

A dangerous experiment

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Several university science and engineering departments have been complaining of a decline in quantity, and some say in quality, of their student intake. The usual response from academics is to lament a loss of interest in science both among school-leavers and the public more generally, and to forecast a future in which the lack of a technology base in Britain leaves our economy in a parlous state.

But how real is that danger? And does our future in fact rely on maintaining a tradition of excellence in science? Or are our universities intent on pursuing a course of academic achievement divorced from a changing economy that has become far less dependent on production and more so on services?

These questions have been sharpened by what has been described as a recent crisis in chemistry at British universities. This subject has always been one of the least glamorous of the basic sciences, but students have recently been deserting in droves. The chemistry departments at the universities of Exeter, Hertfordshire and King's College London have closed, that at Birkbeck has undergone a merger, and at Sussex, where the department has produced two Nobel laureates in the past three decades, a planned closure is currently in abeyance following an outcry from academics.

Yet despite dire warnings from academics and the media, British science remains strong, and the outlook in many disciplines is far from bleak. Britain's citation figures for publications in the life, medical and environmental sciences are second only to the US and well ahead of Germany, France and Japan. This is also true, perhaps surprisingly, in mathematics. British physical sciences rank less well—fourth in the world—but that is still an impressive showing. Meanwhile, the proportion of university students studying science-related subjects, including maths and engineering, has risen from 37.4 per cent in 1997-98 to 41.3 per cent in 2004.

There are problem areas, however: while life sciences and computer sciences have enjoyed rises in student intake of around 65-70 per cent over that time, the physical sciences have seen no overall growth in absolute numbers, while engineering is down by around 7-8 per cent. "There isn't a crisis," says John Selby of the Higher Education Funding Council for England (Hefce), "but there is vulnerability and there are risks."

Moreover, academics are realising that they cannot take it for granted that they and the government are singing from the same songsheet. In 1999, Tony Blair wrote that the value of science education is "to sustain and develop the UK's competitive edge in global markets." That argues for a programme set by the needs of industry and commerce, not by what academics consider to be the essential foundations of a scientific education. The two need not be incompatible, of course, but neither are they necessarily congruent. Does academia fulfil the role of a training ground for applied scientists, or is it mired in outdated ideas about how science should be taught and how its disciplines should be divided?

Britain invests less per capita in research and development (R&D) in manufacturing firms, and less in university research, than the US. Does this matter? Some might argue that the

decline in Britain's manufacturing base and the transition to service industries reduces the need for a cadre of home-grown, world-class scientists. But Don Braben, former head of BP's Venture Research Unit, disputes that: "Without science and technology, all you do is rearrange the deckchairs. Robert Solow won the Nobel for economics in 1987 for his work that proved that about 90 per cent of long-term economic growth was due to technical change"

It would be unwise to regard a national expertise in science and technology as expendable. "Our North sea oil is running out," says Sandy Gray, vice-president of the Society for Chemical Industry (SCI). "Alternative energy sources require new technologies to generate them. If we have to buy all of these technologies from outside, they will have to be paid for. If we don't maintain strengths in selected areas of high-technology development, our long-term economic viability will be steadily eroded. Britain cannot, even today, compete with eastern Europe, let alone much of Asia, South America, and Africa, in low and, increasingly, medium-skilled manufacturing. We have to raise our national skill and knowledge levels."

The argument that scientific excellence goes hand in hand with a strong economy seems incontrovertible. An analysis by the DTI, based on figures for 1993-2002, showed that a nation's GDP per head increases with its "citation intensity"—the number of citations of its scientific papers per capita, a measure of its output of good-quality science. Above a certain level of wealth, the relation is less clear—small countries such as Israel and Sweden have a disproportionate "citation impact," for example—but the link is plain for nations with a low per capita GDP, like India, China, Brazil and Poland. "The economic fortunes of a nation are maintained and developed through the production of highly trained people," says David King, the government's chief scientific adviser.

This sounds like the usual argument that national innovation and competitiveness depend on skills in basic research. But it is not a simple formula, as the figures show: another way of expressing the fact that in science Israel and Sweden punch above their economic weight is to say that they are producing good-quality scientists who have no direct impact on wealth creation. Terence Kealey, vice-chancellor of the private Buckingham University, claims that in any event most of the technology that supports successful companies is not home-grown but copied or adapted from that developed elsewhere. "The purpose of R&D is to develop a capacity to copy," he says.

