public participation and a new deal for science and society (e.g. Fuller, 2000). Many books describe the ‘good practice’, the know-how and the financial implications of public deliberations for ‘angels’ as the target audience (Seargent & Steel, 1998). Thus, an industry of advice emerged exuding confidence on how to handle and to overcome this crisis of confidence between science and the public.

Critique

‘Science and society’ is the flavour of the day, and there is as yet little critique of its achievements. The ethos of public participation is recently complemented by an interest in evaluating its outcomes. To the utilitarian spirit of modern politics, an ethos is not sufficient. Sooner or later the question arises: and what does this participatory approach bring (effectiveness)? How do different approaches compare? Can one save money with one approach doing equally well as with another (efficiency)? These questions call for the definition of objectives and for measurable criteria so that such activities can be publicly audited (Rowe & Frewer, 2004). In the UK, the introduction of public consultation as a legal requirement of ‘due process’ in law and policy making in general, created a bottleneck of know-how and capacity in the civil service, which was quickly filled by a market sector for outsourcing consultation. Such a private sector creates a dynamic of claims-making and spurious product differentiation that urgently requires ‘critical consumer testing’.

The science and society agenda emphases reaching a consensus, which raises a number of questions. For example, will “dialogue” simply be appropriated by the old deficit model as a better means of persuasion? This approach was demonstrated during the *GM Nation* debate, a UK government-backed consultation in 2003 on genetically modified crops and their GM food products. This national debate, which included focus groups, deliberative debates and opinion polling, produced the evidence that the British public were far from convinced of the benefits of GM crops and foods – *not* what the government wanted to hear. There were two responses: to attack the process for allowing environmental groups to have too much influence, an attack on *methodology*; and to conclude that further dialogue was needed to get the public to adopt the “right” attitude, a rejection of the *outcome*. In this way, what is called dialogue becomes ‘monoaud’: both “sides” of the science and society divide are talking; but only the public is supposed to listen and to change. In much writing on science and society issues (e.g. European Commission, 2001), much emphasis is placed on the role of the media. But just what is the role of the media in the processes of consensus-making? Media arenas are hardly suited to consensus building: “Blair and Chirac agree on everything” is not newsworthy; “Chirac slams Blair over ….” is much more likely to get front-page treatment.

The call to evaluate participatory science policy making re-opens the door for the traditional canon of public understanding of science research. Researchers on public participation in science and technology policy come to advocate quasi-experimental designs of deliberative events [REF PUS NANO SPECIAL ISSUE]. They suggest indicators such as media coverage, shifts in public attitudes, and changes in the policy agendas attributable to public consultation (e.g. Butschi & Nentwich, 2002; Joss & Belluci, 2002). This call for measurements of public attitudes, media coverage and agenda setting effects reinvents the wheel, albeit this time for a different car. The re-entry of literacy and PUS via the backdoor of evaluation research seems ironic but unavoidable. Does the ‘democratic process’ pay off?’ is a pertinent question. And when people ask about costs and benefits, a currency will be needed.[v] It just may be that changes in media coverage, public knowledge, interests and attitudes offer the currency to audit public participation.

Liberating and widening the research agenda

Is the path from ‘Scientific Literacy’ to ‘Science and Society’ a path of progress? Clearly the protagonists of each phase used a rhetoric of Progress writ large, and would want us believe it. PUS researchers might claim that they left behind the limited concern with scientific literacy and they moved on to attitudes. For the Science and Society protagonists, both literacy and attitude researchers commit an attribution error in blaming the public for the crisis of confidence between science and the public. Public participation and ‘angelic’ mediation is the new mission; empirical social research becomes a somewhat anachronistic preoccupation. Progress, or is it?

In our view progress is modest: new questions and new discourses. None of the new discourses make the previous one obsolete as the rhetoric wants to have it (Miller 2002). PUS preserves the relevance of knowledge measurement, central to scientific literacy, and adds a concern for attitudes. Science and Society, whilst rejecting the public deficit models, cannot, once consolidated, avoid the thorny problem of auditing its angelic activities. And ironically, it might rediscover old wine, albeit it in new bottles. The public deficit may not be the focus anymore; rather the performance of the outsourced ‘angels’ of public participation, who spend public money, find themselves having to be publicly and *quantitatively* accountable. One can only hope that the polemic over the deficit model, which stigmatised survey methods, has not eradicated the memory of past efforts.

