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# What is Post-Normal Science

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In response to the new conditions of science in its social context, with increasing turbulence and uncertainty, the idea of 'Post-Normal Science' has been developed. Going beyond the traditional assumptions that science is both cetain and value-free, it makes systems uncertainties' and 'decision stakes' the essential elements of its analysis. It distinguishes between 'applied science' where both dimensions are low, 'professional consultancy' where at least one is salient, and Post-Normal Science where at least one is severe. In the latter case, science derived from textbooks must be supplemented by other ways of knowing. Its theoretical core is the task of quality-assurance; it argues the need for new methods, involving 'extended peer communities', who deploy 'extended facts' and take an active part in the solution of their problems. It is already being realised in many initiatives; for those it provides a theoretical basis and legitimation.

The situation of science in its social context has become increasingly turbulent in recent years. Through the campaigns in the UK over Brent Spar, BSE and, most recently, Genetically Modified foodstuffs, science has become every more deeply involved. In Brent Spar, it was a question of procedures, of principles, and also of competing sorts of expertise. With BSE, the diasaster was largely the result of administrative styles, but science and scientists were recruited for providing the official assurances of safety. But with GM foodstuffs, science is at the heart of the matter. One question is in whose interest, and under whose control, the basic science is done. The other is the traditional paradox of 'quis custodiet custodes ipsos?' who regulates the regulators? Quite soon we will confront the disruptive effects of the Millennium bug, the result of a failure of quality assurance in an industry which is totally created by science.

Such developments are of great concern to all those who depend on science, either individuals or institutions in either the private or public sectors. Our productive system and indeed our whole culture have come to be characterised by reliance on science. A disturbance in the societal position of science, in its image and in the

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expectations invested in it, will have effects in all directions. For the management of these, we need a comprehensive understanding of science in its new social context.

Although there are still some who imagine science to be essentially an innocent pursuit cultivated by individuals motivated by curiosity, that picture now carries little credibility. There is a consensus on science as a major social institution, with structures of prestige and influence, and possessing the power to initiate, defer, stop or even suppress research. Also, there has now developed an institutionalised counter-expertise, seen in the major environmental groups, capable of engaging in a critical dialogue with the official experts.

This new social organisation of science, sometimes described as 'Mode 2' [1], is defined by the dominance of 'goal orientation'. This is controlled by managers or funders; scientists are being reduced to 'fungible' units of manpower, proletarians deprived of property rights to the products of their labour. This marks a evolution of the 'industrialised science' of the postwar period [2].

With these structural and social changes has come a new understanding of what science is like in the policy process. The previous belief that scientists should and could provide certain, objective factual information for decision-makers is now being increasingly recognised as simplistic and immature. It is appreciated that the commitments of scientific advisors can legitimately influence their judgement on issues where there are deep and unresolvable uncertainties. When they enter a negotiation, they cannot leave their values at the door. Their integrity lies not in their 'disinterestedness', but in their honourable behaviour as stakeholders.

All of this should be familiar, as the emerging common sense of science as engaged in the policy process. The new situation of science has great promise, in providing the stimulus for a creative response to new challenges. But it also presents great hazards, in the possible corruption of science through its involvement in new tasks for which scientists have no professional preparation. We therefore need some new picture of science, on which goes beyond the simplistic certainties of yesteryear, and which provides guidance through the new perplexities of the uncertainties, value-loadings and commitments that characterise contemporary policy-related science. For this we have developed the concept of 'Post-Normal Science', as an extension of traditional problem-solving strategies that is appropriate for our times.

