

THE COMPLEMENTARITY OF KNOWLEDGE AND IGNORANCE IN SCIENCE

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Not many years ago, an eminent scientist with philosophical leanings described science as « the art of the soluble ». This elegant formulation reveals much about the implicit limits of scientific enquiry and its picture of the world. For what is not soluble is not scientific ; it does not count, it does not exist. This attitude is well known to those concerned with foundational problems ; they are accustomed to their work being viewed by research scientists as irrelevant or worse, to the real tasks of science. The extension of this presupposition to technology has produced a host of unanticipated policy issues in risks and the environment. For the “downstream” phases of production cycles rarely present neatly “soluble” engineering problems ; as in the example of the wastes of nuclear power, they typically suffer neglect until they suddenly present crises in all dimensions.

This restricted view of science as the « art of the soluble » may well have enhanced its power in the past, to the point where it now presents perils for the future. It also has other, even deeper effects on our vision of knowledge and the world. For it entails a total exclusion of ignorance from our view. Uncertainty exists only as far as it can be managed interestingly, in the form of the soluble research problems at the margin of our scientific knowledge. Ignorance is not soluble by means of ordinary research ; therefore it does not exist. A scientist who explores problems which cannot be solved (such as Einstein in his later years) is generally considered by his colleagues to be wasting his time. In the classic image of science, purveyed by philosophers and publi-

cists, and imbibed by generations of teachers and their pupils, science is about certainty. Uncertainty is there to be banished, and ignorance is to be rolled back beyond the horizon.

For it to remain plausible, this simplistic vision of the triumphal advance of science needed to maintain ignorance of one very practical problem in scientific activity : priorities and choice. For whenever a proposed research project is given a low priority (in whatever sort of decision mechanism), it is not undertaken. As a result, the chance of gaining new knowledge is lost ; and in that respect we remain in ignorance. There is an asymmetry here : a project that is undertaken might fail, thereby not increasing our stock of knowledge in spite of our intentions ; but if a project is not undertaken at all, then we are intentionally kept in ignorance. Such considerations became salient in the era of “big science”, when there were more interesting problems (and promoters) than resources for all of them. Priorities then became the name of the game, and the preservation of ignorance in the less favoured fields of science became established as an unavoidable aspect of science policy.

The asymmetry goes deeper, in the cognitive and social structures of science. It has generally been assumed that only trained, certified scientists could advance knowledge through research ; and also that in some important fashion their research is “value-free”. Thus the knowledge that has emerged is the product of a highly specialized, indeed esoteric, activity ; and when taught or popularized it has the appearance of inevitability

and incontrovertibility. By contrast, our ignorance is obviously very strongly conditioned by values. Thus, if our society is relatively less interested in (say) occupational health and alternative energy supplies than hi-tech medicine and nuclear power, we remain in ignorance about the former. Since ignorance has no positive content, it is very difficult for anyone to point to it, invoking authoritative expertise to analyse it. So the focus is on the science that we have, with this apparent inevitability and incontrovertibility. We are never made aware that it exists only in relation to the value-loaded decisions to obtain some particular sort of knowledge at the expense of remaining in ignorance of other possible, equally valid and worthwhile, sorts. In this way, we can speak of ignorance being “socially constructed”, indeed to some extent politically constructed.

By focussing on ignorance rather than on knowledge we can escape some of the relativistic, sceptical implications of a contextual theory of science and its products. It is possible to imagine ignorance as being more conditioned by values and power, while knowledge (or what is accepted as such at any time), being rather less conditioned. The distinction is not absolute ; although philosophers of science have paid relatively little attention to this topic, the role of values in shaping our facts is clearly seen in the way that confidence-limits (and other parameters of statistical tests) embody prior decisions about the relative error-costs of the different sorts of erroneous inferences from statistical arguments. Indeed, the methodologies for treat-

ment of outliers among data could serve as an excellent case study for the shaping by values of both our ignorance and our knowledge.

A yet deeper consequence of the triumphalist, positivist image of science is that all of the understanding of ignorance has been systematically suppressed among students of science. Who has ever seen an examination in a traditional science where there are questions involving ignorance, uncertainty, choice or values? Examination questions with the instruction "Critically evaluate", common in all other disciplines, are rare in the extreme in natural science. Those who emerge from a prolonged training in scientific research, perhaps even with the title of Doctor of Philosophy, have been conditioned to remain ignorant of their ignorance. This is the basis for Kuhn's profound, eloquent and deeply troubling image of the puzzle-solving scientist, with a training more restrictive than any but orthodox theology, and whose disciplinary histories resemble those of 1984. With this perspective we can better understand why Popper considered "normal science" (as so ambivalently named by Kuhn) to be « an enemy of science and of our civilisation ».

Worse yet, this reductionist conception of the human intellect has generally been identified as the genuine rationality of our intellectual culture. Traditional spokesmen of science have derogated other forms of knowing, involving the recognition of ambiguity, contradiction, uncertainty and ignorance, as inferior or unreal. In this way, the lived experience of individuals, and the historically developed culture of peoples, are all either crammed into the scientific mould of simplistic certainty, or discarded. While this presupposition is so plausible as to be almost invisible in the case of the physical sciences and their applications, the imitation of physics in the sciences concerning humanity shows clearly how ludicrous and damaging can be this restriction of knowledge, and this culturally imposed ignoring of ignorance. It is easy to detect "ignorance-squared" in supposedly scientific statements: just verify that numerical precision goes up as measurement accuracy goes down. Those extra

pseudo-precise digits conceal ignorance from all, usually including the author as well.