Yet good scientists are still needed to do the copying. Kealey argues that the idea that we can let other countries do the intellectual hard work while second-rate scientists and technologists reap the benefits by scanning the scientific literature is misleading. It is actually very hard to copy other people's work, and requires highly trained scientists.

This, of course, hardly fits the celebrated model of scientists as intellectual pioneers. Students are unlikely to be attracted to science courses if they are taught to regard them as mere training in how to duplicate and tinker with the findings of others. In truth, however, even purely academic research usually has this flavour. The primary value of such research, in Kealey's view, is not the new technological potential it generates, but the way it plugs scientists into a network through which useful knowledge is dispensed. "If you're in a biotech company," he says, "99 per cent of the science you need takes place in other companies. You need to be part of the network." In this picture, even genuine innovation is not valuable in its

own right; rather, says Kealey, “good innovators are good copiers.”

So while cutting-edge science is not just a product of “high-tech envy” that makes countries vie for Nobels, neither is the practical harvest of that intellectual excellence the goal in itself. Rather, it is the cultivation of minds that produces useful results. “Universities generate prepared minds,” says Don Braben. “It doesn’t matter what the subject is.” David King agrees: “The reason we should continue to fund areas such as astronomy and particle physics is that they inspire young people and pull them into other areas of science.”

But even if we can agree that basic science is important for a sound economy, does it need to be publicly funded at universities? A 2003 survey by the OECD argued that publicly funded R&D “crowds out resources that could be alternatively used by the private sector.” Kealey agrees—by relieving market pressure, he says, governments blunt the edge of innovation. He points to a survey last year that identified IBM as the second highest source of cited scientific papers globally, after Harvard.

Moreover, the figures suggest that belt-tightening can be good for academic research. Britain’s citation numbers for scientific papers are second only to the US, and our citation intensity (citations per unit GDP) is the highest of any large nation. This is despite significant cutbacks in public spending on science between 1980 and 1995. The cuts, says King, “encouraged a level of resourcefulness among researchers, and approaches to industry and the EU that are now bearing fruit.” And private investment in the public research sector is still on the increase: companies are putting money into universities. Between 1995 and 2002, such funding as a percentage of public spending on university research grew from 6.5 per cent to 11 per cent, the highest of all G8 nations.

Still, many scientists feel that the private sector cannot be trusted with producing the kind of innovation that truly transforms areas of science and technology. They might be good at taking a fundamental discovery and turning it into a useful product; but the discoveries that open up a field in the first place come out of the kind of blue-skies research that companies such as IBM, AT&T Bell Labs, BP and ICI started to abandon in the early 1990s. It was this short-termism that led many leading scientists in these private research labs to seek less restrictive horizons in academia. “The private sector is very reluctant to invest in areas where the returns don’t come within 20 years,” says King. “Truly new, disruptive technologies depend on publicly funded research.” He points to the example of “plastic electronics”—cheap, printable circuits and display devices made from polymers. Some of the key developments in this burgeoning field came from research in the Cavendish Laboratory at Cambridge University, spawning thriving start-up companies such as Cambridge Display Technology, while major electronics companies such as Philips are now moving into the field.

Fears for the security of traditional science departments are long-standing—and well founded. In 1997 Essex University stopped recruiting for its undergraduate course in pure chemistry, which was attracting only about 25 students a year, while the Universities of East Anglia and Coventry dropped their undergraduate courses in physics for the same reason. Brunel has also closed its chemistry department: its science base now revolves around vocational topics such as computer engineering and sports science.

Now, less than half of all British universities offer undergraduate chemistry degrees, a

situation that Nobel laureate chemist Harry Kroto, formerly at Sussex, describes as “a disaster.” And there may be worse to come. Philip Kocienski, head of Leeds University’s school of chemistry, thinks that the current total of about 40 chemistry departments may dwindle further to just 20. “I suspect the government has this number in mind,” he says.

In December 2004, the then education secretary Charles Clarke asked Hefce to look into ways to protect strategic areas of study, including science, engineering and technology. The report, released in June 2005, concluded that Hefce “should guard against an overly interventionist role in the market,” but should be ready to “identify where the aggregate individual interests of higher education institutions do not match the national or regional interest.” King agrees, saying that “government should only step in if we’re producing disproportionate numbers of graduates in certain areas.” That may be the case for engineering, where King feels intervention might be warranted.

Yet John Selby of Hefce says that the organisation does not consider it a duty to micromanage what universities offer. “If an individual department closes, that doesn’t necessarily mean there is a problem for the subject,” he says. And he suggests that some of the shifts are taking place within the sciences, rather than that students are abandoning them altogether. “Some may be going into areas such as medicine and dentistry where previously they might have taken pure sciences,” he says.