The idea of a science being somehow 'post-normal' conveys an air of paradox and perhaps mystery. By 'normality' we mean two things. One is the picture of research science as 'normality' of T.S. Kuhn [3]. Another is the assumption that the policy environment is still 'normal', in that such routine puzzle-solving by experts provides an adequate knowledge base for policy decisions. Of course researchers and experts must do routine work on small-scale problems; the question is how the framework is set, by whom, and with whose awareness of the process. In 'normality', either science or policy, the process is managed largely implicitly, and is accepted unwittingly by all who wish to join in. The great lessons of recent years is that the assumption no longer holds. We may call it a 'post-modern rejection of grand narratives', or a Green, NIMBY politics. Whatever its causes, we can no longer assume the presence of this sort of 'normality' in the policy process, particularly in relation to the environment.

The insight leading to Post-Normal Science is that in the sorts of issue-driven science relating to environmental debates, typically facts are uncertain, values in dispute, stakes high, and decisions urgent. Some might say that such problems should not be called ‘science’; but the answer could be that such problems are everywhere, and when science is (as it must be) applied to them, the conditions are anything but ‘normal’. For the previous distinction between ‘hard’, objective scientific facts and ‘soft’, subjective value-judgements is now inverted. All too often, we must make hard policy decisions where our only scientific inputs are irremediably soft.

In such contexts of policy making, there is a new role for natural science. The facts that are taught from textbooks in institutions are still necessary, but are no longer sufficient. For these relate to a standardised version of the natural world, frequently to the artificially pure and stable conditions of a laboratory experiment. The world is quite different when we interact with it, either destructively or constructively. Those who have become accredited experts through a course of academic study have much valuable knowledge in relation to these practical problems. But they may also need to recover from the mindset they might absorb unconsciously from their instruction. Contrary to the impression conveyed by textbooks, most problems in practice have more than one plausible answer, and many have no answer at all.

Further, in the artificial world studied in academic courses, it is strictly inconceivable that problems could be tackled and solved except by deploying the accredited expertise. Systems of management of environmental problems that do not involve science, and which cannot be immediately explained on scientific principles, are commonly dismissed as the products of blind tradition or chance. And when persons with no formal qualifications attempt to participate in the processes of innovation, evaluation or decision, their efforts tend to be viewed with scorn or suspicion. Such attitudes do not arise from malevolence; they are inevitable products of a scientific training which presupposes and then indoctrinates the assumption that all problems are simple and scientific, to be solved on the analogy of the textbook.

When the textbook analogy fails, science in the policy context must become post-normal. Under such circumstances, the traditional guiding principle of research science, the goal of achievement of truth or at least of factual knowledge, must be modified. In post-normal conditions, such products may be a luxury, or indeed an irrelevance. Here, the guiding principle is a more robust one, that of quality, understood more comprehensively than in the traditional research setting.

It could well be argued that quality has always been the effective guiding principle in practical research science, but it was largely ignored by the dominant philosophy and ideology of science. For post-normal science, quality becomes crucial, and quality refers to process as much as to product. It is increasingly realised in policy circles that in complex environment issues, lacking neat solutions and requiring support from all stakeholders, the quality of the decision-making process is absolutely critical for the achievement of an effective product in the decision. This new understanding applies to the scientific aspect of decision-making as much as to any other [4].

Post-Normal Science can be located in relation to the more traditional problem-solving strategies, by means of a diagram (see Fig. 1). On it, we see two axes, ‘sys-

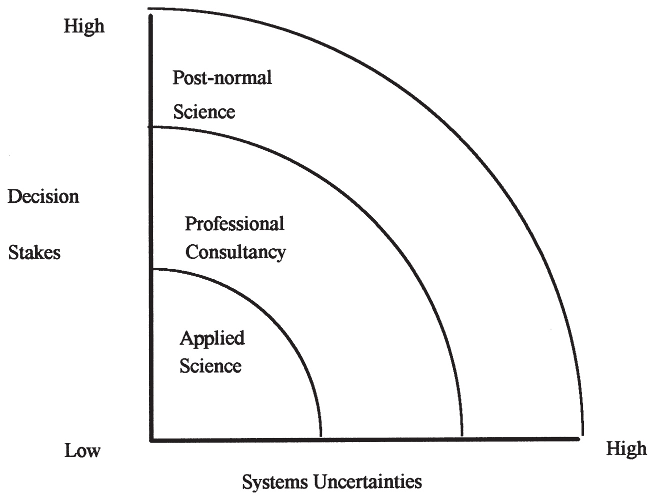


Fig. 1.