Such an "ignorance-squared" can almost be called wilful within our culture. Ignorance of ignorance is a very recent phenomenon in European intellectual history. Continuously from the time of Plato, up to that of Descartes, the ignorance of ignorance was a recognized category among philosophers. Indeed, all those who knew about Socrates knew that his quest was for awareness, for self-knowledge, for discovering and coming to terms with his own ignorance of ignorance. And his method of elucidation was designed to help this interlocutors to cure their own ignorance of ignorance, on some issue that was crucial for right living. The Renaissance humanist writers, including Montaigne, gave prominence to ignorance of ignorance. The big break came with Galileo and Descartes, who imagined human knowledge as limitless in its scope and perfectibility. For them, ignorance was a void to be filled, as quickly as possible; and each had a Method whereby this could be accomplished.

In connection with Descartes, it might seem that the method of Doubt involved a recognition of irremediable ignorance and hence of ignorance-squared. But this Doubt was of a very "philosophical" sort, which was there as a challenge to be overcome at the very beginning of his endeavour. Once removed by his heroic conceptual endeavour, it never returned. Thereafter, the Method would guarantee a steady increase in knowledge and in certainty. Once Doubt had been conquered by Descartes, it hardly ever reappeared in the philosophy of science, until our own troubled times. Thus the philosophical condition of modern science, technically described as "barbaric" by E.A. Burtt, has its roots in a radical philosophical move that soon resonated with the demands of its cultural matrix. Religious dogmatism, responsible for the confusions and horrors of the long Reformation period, was discredited and in its place came scientific optimism, sometimes tentative but also sometimes as dogmatic as its rejected predecessor.

In subsequent centuries, it was left to isolated critics of science to voice concerns

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about ignorance. Each had a very personal basis in experience, as Bishop Berkeley in theology, and Ernst Mach in foundational studies; and so their critique could never achieve coherence as a tendency, or comprehension by a broad reading public. Basic criticisms of science of any sort could be dismissed, for they did not contribute to the onward march of successful scientific research and technological development. Khun's "puzzle-solving within paradigms" expresses all that very well. Of course, the situation is now changing. The loss of mystique of science is reflected in the dominance of the sceptical, debunking scholarly analyses of scientific practice. And the new problems of risks and the global environment have put uncertainty and ignorance at the centre of public debate.

The need to take very large scale decisions about industry, technology and lifestyles, in the face of the recognized global environmental threats, has shown clearly that science can no longer be assumed capable of providing certainty for our policy problems. Debates on risks and the environment sometimes focus less on the supposed facts than on the management of their uncertainty and quality. The crucial decisions are at the methodological level: on the assignment of the appropriate degree of "precaution"; on the estimation of "error costs" of any proposed policy; and ultimately on the placing of burden of proof on one or another participant or stakeholder. None of these decisions can be reduced to a quantitative formalism; they all involve personal judgements and the clash of values. In this way, such major policy issues in risks and the environment are a case of what my colleague Silvio Funtowicz and I have called "post-normal science".

Similarly, in relation to small-scale local issues, the limitations of certified scientific expertise have also become vividly apparent. In connection with health and environmental effects of toxicants, either in industrial processes or in the form of waste, communities have sometimes found themselves in debate against not only those who created the hazard, but sometimes also against those who are supposed to recognize and then

regulate it, and even those who are supposed to provide objective knowledge for its control. Khun's image of the puzzle-solving normal scientists, constitutionally kept in ignorance of anything outside the walls of their disciplinary paradigm, has been discovered to be applicable not only in the laboratories and lecture halls, but also in the spheres of the courts and regulation.

In such situations, ignorance of ignorance can be very damaging indeed. So long as it persists, whole communities can be lulled in a false sense of security. But when it is broken, those who have been implicated in its maintenance lose both credibility and legitimacy. Their expertise is revealed as applying to a small and not very relevant part of knowledge: that which concerns normal-scientific practice, of the reduced, artificial and controlled environment of the research laboratory. The awareness of ignorance occurs, for these unfortunate persons, not in the playful interrogation of a Socratic dialogue, but in the harsh glare of a judicial or adversarial process.

Thus there is a genuine politics of the ignorance of ignorance. In earlier times Science was invoked in the demolition of the ignorance-squared of a traditionalist, theocratic culture; now Ecology is invoked in the challenge to the modern technocratic version of ignorance-squared, in which established science is now implicated. This struggle will have the varieties of conflict, including extremists on both sides, diversionary tactics, and ultimately (we may hope) a reasoned debate where that is possible.

Among the diversionary tactics, there is a long series of attempts to tame uncertainty (and thereby to suppress ignorance) by mathematical means. These have mainly appeared in connection with probability and statistics; their more recent versions involve sophisticated psychological theories on the hand, and gigantic computer programs on the other. In addition, analogues of genuinely uncertain situations in the natural world are sought in particular mathematical systems (e.g. game theory, decision support systems, catastrophe theory, fuzzy sets, chaos theory). It is perennially hoped that theo-

rems in such mathematical systems will provide beacons of certainty for rational decision-making.

We can no longer afford to maintain ignorance of ignorance at the centre of our scientific culture. Only through recognising the complementarity of knowledge with ignorance, realized through open dialogue and debate, can science meet the challenge of the new environmental policy issues of our day. ■