How the new analysis of science can put truth into society

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In the set of linked papers associated with the establishment of the InSECT Project[1], the preponderance of references to the team associated with Collins arises out of the fact that they have been working in a self-consciously consistent way to use the findings of the second wave of science studies to generate a third wave which puts science in a central position in democratic societies. The work, the start of which was marked by the publication of Collins and Evans 2002, has given rise to great interest in the analysis of expertise but other groups have been less likely to link this approach to the political consequences of the erosion of truth and hence the preponderance of references to a narrow group (in which Collins is usually the first named author (for alphabetical if not other reasons)). The expertise material, on the other hand, has been widely cited and been set out in commissioned papers in many handbooks of philosophy, psychology, and the like. We concede that the details of the meta-expertise line need work but there is no urgency about it. There have been critiques of some of the ideas, but not such as could build toward new concepts.

There are three new, crucial, and what seem to us, lasting distinctions associated with the expertise material. These are, firstly, the distinction between *specialist expertise* and *ubiquitous expertise*: ubiquitous expertise is quite different to what some sociologists and philosophers call ‘lay expertise’ which is meant to be the type of specialist expertise which ordinary people possess. We don’t think that

[1] These papers are under peer-review at the time of writing this essay. Links to the published papers will be available at insect-project.org/more in due course.

lay expertise exists, whereas ubiquitous expertise is the highly developed expertise of all members of a particular society, such as natural language speaking. There are, however, types of specialist expertise which belong to non-scientists, such as the expertise belonging to narrow, experience-based groups such as sheep farmers. The second crucial distinction is between *interactional expertise* and *contributory expertise*. And the third distinction is between specialist expertise and *meta-expertise*, the latter being *expertise about expertise*. This is the key expertise that we want to teach to citizens.

This paper arises out of what has been called the second and third waves of science studies (Collins and Evans, 2002). The first wave was what emerged from the history and philosophy of science, with some contribution from the sociology of science, which reached its high point in the aftermath of the Second World War, where science laid claim to be a superior form of knowledge with the success of the atomic bomb, radar, and the like. In this first wave science seemed to stand above society being driven by logic rather than human enterprise. Karl Popper's book, *The Logic of Scientific Discovery,* originally published in 1934, represented this view well; Popper believed that he had solved the problem of induction with his concept of 'falsifiability' as the touchstone of science. Falsifiability is still a productive idea but not in the same quasi-logical way that it was once thought to be.

Thomas Kuhn's, *Structure of Scientific Revolutions*, published in 1962, might well have been the trigger for the second wave of science studies. It is said to be the best-selling academic book of the Twentieth Century. Quite a bit of what it said had been said earlier in Ludwik Fleck's *Genesis and Development of a Scientific Fact*, first published in 1935, but it was in German and was little known until translated into English in 1979. Meantime Kuhn's book introduced the idea of the scientific 'paradigm'. He explained that as far as scientists were concerned, the world could seem radically different if they belonged to one paradigm, such as classical Newtonian physics, rather than another, such as Einsteinian relativity. In classical physics mass and energy were each conserved; in relativity there were interchangeable. Moving from one to another involved radical differences in the way experimentation and theorisation worked. Suddenly, science, for its observers and analysts, was populated by something equivalent to the tribes studied by anthropologists: science was no longer just a matter of logic unfolding with no contact with society – science now had its own society complete with rival tribes. This opened the way to the social analysis of science.

The 1970s saw the growth of the sociology of scientific knowledge (SSK) which, for a few years, dominated the history and philosophy of science. SSK was often portrayed as promulgating the idea that science, far from standing above society in some ethereal realm of quasi-logic, was 'socially constructed'. That is to say, to understand why scientists came to believe this or that about the natural world one had to examine their activities in detail and see how one idea about how the world worked came to dominate as a result of arguments in the laboratory and the agonistic field of theory. Kuhn has shown how competing paradigms could give rise to lasting disagreements within science and this provided materials for the sociologist to study. The major theorist drawn on in practice was not Kuhn but Ludwig Wittgenstein and his later philosophy and the idea of a 'form of life' as found in his *Philosophical Investigations*. This author's introduction to it was Peter Winch's critical essay directed at sociology entitled *The Idea of a Social Science* published in 1958. Thus, four years before the publication of Kuhn's book Winch could be found comparing medical practice before and after the discovery of the germ-theory of disease: as he explained, germs were made in the process of surgeons ceasing to operate in dirty waistcoats and instead painstakingly scrubbing their gloved hands. The form-of-life of surgery and the idea of germs were two sides of the same coin and Kuhn's paradigms could be seen as forms of life within science. The central method of SSK became the case study. This author became well-known for the ‘controversy study’, where he looked for groups of scientists disagreeing with one another and interviewed all the participants over a long period.

