The post-normal sciences of precaution

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Abstract  After centuries of optimism, science has become problematic and compromised. We can no longer assume that innovations are safe until proven dangerous. The ‘technocratic’ approach to science, with its reductionist methodology and its corporate control, is no longer appropriate. We need a ‘precautionary’ science that will be ‘post-normal’ in character. For this, we contrast ‘applied science,’ like the ‘puzzle-solving’ of Kuhn’s ‘normal science’ and the ‘professional consultancy’ like the practice of the surgeon or engineer. Rather, we have a situation where ‘facts are uncertain, values in dispute, stakes high, and decisions urgent.’ For high-quality decision-making, we need an ‘extended peer community’ who will bring their ‘extended facts’ to the dialogue. There are a number of initiatives that advance the post-normal programme, including the endeavours of Poul Harremoës and the conference on Uncertainty and Precaution in Environmental Management.

Keywords  Extended facts; extended peer community; precautionary; post-normal science; technocratic

Background

We are now losing the comforting image of science that has long been so important for the Western optimistic view of humanity’s prospects. Science is the great driving force of modern global civilisation. In the conventional understanding of science, curiosity-driven research discovers nuggets of fact, and beneficent application then shapes them into tools that enable the conquest of nature for the improvement of human welfare.

Now, at every phase of the process, science becomes problematic and compromised. Priorities for research are set not by scientists but by the external interests that supply funds. The work of research on sentient beings raises ethical questions that cannot be answered by science alone. Control of the intellectual property embodied in the products of inquiry is increasingly expropriated, either from the scientific researchers or from the rightful owners abroad. Applications of science are judged by their contribution to profit and power, while issues of safety and ethics are seen as secondary. Regulation, on behalf of humanity and the environment, comes after the event. It is always counted as a cost on ‘growth,’ and is therefore characteristically ‘too little and too late.’ The survival of civilisation itself is increasingly threatened by the degradation and destabilisation of the natural environment as a result of globalised industry.

Until now, our industrial society has developed on the principle that innovations are safe until proven dangerous. Turning it around to the adoption and implementation of a ‘precautionary principle,’ is, however, an enormous task, where many vested interests will resist and are already resisting. Nevertheless, change is inevitable, primarily because the old, secure order does not hold. When policies involving science are debated, in place of facts, we have uncertainty and even ignorance. In place of beneficial application, we have a clash of interests and world-views. The official reassurances of safety during scientific scandals and disasters, such as BSE in the UK, are evidence of a serious and systematic corruption of science advice. Governments in many countries have become worried at the loss of public trust in their management
and regulation of science and technology, but change for the better does not come easily.

**Two approaches to science**

We can discern the emergence of two approaches to the understanding and management of the scientific enterprise. The mainstream approach might be called ‘technocratic’ science. In this, the imperatives for research come from industry and the state, and citizens have a marginal role if any. Technocratic science proudly maintains the reductionist tradition in which complex systems are deemed incapable of scientific study and are therefore to be ignored. The popular and paradigm science now is molecular genetics, with applications in the engineering of life itself. The private sector is increasingly dominant, either converting academic researchers to contractual out-workers, or doing all the work on a speculative commercial basis and therefore needing an immediate return on its capital.

The social processes of research have become transformed. Discoveries are increasingly classed as inventions, in order to secure patent rights. ‘Public knowledge’ exists only on the margins, displaced in the important areas by ‘corporate know-how.’ Independent research has become hazardous owing to the threats of litigation over claimed patent infringements. Being strongly focused on biomedicine, this area of science increasingly invades the domains of the private and the sacred. Public compassion is regularly enlisted in the service of corporate imperatives, as every medical innovation is hyped as the source of new miracles.

The contrasting approach to science, still in the very early stages of development, is best called ‘precautionary,’ since it is usually concerned with reacting to the unintended harmful effects of technocratic science. Its style is ‘post-normal’; it lies at the contested interfaces of science and policy. It addresses issues where typically facts are uncertain, values in dispute, stakes high, and decisions urgent. A clear example of such a science is eco-toxicology, which confronts the effects of the myriad pollutants that have been (and are still being) dumped into the environment at such a rate that prior testing would be an unacceptable extra expense and retrospective testing becomes impossible. Hence, we are locked into the assumption that all industrial activities are safe until proven dangerous. When effects are discovered, they are frequently long-delayed, masked by other causes, synergistic, and extremely difficult to prove by the criteria and procedures of lab-based science. Yet eco-toxics, including endocrine disrupters, are among the more serious threats to our survival.