tems uncertainties' and 'decision stakes'. When both are small, we are in the realm of 'normal', science, where expertise is fully effective. When either is medium, then the application of routine techniques it nost enough; skill, judgement, sometimes even courage are required. We call this 'professional consultancy', with the examples of the surgeon or the senior engineer in mind. Our modern society has depended on armies of 'applied scientists' pushing forward the frontiers of knowledge and technique, with the professionals performing tasks requiring greater personal responsibility.

Of course there have always been problems that science could not solve. But increasingly over recent generations, our civilisation has been able to tame nature in so many ways, so that for unprecedented numbers of people, life is more safe, convenient and comfortable than could ever have been imagined in earlier times. But now we are finding that the conquest of nature is not, and cannot be, complete. As we now confront nature in its disturbed and reactive state, we find extreme uncertainties in our understanding of its complex systems, uncertainties which will not be resolved by mere growth in our data bases or computing power. And since we are all involved with managing the natural world to our personal and sectional advantage, any policy for change is bound to affect our interests. Hence in any problem-solving strategy, the decision-stakes of the various stakeholders must also be reckoned with [5].

This is why the diagram has two dimensions; this is an innovation for descriptions of 'science', which had traditionally been assumed to be 'value-free'. But in any real problem of environmental management, the two dimensions are inseparable. When conclusions are not completely determined by the scientific facts, inferences will (naturally and legitimately) by conditioned by the values held by the agent. This is a necessary part of ordinary research practice; all statistical tests have values built in through the choice between selectivity and sensitivity, and the management of 'outlier' data calls for judgements that can sometimes approach the post-normal in their complexity. If the stakes are very high (as when an institution is seriously threatened by a policy) then a defensive policy will involve challenging every step of a scientific argument, even if the systems uncertainties are actually small. Such tactics become wrong only when they are conducted covertly, as by scientists who present themselves as impartial judges when they are actually committed advocates.

The contribution of all the stakeholders in cases of Post-Normal Science is not merely a matter of broader democratic participation. For these new problems are in many ways different from those of research science, professional practice, or industrial development. Each of those has its means for quality assurance of the products of the work, be they peer review, professional associations, or the market. For these new problems, quality depends on open dialogue between all those affected. This we call an 'extended peer community', consisting not merely of persons with some form or other of institutional accreditation ('stakeholders'), but rather of all those with a desire to participate in the resolution of the issue. Seen out of context, such a proposal might seem to involve a dilution of the authority of science, and its being dragged into the world of politics. But here we are not talking about the traditional areas of research and industrial development; but about those issues where quality is crucial, and where traditional mechanisms of quality assurance are patently inadequate. Since this context of science is one involving policy, we might see this extension of peer communities as analogous to earlier extensions of franchise in other fields, as allowing workers to form trade unions and women to vote. In all such cases, there were prophecies of doom which were not realised.

For the formation of environmental policy under conditions of complexity, it is hard to imagine any viable alternative to extended peer communities. They are already being created, in increasing numbers, either when the authorities cannot see a way forward, or when they know that, without a broad base of consensus, no policies can succeed. They are called 'citizens' juries', 'citizen foresight', or 'consensus conferences', or any one of a great variety of names; and their forms and powers are correspondingly varied. But they all have one important element in common: they assess the quality of policy proposals, including a scientific element, on the basis of whatever science they can master during the preparation period. It turns out that educated common sense can be quite effective in the assessment of policy implications of even the most technical of scientific subjects. And their verdicts all have some degree of moral force and hence political influence.