Where, indeed, substantive progress may be found is in the measurement of public interest, knowledge and attitudes and in the assessment of agenda setting effects. The international survey of educational achievements (PISA) envisaged for 2006 will focus entirely on ‘scientific literacy’, albeit for children of school age. These results might well re-launch the discussions over adult literacy. If we dare make a prediction, it will be that PUS research, based on survey, focus group and media analysis, will revive, albeit within the wider framework of science and society.

We see four major areas of future development in PUS: various ways of contextualising survey research; performance or cultural indicators; longitudinal data analysis; and widening the range of data.

Context I: Reframing the knowledge-attitude problem as political sophistication

One possible cause of the fragmented nature of progress in PUS research is perhaps to be found in the cross-disciplinary character of the whole PUS enterprise. Research is carried out by psychologists, sociologists, political scientists, cultural theorists; even philosophers are increasingly getting in on the act. Whilst this must confer some advantages in broadening the range of perspectives and the explanations that are judged plausible, there are serious disadvantages. Having no firm disciplinary foundations has perhaps led to a reluctance on the part of PUS researchers to see the issue as but one example of a more general set of problems to be tackled within existing disciplinary frameworks.

As a thought experiment, try to place PUS into one disciplinary tradition only. Which might it be? A very strong candidate is political science. After all, science and technology issues are only a small sample from a much larger universe of social and political issues that confront citizens directly or indirectly in their daily lives. Why should the relationship between the public and science and technology deserve its own methodological and substantive paradigms and what is the possible benefit? The benefits certainly look rather slender considering the mixed progress of the field over the past two decades. So let us imagine a world where 'ghettoised' PUS research did not exist and the question of public opinions about and knowledge of science was addressed by only political scientists. What might we have learnt during the last two decades?

We would be in no doubt that the extent to which citizens make informed or ill-informed judgments about scientific issues makes a profound difference to the outcomes of collective decision-making (Althaus, 1996, 1998; Delli Carpini & Keeter, 1996). The debate over citizen competence and political participation is far advanced of anything we have seen in PUS, from both theoretical and applied perspectives. As early as 1964, Converse showed that what appeared to be stable political preferences amongst the mass public in the US concealed a huge swathe of what he termed 'non-attitudes' (Converse, 1964). This was demonstrated by the massive 'churn' in responses over successive waves of panel surveys. A large proportion of the public, so Converse argues, was responding essentially randomly to questions about important political issues of the day. This random response pattern shows a steep gradient with political knowledge. Those who know more tend to have more stable preferences. We may well find the same situation would apply in the case of public attitudes to science and technology but this research has not yet been carried out.

In the early seventies, a major critique of the non-attitudes thesis was that it was really just a 'measurement error' problem (Achen, 1975). More recently 'online-processing' has been proposed as a mechanism by which people may use information to form political opinions but then discard the information so that it cannot be recalled later on. This is a critique of research that uses political knowledge questions to evaluate the basis of citizen's political judgment [refs]. There are also models that link information, knowledge and values in the formation of political preferences, the role of 'cues' as non-cognitive substitutes for political information (Zaller, 1991, 1992).

Seen in this light, the heated and overtly normative debates about a 'deficit model' of public attitudes become non-controversial and even trivial. Practically every piece of evidence from the political science literature would lead us to begin with the assumption that for attitudes towards science and technology, as for every other issue of the day, information and the ability and motivation to process it is of crucial importance. Predicting the attitudinal outcome of differences in the amount and type of knowledge and understanding people bring to a particular issue is of less importance than it is in the PUS tradition and the focus would switch to understanding the processes and contexts through which these differences have their effects. The outcomes in particular contexts are a matter for empirical investigation on a case by case basis. Applying these insights to PUS research constitutes what we consider to be an agenda long overdue.