Water management is a science-based field of practice that has begun to show its post-normal character. Previously it had seemed to consist of a collection of straightforward tasks: ensuring the quantity of supply through various engineering works, and assuring its quality by chemical and biological techniques. However, now dams have become the focal points of bitter controversy. The provision of urban water supply in poor countries seems to get lost between corrupt local administrations and greedy foreign firms. The basic science of hydrology has discovered that its computer models, in spite of producing simulations with great precision, are unable to provide descriptions with good accuracy. Everywhere we find uncertainty, value-loading, and political and social issues of all sorts. Policies are necessarily based less on facts than on guiding principles, all expressed as precaution for the protection of some interest or other. Some are concerned for jobs, growth, or short-term property values, while others are concerned for quality, both of human life and the environment. Traditional ‘professional’ science and engineering cannot adjudicate among such conflicting values. A new approach, involving whole communities, is needed.
Post-normal science

How can we best explain the themes of uncertainty, value-loading, and precaution that characterise this new sort of science? We have chosen the name ‘post-normal science’ to highlight the novelty of our situation. It has two points of reference. First, ‘post-normal’ is a commentary on the classic analysis by the American philosopher T.S. Kuhn, who in his *Structure of Scientific Revolutions* (1962) described ‘normal science’ as uncritical puzzle-solving within an unquestioned framework, or ‘paradigm.’ As he said, this is what all scientists do most of the time and most scientists do all the time. Scientists are prepared for this rigorous effort by a totally dogmatic training, which is reinforced by naive and simplistic accounts of how scientists discover truth. However successful this approach had been in traditional research, it cannot suffice for the new problems where science is related to policy. There are many reasons for the failure of Kuhn’s ‘normal science’ and for the need for something ‘post-normal.’ The fundamental reason is that the times themselves are no longer ‘normal.’ The days are gone when we could assume that the discoveries of science would automatically be applied for human benefit through medicine, engineering and industry. In the half-century from The Bomb to 9–11, ‘normality’ has been in retreat. In that sense we live in ‘post-normal’ times, and that is the second sense of the term as we use it.

Our scheme for ‘post-normal science’ (Figure 1) indicates three sorts of problem-solving practice in relation to policy issues. We call the first ‘applied science,’ and this corresponds to Kuhn’s ‘normal science’ where uncertainties are tamed by statistics and value-loadings can be ignored. This category includes the bulk of the work of routine mission-oriented research and monitoring. This ‘normality’ is necessary as a foundation for a science-based economy and culture; otherwise we would be lost in indecision and endless debates. On the other hand, we have the new category of ‘post-normal science,’ where (in the terms of our analysis) either ‘systems uncertainties’ and/or ‘decision stakes’ are high. In this situation, the traditional systems of quality-assurance and governance of science are inadequate. We say that we need an ‘extended peer community’ who will bring their ‘extended facts’ to the dialogue. This new community consists of all those who are committed to resolving the science-related policy issue at stake. This actually means a significant democratisation of scientific expertise. It has its own difficulties and dangers, but there is no going back to the cosy world of the accredited experts and their by guest
employers. To a scientist who had grown up in the safe world of uncontroversial research, this new state of affairs should not be described as 'science.' We partly agree, and so we call it ‘post-normal science.’ A more extended discussion will be found on the website www.nusap.net (van der Sluijs, 2005).

To have just two categories in this scheme might give the impression that this is just another case of contrasting the good old days with the current troubled times. To enrich the analysis and to demonstrate that it has real content, we include an intermediate category, ‘professional consultancy.’ We can motivate this with the question, why does a successful consultant get paid more than a successful researcher? We think here of the surgeon or senior engineer. One answer is that the researcher is content to get paid less because he is having fun. Another, though, is that the consultant has more responsibility and risk than the researcher. If he makes a mistake, his client can suffer, financially or even in health or life. Once engaged on a job, he must see it through regardless of any unexpected difficulties that turn up. In terms of the post-normal science analysis, professional consultancy corresponds to moderate ‘systems uncertainties’ and/or ‘decision stakes.’

Until recently, it was assumed that problems of risks and the environment could be managed by a combination of ‘applied science’ and ‘professional consultancy.’ This latter category would include senior scientists and engineers acting as government advisors. Also, there did not seem to be any special problem with the governance of science and technology as a whole, as it brought such great benefits to humanity. All that has changed, and we may say that the authority of ‘professional consultancy,’ even more than ‘applied science,’ has been challenged by the new problems and threats arising from science and its applications. All the problems of governance of science, realised as dangers from new technological developments or the collapse of public trust, are reflections of our ‘post-normal’ condition. Furthermore, all the solutions in the way of ‘transparency,’ openness,’ or ‘participation’ are effectively calls for the involvement of what we have called an ‘extended peer community.’

In this new sort of science, problems become salient as a result of a broad public debate. Issues are forced into public and official consciousness by campaigns involving activists and the media, which reveal suspected scandals and disasters. Once public trust is lost, experts’ authority become very difficult to maintain. Persons involved in these debates discover that scientific prestige or official status is no guarantee of credibility or even of assured honourable behaviour. For the researchers themselves, engagement with policy is a very different type of career. The traditional rewards for successful puzzle-solving on tame abstracted problems do not apply here. Indeed, there is no Nobel prize for safety. Until now, the academic research community has not yet adopted precaution in its criteria of excellence. By contrast, some political institutions, notably the European Commission and the European Environment Agency, are struggling to integrate the Precautionary Principle in their programmes; and in this they also recognise the issues of the democratisation of expertise.