For example, in the early 1970s an American scientist called Joe Weber claimed that he had detected gravitational waves from outer space while many other scientists disputed his claim. In 1972 I drove across the US interviewing everyone who was involved and followed the way this controversy was resolved with another trans-American trip in 1975. I was also armed with an earlier finding where I had looked at the way physicists tried to build a new kind of laser – the Transversely Excited Atmospheric Pressure Carbon Dioxide Laser (TEA-laser). I discovered that success only came to those who had social contact with another successful scientist, because much of the skill was tacit – successful laser builders were building in a certain way without knowing why and without describing what they were doing because they did not know it was important. This made it possible to understand why gravitational wave detection scientists could continue to disagree: no-one could be sure who had built a satisfactory device. I called this ‘the experimenter’s regress’ because you had to know what a successful device should do (eg make a beam of infra-red light capable of making concrete smoke in the case of the TEA-laser or detecting or not detecting gravitational waves) – and in the case of the GW detector, no-one knew which it should be!! In the case of a gravitational wave detector, to be sure that the experimental apparatus had been built right you had to know whether or not it should detect gravitational waves and this was exactly what the scientists were arguing about. In the gravitational wave case, the way matters were resolved was a social process – one scientist making clear and aggressive counter claims while Weber made mistakes in his reports that otherwise might not have been fatal. This was an example of the ‘social deconstruction’ of (Weber’s high fluxes of) gravitational waves. This approach to the social study of science, including analysis of the TEA-laser and the early gravitational wave experiments, is put together in a philosophical framework in Collins's fairly well-known *Changing Order: Replication and Induction in Scientific Practice*, first published in 1985 with a second edition in 1992. A more popular series of case-studies was put together in Collins and Pinch's, *The Golem: What you should know about science*. This includes discussion of the Michelson-Morley case and a useful debate about it with physicists in found in the second, 1998, and later editions. It has turned out that I stuck with the gravitational wave story, immersed with the scientists for 45 years, beyond the point when the first wave (very much weaker and rarer than Weber's claims) was detected to the satisfaction of the scientific community. I wrote 4 books and many papers on the topic.[2]

This kind of thing makes up what Collins and Evans, in their 2002 paper, call the second wave of science studies. But the second wave branched off in a number of competing directions. By far the most successful of these in terms of academic recognition was what came to be called Actor Network Theory (ANT) led by Bruno Latour. Latour, who died in 2022, was described in a recent paper (Seguin and Vinck, 2023) as 'the greatest thinker of the twenty-first century' though this is surely a claim that would have him spinning in his grave. Latour was undoubtedly the most dominant character in the field of Science and Technology Studies (STS), and undoubtedly its pre-eminent scholar in terms of academic brilliance, and undoubtedly created a theory of scientific success that he proved through his own achievements, but this was essentially a collaborationist theory – it showed how to build a networks of friends and allies rather than how to stand up to opposition irrespective of recognition, as is the characteristic of the more typical scientific hero which we would endorse here, such as Galileo.

[2] For example, Collins, 2004a, 2017, 2020a

What Latour did was expand the audience for studies of science enormously by reframing it as a version of literary studies. This enabled science to be analysed without understanding any science: you had only to understand the way the published literature worked, making some scientists invisible and bringing others to the fore. By following Latour, all those humanities scholars on the wrong side of CP Snow's 'two cultures', typically excluded from critiquing science because of their ignorance of it, could find themselves back in centre stage; Latour now had a huge number of friends and allies. One can see how Latour worked by looking at the article that claims him to be the greatest thinker of the twenty-first century. It is the introduction to a special issue of a journal showing how many different ways Latour's remark that 'science is a continuation of politics by other means' can be interpreted. Where does this place him in terms of the Locus of Legitimate Interpretation?

Later in his life (2004), Latour belatedly discovered the pre-eminence of science and turned against his old critiques, remarking that they 'burned his tongue' given the reality of climate change. But the method he introduced to the study of science provided no argument for this *volte face*.[3]

Another set of approaches concentrated on statistics. Thus, many scientific results emerge out of statistical calculations. On the one hand, this has led to what is known as the replication crisis in psychology and medicine because in disciplines such as these the statistical warrant for publishing a result as a finding is that there is less chance than 1 in 20 for it to have been due to chance – the 2-sigma level. But physics is the only science which has empirical results that show us what sigma level we need to be sure of our results because physics – for example, high-energy physics – conducts

[3] For this author's critique of the Latour approach, see Collins and Yearley, 1992 and Collins 2012

huge numbers of experiments. What physicists have found is that if they want to be pretty sure of an outcome, they need 5-sigma – that is only one chance in 3.5 million of the result being due to chance. This is because the main reason for results being unsound is systematic error not random error and physicists have found that 5-sigma provides a chance of swamping systematic error; it cannot swamp it for certain because bad enough systematic error can ruin any experimental result, but this is the conclusion as a rule of thumb. Most of the other sciences cannot possibly attain 5-sigma so the replication crisis could have been foreseen and most of the attempts to combat it with marginal improvements in statistical procedures are misplaced (for an alternative approach see Collins, 2019).

Teachers may consider that the way statistics have been used in the majority of sciences, and how this compares to their use in physics, and the concept of systematic error and how this should not be confused with random error, should be part of the main syllabus rather than relegated to this bibliographical essay.