Context II: From industrial to post-industrial PUS

Cross-sectional survey analysis has shown that the correlation between variables might itself be a key indicator of context. Examinations of cross-national co-variation of interest, knowledge and attitudes led to the '**two culture model' of PUS**. In this analysis, PUS in industrialised (e.g. France, U.K.) and industrialising (e.g. Portugal, Ireland) countries is characterised by a high correlation between interest, knowledge and attitudes, while in post-industrial countries (e.g. Denmark, Germany) PUS shows lower correlations, or no correlation at all (Bauer, Durant & Evans, 1994; Durant et al., 2000; Allum, Boy & Bauer, 2002). Widening the range of countries for which PUS data is accessible will allow us to specify this model of socio-economic transition further. And while this speculation has arising from cross-national comparisons, taken at a single point in time, to test this 'two culture' hypothesis dynamically we need time-series, longitudinal data. Only longitudinal data will allow us to show that this transition takes place in any particular context, and if not, how the development of PUS might be understood and modelled in different contexts. This will bring comparative PUS research in line with the STS discussions over the conversion or diversification of global techno-scientific culture and 'civic epistemology' (Jasanoff, 2005).

Context III: Benchmarking PUS within a 'science & technology' indicator framework

Another route of contextualisation is the construction of an integrated framework of PUS activity indicators for the purpose of international benchmarking. In 2002, the European Commission published its *Report of the Expert Group Benchmarking the Promotion of RTD Culture and Public Understanding of Science* (Miller *et al.*, 2002). The EU is keen on comparing policies and performance on science and technology across the European Union, in the hope that simple (magic bullet) solutions to improving economic performance may be found. But, lest we are accused of advocating purely administrative research, we note that this does not have to be the only motive for carrying out such research.

The Expert Group collected information on all (then) 15 of the EU member states, based on submissions from government representatives, their own experience, and further research. The Group considered many “actors”: governments, the scientific community, formal and informal education, science museum and centres, the media, and industry. These actors were investigated for a number of attributes, including their leadership role, the resources at their disposal, and any particular orientation to “promoting” science and technology among women. The result of this work is useful, though far from sufficient; it provides a preliminary context for comparing datasets and for tracing the evolution of the “PUS movement”. And it did allow some of the more obvious conclusions to be drawn.

The worked showed, for example, that Europe is heterogeneous in approaches and levels of activity, although most actors address the “deficits” of the public that we discussed above. One clear, but rarely considered, deficit the Group picked up on was in the knowledge of governments about what they themselves were doing: it was impossible to get meaningful figures from the relevant ministries on the amount of money being spent on RTD promotion and PUS activities, let alone to say if there was “value for money” in what they were doing. There were, of course, exceptions: *Ciencia Viva* in Portugal, received a dedicated 5% of the country’s research budget from 1995-2002; Germany’s *PUSH ‘Wissenschaft im Dialog’* , a federal project where the Länder had traditionally been to the fore, had a clearly identifiable budget.

Another obvious “deficit” was in the area of training. In all but a few countries, little is done to prepare scientific researchers for communication activity with lay audiences, despite the importance that is being laid on PUS in official documents. And even in pioneering Britain, still only a tiny proportion of research scientists gets communication training. The education system is clearly the first point of contact with science for most people. In later life, “informal” and “life-long” education, in addition to formal schooling, shape attitudes to science and technology. The links between schools and science centres are important for children, and that the latter are important arenas for public dialogue, as in Paris’ *La Cité (des Sciences et de l’Industrie).* Perhaps surprisingly, it appears that industrial actors who show an interest in PUS, are also moving towards two-way communication strategies, reconsidering by their one-way corporate PR.