In the course of a dialogue that includes the ‘extended peer community,’ lay participants can show their competence in scrutinising and assessing research reports. The public has discovered that the claimed scientific facts can be as controversial as the underlying ethical and political principles. Since uncertainty cannot be tamed by statistical techniques whose value-commitments are concealed, debates will explicitly involve the participants’ different agendas and perspectives. These produce conflicting criteria of quality and hence different principles of experimental design; scientific methodology itself becomes politicised. Regulatory principles like ‘absence of
evidence of harm is not evidence of absence of harm’ are regularly invoked in public debate.

In all these debates, sometimes angry and confused, the policy issue itself evolves. Both the crucial uncertainties and the relevant value loadings converge. Indeed, an issue can really be resolved only when it comes out of the Post-Normal sector, and there is sufficient agreement on facts and sufficient acquiescence on values. This sort of evolution is very well displayed in the case of debates on the ‘Zwolle Barrier’ issue in the Netherlands (Figure 2). We see that most issues move back towards the safe centre, but there is one that flies out directly from the inner to the outer zone!

The products of the work of ‘precautionary’ inquiry are generally in the public domain, but they are also likely to be found outside the mainstream specialist published literature. In such a science, quality-control, or more generally quality-assurance, is very different from that in traditional or even ‘technocratic’ science. Here the ‘peer community’ is extended beyond research colleagues and industrial sponsors. Since the products of research are deployed in policy processes, all concerned members of the public are involved. And when such work is done well, there is a process of mutual learning among those with different perspectives and commitments, including the scientists themselves. The very idea of ‘science’ expands beyond specialised inquiries done within artificially controlled conditions. It now includes effective problem-solving in all societal and cultural milieux.

Of course the two sorts of science are not totally distinct. All policy-relevant research is now subject to public debate, and is sometimes regulated for its ethical aspects. Many prominent research scientists, and editors of leading journals, have spoken out against the unbridled commercialisation of their fields of inquiry. On the other hand, the leading ‘precautionary’ field, global climate research, has used state of the art computing for its analyses. Even the most ‘alternative’ technologies, as in energy, freely use sophisticated materials for their devices. However, until recently the overwhelming bulk of resources, and of prestige within science, have been devoted to ‘technocracy’ rather than ‘precaution.’ The ongoing tendencies to the commodification of the scientific process, and its incorporation in the concerns of private and state institutions, make real change more difficult. As long as the major institutions, state and private, are committed to continued material growth, with ‘sustainability’ as an extra, there will be little chance of a genuine synergy between technocratic and precautionary science.

![Figure 2 Trajectories of inquiry, the “Zwolle Barrier” issue is inserted here](image-url)
How it is happening

This precautionary, post-normal science is still very small, marginal and informal. As a research effort, it is perhaps best developed in the ‘community research’ movement in the United States (The Loka Institute, 2005). The ‘science shops’ movement (Living Knowledge, 2005), long established in Europe but now also growing in the US, is very much a post-normal exercise. In the UK, the three new regulatory commissions (the Food Standards Agency, the Human Fertilisation and Embryology Authority, and the Agriculture and Environment Biotechnology Commission) all embody principles of transparency, openness, and participation to an unprecedented degree. In many medical fields, there is active collaboration between patients’ groups and the established institutions. In this field as in others, the internet is a powerful enabling force. It may well transform the politics of scientific knowledge in our time as much as the printing press transformed the politics of religious knowledge in the Reformation.

A methodology for post-normal science has been developed in the Netherlands at the environmental research institute RIVM (Janssen et al, 2005). Their ‘Guidance’ is a highly articulated analytical checklist. It provides guidance for all stakeholders in a science-related policy dialogue to identify the important uncertainties and value-loadings in their information. Those who have gone through a Guidance procedure have a greatly enhanced awareness of these issues, and they are also provided with tools for managing them (van der Sluijs, 2005).

Finally, the close relation of precautionary and post-normal science is shown most clearly in the classic collection of essays edited by Poul Harremoës, ‘Late Lessons from Early Warnings: the Precautionary Principle 1896-2000’ (Harremoës, 2001). What we find there, in case after case, is that the high ‘decision stakes’ have overwhelmed the ‘systems uncertainties.’ The early warnings are typically ignored because their recognition would produce discomfort of one sort or another to vested interests. Precautionary science must by its very nature cope with uncertainties, sometimes severe, and strike the fine and unstable balance between complacency and alarmism. The work of monitoring is nearly all ‘applied science,’ but its interpretation is ‘professional consultancy,’ and the decisions on action are firmly in the realm of Post-Normal Science. Therein lies the unity of this essay, and indeed of the whole conference on Uncertainty and Precaution in Environmental Management, a fitting memorial to Poul Harremoës.

Conclusion

A very different style of science is emerging, in response to the new challenges presented by environmental issues where uncertainties and value-loadings are severe. We call it ‘post-normal,’ and we emphasise that it requires the involvement of an ‘extended peer community’ who bring their ‘extended facts.’ There are already many initiatives in that direction, including as a great example the work of Poul Harremoës.

References