Along with this regulatory, evaluative function of extended peer communities, another, more intimately involved in the policy process, is springing up. First, in the Post-Normal Science context, what we might call 'extended facts' can become important in the dialogue. These can range from 'housewives' epidemiology', through pupils' surveys, to investigative journalism and leaked secret documents. While this material does not necessarily conform to the quality criteria of traditional research, with the proper interpretation and weighting it can be important, sometimes crucial, in a debate. Furthermore, particularly at the local level, the discovery is being made, again and again, that people not only care about their environment (natural, social and personal) but also can become ingenious and creative in finding practical, partly technological, ways towards its improvement. Here the quality is not merely in the verification, but also in the creation; local people can imagine solutions and reformulate problems in ways for which the accredited experts, with the best will in the world, are not prepared. This can be seen in community endeavours all over the world, and in the rise of medical self-help groups. It can also manifest in the most surprising ways; recently a London borough that was designing safe routes to schools enlisted the help of the children themselves.

No one can claim that the maintenance of quality through extended peer communities will occur easily, and without its own sorts of errors. But in the processes of extension of peer communities through the approach of Post-Normal Science, we can see a way forward, for science as much as for the complex problems of the environment. In traditional research science, the quality-assurance function has depended on the morale, and moral commitment of peer communities; the assessment of research needs deep familiarity with its content and methods, both explicit and implicit [2]. There is no possibility of quality testers standing with gauges at the end of the scientific production line. This makes research science quite vulnerable to loss of morale; if individualism rules, then a Gresham's law of quality could dominate very quickly. Given that insight, we may well ask, how can quality be maintained in the essentially adversarial and frequently conflicted situation of Post-Normal Science? It is well known that in the forensic context of civil liability cases, scientific standards tend to be the first casualty. Here we can only identify the challenge, and remind what is involved in a solution. This is a new conception of what stakeholder negotiations are all about. We might call them 'win-win' rather than 'win-lose'; or we might say that the growth of mutual recognition and compassion is not only essential to achieving the product in an agreement, but is just as much what the process is about. Martin O'Connor deals with this in his essay in this issue; and a hard-headed approach to enlightenment has been described by a leader in the theory of business negotiation [6].

The UK Royal Commission on Environmental pollution has recently published guidelines which embody some basic elements of Post-Normal Science. In its 21st Report, on Setting Environmental Standards [7], a number of observations and recommendations were made reflecting this new understanding. Thus, on uncertainty, we have:

> 9.49: No satisfactory way has been devised of measuring risk to the natural environment, even in principle, let alone defining what scale of risk should be regarded as tolerable;

on values:

> 9.74: When environmental standards are set or other judgements made about environmental issues, decisions must be informed by an understanding of peoples' values...;

and on extended peer communities:

> 9.74 (continued): Traditional forms of consultation, while they have provided useful insights, are not an adequate method of articulating values;

and on a plurality of legitimate perspectives:

> 9.76: A more rigorous and wide-ranging exploration of people's values requires discussion and debate to allow a range of viewpoints and perspectives to be considered, and individual values developed.

The Post-Normal Science approach should not be interpreted as an attack on the accredited experts, but rather as assistance. The world of 'normal science' in which they were trained has its place in any scientific study of the environment, but it needs to be supplemented by awareness of the 'post-normal' nature of the problems we now confront. The management of complex natural and social systems as if they were simple scientific exercises has brought us to our present mixture of triumph and peril. We are now witnessing the emergence of a new approach to problem-solving strategies in which the role of science, still essential, is now appreciated in its full context of the uncertainties of natural systems and the relevance of human values.

We now see that the complexity of policy problems corresponds to the complexity of the relevant knowledge. The maintenance and enhancement of quality, rather than the establishment of truth, is the key problem for science in the post-normal age. Accomplishing this requires the incorporation of several new features in the methodology of science, transcending the bounds of normal training and research. Another is mutual respect among participants in a diaglogue, and a recognition that no side necessarily has a monopoly of truth or morality. And finally, there is the readiness of all sides to learn from their mutual contact. In this way, science can rejoin the polity.

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