One could look at all of these conclusions as comparative measures of *performance* indicators in the field of PUS across the members of the European Union. That, indeed, was the goal of the sponsor of the research, the European Commission. It was hoped that some magic formula for improving public knowledge of and attitudes towards science could somehow be derived from the heterogeneous mass of generally incomparable information. And it was further hoped that a combination of benchmarking in the field of PUS, combined with the benchmarking of other socio-economic activities that involved a science-and-technology dimension, would indicate how activity in the one area benefitted activity in the other. In that sense, the exercise in benchmarking across the whole range of subject covered was a “failure”. But instead of using the information gathered in a performance evaluation framework, in can be just as readily and validly be interpreted as an indicator of the *cultural climate* for PUS, on a country-by-country or a Europewide basis. The methodology is separate from the agenda; the information may be used for more than one purpose.

Public understanding of science: outcome or context of policy

So the idea of integrating PUS indicators into the wider scheme of accounting for the nations science base, alongside the figures for R&D investments, research outputs in terms of patents, publications and citations counts, is not entirely new, but deserves reiterating. Since the early 1980s the US NSF included a survey of public understanding in their Science Indicator Reports, but got stuck with a framework with limited space for innovation. Some years ago Canadian researchers proposed an elaborate system of indicator of public understanding of science that included measures of education, mass media coverage and public perceptions (Schiele, 1994; Godin & Gingras, 2000). Very recently, PUS workers in India have undertaken the first attempt to construct indicators for public perception of science in India, which foresees a range of input and output data (Shukla, 2005).

However, these attempts at widening the database and indicators will have to address the issue of what kind of indicators they are. Are these performance indicators or cultural indicators? A performance indicator measures the outcomes of actions, and these outcomes are causally linked to identifiable actions. They are used in planning to operationalise objectives and to evaluate these action's success or failures. By contrast cultural indicators do measure the conditions of action, they indicate context-for-actions. No actor considers the change of the culture within his or her remit, however, many actors will have to consider culture or climate for as immediate action context (Bauer, 2000). Opting for a performance or culture framework encourages the collection of different types of data. Performance indicators will privilege survey data, and maybe mass media monitoring, as metrics for success and failure of PUS activities. Cultural indicators will broaden the spectrum of data to qualitative analysis of discourses, case studies of particular activities, mass media analysis, including television and cinema.

This type of indicator has implications for analysis of large scale survey data. As performance indicators, the unit of analysis is geopolitical. It is therefore the remit of particular PUS actors, typically the national polity. For cultural indicators, the unit of analysis is more flexible. Cross-cultural analysis might focus on finding clusters and configurations of responses which indicate culturally distinct attitudes and relationship vis-à-vis science and technology and associated with particular social and cultural milieus. Here a combination of survey diagnosis and ethnographic case studies will be help to elucidate cultural differences within and across national borders, for example within and between European regions and micro-regions. Studies of the spatial distribution of political values correlated with historical variations in kinship relations across Europe might serve as a model to map techno-scientific cultures (Todd, 1996)

Integrated databases to conduct longitudinal data and analysis

A burgeoning field of research is the history of popular science and public understanding of science. Generally, historical studies reveal the range of activities, ideologies and motives, and the historically changing relationship between science and society, and the role played by the public understanding movement in boundary work (see Gieryn, 1999; Gregory & Miller, 1998). Naturally, historical orientation requires a long-term perspective (e.g. Lewenstein, 1992; Bauer, 1998b).

PUS research has hitherto been dominated by single snap shot studies, either at one location or, in a few cases, comparative across several countries. Public understanding is a dynamic phenomenon and requires time-series data for an adequate representation. In several contexts, namely the USA (bi-annual since 1979), the UK (1986, 1988, 1996, 2000, 2004), France (1972, 1982, 1989, 1996), and the EU (1989, 1992, 2000, 2005) repeated surveys were conducted which invite longitudinal analysis. Regrettably, few resources have been invested in systematic analyses of these data series. Secondary analysis does not carry much academic kudos, apparently. Presenting the world with the latest news on literacy and attitudes carries more academic publicity than data archiving and data management, and funding agencies have to date also lacked the long-term perspective to fund such activity - in Europe at least.