More positively, philosophers cleverly showed how societal values could not be separated from scientific conclusion-making. (For a comparison of the current approach with the philosophical approach see Collins's 2023 paper, 'Science as a counter to the erosion of truth in society'.) A view shared by the philosophers and the sociologists is captured in the philosophers' term 'inductive risk'. The sigma-level to which you should aspire before making a statistically-based scientific claim depends on the effects of a false positive and this can obviously be very high where great dangers are involved for individuals or for the world we live in. Thus, scientific values – and the sigma-level chosen for publication is a scientific value, depend on social values. This idea is compatible with what we are arguing in our proposed course.

Another version of the relationship between social values and science is incompatible with it. This is the idea that there is widespread expertise among ordinary people which is comparable or superior to scientific expertise. An example was the response of leading members of the social studies of science community, such as Shiela Jasanoff and Brian Wynne, to the parental revolt against measles mumps and rubella vaccine. Jasanoff and Wynne led a group who sided with the parents in their revolt, Wynne claiming, for example, that irrespective of the epidemiological evidence showing that there was no increase in the incidence of autism consequent on the first introduction of MMR into the vaccination regime of a new country, a small increase could still be happening but invisible within the statistics. This is, of course, true, but it would rule out any new medicine or item of diet. For example, though there was no epidemiological evidence for it, it could be that eating Kiwi fruits had dangerous side-effects obscured by the statistics. It is noteworthy that in spite of the revelation of Andrew Wakefield's unethical behaviour and the retraction of his article that could be said to link MMR and autism, and in spite of the upsurge of dangerous measles epidemics consequent on the MMR revolt, none of those who supported the parents' revolt such as Jasanoff and Wynne have ever retracted or reanalysed their claims.

It was this kind of thing that led Collins and Evans to call for a third wave of science studies that would be compatible with the new descriptions of science provided by the second wave but still support science as a central feature of Western democracies. The first approach to this dilemma was to switch attention to expertise because expertise can be recognised in real time more in tune with the speed of politics: we do not need to know who is right to know who belongs to a body of experts and we can argue immediately that descriptions of the natural world should be decided among relevant experts.

The second element of this approach was to describe bodies of scientific experts as having the formative intention and formative imperative of truth telling.

Much has been learned about expertise since the 2002 paper put forward the need for expertise analysis. The 'Periodic table of expertise' will be found in Collins and Evans's book, *Rethinking Expertise*, published in 2007. An important distinction made there is that between 'interactional expertise' and 'contributory expertise', the latter being the ability to contribute to a scientific specialty. This distinction emphasises the importance of spoken discourse in the development of expertise, though, of course, the emphasis on the importance of spoken discourse goes back to the 1974 TEA-laser study and its focus on tacit knowledge. The analysis of tacit knowledge is developed in Collins's, 2010, book, *Tacit and Explicit Knowledge*. The meaning of interactional expertise is often misunderstood, however – it is weakened to mean something that a typical journalist might acquire. But interactional expertise is a high-level spoken expertise more typical of what the contributory experts in a domain – those who actually contribute to the advance of scientific knowledge – need in order to manage the division of labour between themselves and other specialists whose work they cannot do but whose work they must understand so that efforts are coordinated. Interactional expertise is much more carefully analysed in a number of papers including Collins, 2004b, Collins, 2011, Collins and Evans, 2015, while the role of spoken discourse in science is explored further in Collins, et al, *The Face-to-face Principle: Science, Trust, Democracy and the Internet*, published in 2022.

The 2002 'Third Wave' seems to have had quite an influence in respect of the analysis of expertise: currently it seems to be one of the most dominant approaches. But the other direction in which that paper led was the political significance of expertise. In a recent paper (Collins, Evans, and Reyes-Galindo, 2025) we remarked that the Science and Technology Studies (STS) community was still acting as though its last century approach had no consequences whatever beyond the local academic community. We remarked, taking the movie *Don't Look Up* as an analogy, that in a similar way the STS community was refusing to look up at the potential political consequences of its position in spite of Latour's *volte face*. And this is at a time when the position of those who took the side of the parents rejecting MMR vaccine is almost identical to that of Robert F Kennedy Jr or even more radical, with the Covid-related role of Antony Fauci being roundly criticised for its authoritarian elitism in the face of citizens' opinions.

The political tendency of the Third Wave goes back at least as far as Collins's, 2014, *Are we all scientific experts now?* Collins and Evans's, *Why Democracies need Science* published in 2017, with Collins et al, *Experts and the Will of the People: Society, Populism and Science,* published in 2019. These titles are self-explanatory and also give a sense of a program that was building up in the face of the 'don't look up tendency'.

More recently, Collins and Evans's *Veritocracy: Truth, science, and how to preserve democracy* is in press and is very much the foundation of the current exercise which attempts to safeguard democracy through science, or more properly, 'knowledge', education. The bottom turtle motif will be found there too.

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