Some universities have responded to these trends by offering courses that sound more appealing to young school-leavers, by associating them with fashionable areas such as forensics or sport sciences. According to a 2005 report by the Society of Chemical Industry, there has been a sharp increase in the number of courses that offer chemistry as a kind of tacked-on supplement: such-and-such “with chemistry.” The report says that, “Many of these courses are poorly understood by industry and are often more an attempt by universities to promote a subject in an increasingly market-led system.” Labour MP Ian Gibson, former head of biological sciences at UEA, dismisses this as window-dressing: university administrators, he says, “will teach anything to get students.”

But perhaps instead of discussing the types of departments that are closing, the discussion should be about which departments we should have? “I couldn’t agree more”, says Sandy Gray. “Academia, industry and government must work together to establish a nationally and regionally co-ordinated approach to tertiary science education and research. The problem with the current closures is that they are not co-ordinated and are being determined solely on the basis of the finances of individual universities, while central funding is determined more on the basis of research capability than teaching excellence.”

In the end, the question comes down to what a university is for. Academics can have a rose-tinted view. It’s sometimes said, for example, that the name “university” implies that teaching should be universal and embrace the whole universe; but in fact *universitas* derives from the organisational name used by medieval trades guilds, and the first “universities” were comprised of single-subject faculties. All the same, there is now a feeling that a university should possess a certain intellectual breadth and depth to be worthy of the title. “There is no US university that would dream of damaging its chemistry department,” says Ronald Breslow, a chemist at Columbia University and former president of the American Chemical Society. “It is as fundamental to the core of the universities as the history and literature

departments.”

“If we continue to close chemistry departments,” says Gerry Lawless, the chemistry departmental head at Sussex who fought off the recent threat of closure, “this calamitous slope of national decline as a serious producer economy will become steeper and considerably more slippery.” But not everyone sees it that way. If the student demand isn’t there, says Kealey, “I’d have no problem with closing chemistry departments.” He argues that “universities are for what young people want,” and suggests that they have a better nose for the market than they are commonly credited with. In terms of employment prospects, for example, graduates with humanities degrees don’t suffer any disadvantage, as is often implied. If giving young people what they want means opening media studies courses now and closing them in ten years’ time when another subject becomes more fashionable, he says, so be it.

But are the changes in student intake for the sciences a genuine indication of their preferences in a level market? One explanation offered for the drop in student numbers in some areas of science is that school teaching is often poor and does little to motivate pupils. Even of those pupils who study A-level chemistry, only 7 per cent will go on to take the subject at university. Moreover, those who do take “hard” sciences at school may not be taught by a teacher who has a background in the topic. One fifth of places for mathematics teachers are unfilled, and another fifth is occupied by people untrained in maths. Sixty per cent of chemistry sixth-formers are not taught by teachers with a chemistry degree. John Selby claims that the hard sciences “recruit disproportionately from independent schools, where there is often better teaching.” He says that Hefce is working with professional organisations such as the Royal Society of Chemistry, the Royal Academy of Engineering and the Institute of Physics to raise demand for these subjects in schools.

The idea that universities are hubs of pure learning is an unfashionable one in an age obsessed with notions of inclusion and targets. But the bare fact is that attempts to make university research more relevant and accessible seem only to have left core disciplines such as physics and chemistry in a state of stasis, if not crisis—which troubles industrialists as much as it does academics. According to Mike Pitts of the British chemicals company Reaxa, British firms are concerned not by what graduates do and don’t know, but by the fact that there are fewer of them. “The main concern within industry is a shrinking pool of quality science graduates. Industry is already forced to recruit abroad to fill skill shortages, especially in certain areas such as nuclear engineering and toxicology.” So the government can debate all it likes about resurrecting the nuclear power industry, but as Braben says, “We’ve got no nuclear physicists. We’ll have to import them.”

Neither, however, is the answer to create specialised degree courses in nuclear physics and engineering (although that is now happening). “Industry still has a need for graduates with a strong training in basic science”, says Pitts. “The plethora of degree subjects designed to appear vocational are misleading to students. It is more important to take a sandwich degree and spend a year in industry.”

It would be naïve to claim that university science has its priorities right simply because that is what they’ve always been. But to allow basic science to decline, to force it to adapt to the market or to entrust it wholly to private enterprise would be to conduct an experiment that has

never been tried and which would have very little chance of success.