Measuring the unmeasurable

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Government, academia and industry invest billions of pounds each year in chemistry research. With budgets coming under increasing pressure, Simon Perks asks whether we can, and should, measure what we are getting for our money

Our growing understanding of chemistry has changed the way that we live our lives. Whether it is developing sustainable alternatives to fossil fuels in the fight to combat climate change or enhancing our national security by creating more sensitive devices to detect explosives, chemistry research lies at the heart of scientific discovery and technological advancement. But as the purse strings tighten, researchers in academia and industry are coming under increasing pressure to justify society's investment in their work.

Impact factors

University research is increasingly under pressure from its funders to provide evidence of its impact. Research Councils UK, the umbrella body for the UK's seven research councils, now requires all researchers submitting grant proposals to set out the 'pathways to impact' of their work, explaining who will benefit from it and how they will do so. This goes beyond the purely academic impact of the research in advancing knowledge, to include economic and social impacts, such as fostering economic growth, increasing the effectiveness of public services and enhancing the quality of life.

The Engineering and Physical Sciences Research Council (EPSRC), which oversees government research funding for chemistry, has gone one stage further. Since November 2011, grant applicants need to explain how their work is of 'national importance'. EPSRC defines this as the extent to which the research has the potential, over 10–50 years, to meet the UK's 'strategic needs', for example, by enhancing industrial competitiveness or addressing identified societal challenges. After research quality, this is the second most important factor in determining which proposals get funded and which do not.

Impact is a hot topic in industry, too, though with a more quantitative focus. 'In industry, you generally have a target that you are trying to achieve. You have to work towards that,' says Paul Murray, chief scientific officer at CatScI, a chemical research company in Cardiff, UK. Chemistry research allows industry to make more and better products, he says, such as more effective drugs or more complex molecules. While this leads to a better deal for their customers, companies cannot afford to take their eye off the bottom line. 'All companies measure the different benefits of what

they do,' says Murray, 'but it has to make financial sense.'

However, the benefits of chemical research go beyond individual researchers, universities and companies. In a recent report commissioned by EPSRC and the Royal Society of Chemistry (RSC) to investigate the economic benefits of chemistry research to the UK, Oxford Economics identified that the UK chemicals industry and chemistry-using sectors generated £258bn of value-added in just one year, equivalent to 21% of UK GDP.

These sectors also support over 6m jobs in the UK and account for 15% of the goods exported by UK companies. The report also found that chemistry research has less tangible economic benefits, such as maintaining and enhancing the reputation of the UK science base, providing a skilled and highly productive workforce, and generating non-economic benefits that improve the quality of life.

A culture of measurement

While researchers accept that their work needs to have value to society, they are concerned that the current focus on measuring impact could detract from what they are trying to achieve. 'There has to be some measurement of the benefits of research,' says Tony Wilkinson, professor of chemistry at the University of York. 'But,' he adds, 'measuring impact is very hard. We can easily waste resources trying to measure the unmeasurable. At York, enough of the research naturally has impact. Impact is a good thing. It is the way the term is being used and the emphasis on measuring it that concern me.'

'A culture of measurement is not helpful,' agrees David Lathbury, vp of chemical development at Albany Molecular Research, a US-based company with operations in the UK, which supports the discovery and development of pharmaceutical products. 'In the pharmaceutical industry, it has been an unmitigated disaster,' he says.

While it is possible to measure impact, he says, you need to measure the right things. He explains how process metrics, for example, have 'done more harm to basic research than anything else', as they focus on quantity rather than quality. He compares this with the use of citation indices in academic research. 'You wonder if it really does help the process as a whole,' he says.

Scientists are also concerned that an emphasis on measuring impact will influence researchers' approach to their work. 'The research councils' focus on measuring impact promotes risk aversion and leads to "safe", incremental research. It is unlikely to result in real paradigm-changing, ground-breaking discoveries,' says Geoff Cloke, professor of chemistry at the University of Sussex. 'Many seminal discoveries come from talented people doing blue skies research,' he explains. He cites the example of Harry Kroto, whose discovery of the C_{60} buckminsterfullerene molecule arose serendipitously from an experiment aimed at producing carbon plasmas to replicate and characterise unidentified interstellar matter, and led to Kroto and his collaborators being awarded a Nobel prize.

But fundamental research will not always pay dividends in such a spectacular way. 'Blue skies research is high risk,' says Simon Ward, professor of medicinal chemistry at Sussex. 'We don't know what the outcomes will be.'

It is true, agrees Murray, that it is easier to assess the impact of applied research than investigations into more fundamental areas. There is also less risk, he explains, as scientists can see more clearly where their work could go. But this does not mean that applied research is best. 'I think it is a mistake to drive things down these lines,' he adds. Cloke agrees, highlighting the danger that scientists focus only on research with clear short-term benefits. 'We need a balance between blue skies and applied research,' he says.

EPSRC's new 'impact' criteria have come in for particular criticism from academics, especially the latest stipulation that research must be of 'national importance'. In an open letter to David Willetts, Minister of State for Universities and Science, published in *Times Higher Education* earlier in 2012, over 100 senior chemists, physicists and mathematicians protested against the move. 'This flies in the face of so many fundamental scientific discoveries,' they wrote, 'as has been pointed out to the research council by every professional scientific society in the UK on numerous occasions, both publicly and privately. It is incomprehensible that the EPSRC can be so short-sighted as to believe that this policy somehow has merit.'

At the heart of the debate lies a fundamental irony. While it is easy enough to measure how much money a research project costs and how many papers are published as a result of it, it can be difficult – if not impossible – to quantify the benefits that it will yield. There can be no simple calculation showing that for every pound invested in chemistry research, so many pounds of impact will be achieved. Not just because it can be difficult to measure this impact, but because in many cases we do not even know what the impact will be.

'If I was in government,' says Lathbury, 'I'd be looking back at inventions and looking at how they came about and how long it took them to become famous. Take the discovery of DNA, for example, it took 30 years for people to realise its commercial significance.'

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Geoff Cloke *University of Sussex*

A dangerous compromise

With the impact of research projects so difficult to predict, and benefits potentially taking years – if not decades – to become apparent, researchers worry that funding decisions could come down to who can 'talk the talk'. 'In academia, you're getting down to those who can spin a story. It doesn't necessarily reflect what the project will achieve,' warns Murray. If chemists need to demonstrate that their project will have impact or be of national importance in order for it to get funded, then it does not take a Nobel prize winner to recognise that it is those who are more adept at self-promotion who will do best.

The key to impact, says Lathbury, is finding the right people and letting them get on with it. 'The people are more valuable than the discoveries that they will come up with,' he explains. 'Great and interesting people do great and interesting things.'

So rather than collecting data on benefits that may or may not come to pass, perhaps society's funding could be spent in supporting scientists in doing what they do best – harnessing the power of chemistry to make the world a better place for us all.