There are hopeful signs of change. In the US, NSF has already consolidated its science indicator data into a single database including the surveys from 1979 to 2001. Similar efforts seem to be under way for the International Social Survey Programme (ISSP) which has for many years collected survey data on various issues pertaining to science and technology in variable sets of contexts. Eurobarometer has a tradition of doing PUS type surveys in the EU member countries (initially 8 and now 25) since 1989 at irregular intervals; some relevant items can be traced back to the 1970s. France and Germany have national databases on public attitudes going back many into the early 1970s. All of these data need consolidation into integrated databases that are made available to PUS researchers in order to begin to understand historic developments in PUS.

Once such integrated databases exist, the way will be wide open for longitudinal analysis, and this will be a step change in PUS research bringing to bear sophisticated statistical modelling techniques. We can finally move away from snapshot reporting of results, where it is sometimes difficult to distinguish the research value from the temporary news value, to dynamic modelling of the phenomenon across national contexts and social strata. We clearly have to move away from reporting that ‘only 80% of X’ believe that the ‘earth is turning around the sun’ (probably the most travelled item of PUS research) or ‘35% believe that ordinary tomatoes do not contain genes’ - shock and horror!! These figures only really represent anything when compared across contexts and over longer time-periods. As snapshots, these figures serve only a projection ground for moral panics. Consolidated databases and longitudinal modelling will also inform the above attempts at international benchmarking and contextualisation.

Widening the scope of data and develop suitable methodologies

Once more, our plea is to widen the range of data "officially and legitimately" considered relevant for monitoring public understanding of science. Qualitative information has been in the field for some time. So have mass media analysis. But little effort has gone into a sustained effort of repeated collection of comparable data. Yet both mass media and qualitative enquiry lend themselves to longitudinal enquiry, although here the methodology is less widely accessible and might need further development. In this way, an inter-disciplinary field of enquiry like PUS might make significant research contributions applicable to other disciplines, not least in developing existing methods of data collection and analysis. For example, the analysis of representations of science, through the longitudinal analysis of newspapers or magazines which are well suited to yield long-term indicators of public salience and issue framing (LaFollette, 1990; Bauer et al, 2006), might contribute significantly to a dynamical theory of social representations, dealing more generally with beliefs and forms of knowledge other than scientific (see Wagner & Hayes, 2005).

In conclusion: we have traced the recent history of PUS research from literacy to public understanding to science and society and deplored its entanglement in a now unproductive polemic between the deficit concept and the critical posture. Breaking the perceived linkage between methodological protocol and knowledge interest is a precondition for opening the agenda for research: we need to distinguish between rhetorical utility and empirical evidence. In this light, we hope that the field will see fertile and burgeoning research activity in the years to come.

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Endnotes

[i] This cannot be an encompassing undertaking, ours is informed by a British perspective, which however had considerable influence in Europe and beyond over the last 20 years.
[ii] This dichotomy is already a simplification of a complex issue which Habermas (1965) later caught in the trichotomy of technical-instrumental, practical-normative, and critical-emancipatory knowledge interests.
[iii] Martin Bauer joined PUS research programme in the late 1980s as a 'number cruncher' for John Durant at the Science Museum in London. He remembers that many of the members of this research programme were on non-speaking terms. The debate curiously centred on methodology and whether a team would use numerical or qualitative protocol for their observations. The publication that finally presented the 'main results' of this programme (Irwin & Wynne, 1996) excluded three projects with numerical data: the survey of the British adult population (J Durant), the survey of British children (G Breakwell), and the analysis of mass media reportage of science (A Hansen).
[iv] PUS was also extended to PUST to include 'T' for technology, PUSTE to include 'E' for engineering, or PUSH to include 'H' for the humanities, the latter indicating a more continental understanding of 'science' as 'Wissenschaft'. The dating of these phases is liberal follows mainly the influential UK experience. In the US all through the 1970s the AAAS had a standing Committee on Public Understanding of Science (see Kohlstedt, Sokal & Lewenstein, 1999, p 140ff.
[v] The above mentioned UK GM Nation debate cost the government close to £1 Million. A simple survey of public attitudes would have cost around £50,000. This differential of costs will have to be justified with added value, in particular if such debates should become routine and not just an one-off experiment.