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Number-crunching

How can we have a "knowledge economy" if no one learns maths or physics?

MICHAEL PROWSE
MICHAEL PROWSE IS AN ASSOCIATE OF THE LSE CENTRE FOR ECONOMIC PERFORMANCE

Education and innovation are at the heart of Labour's plans for modernising Britain. The government has an ambitious ten-year programme for boosting the nation's R&D performance, thereby creating a "knowledge economy." Yet this cannot succeed in the absence of suitably qualified people. A lack of the right sort of human capital is a far bigger constraint on innovation than a lack of cash or laboratories. Microsoft and Google were set up in garages by students with few assets other than their highly numerate brains.

Yet while endlessly stressing the importance of scientific research, ministers have failed to implement the education policies needed to realise their goals. The contrast between rhetoric and reality was illustrated again in November's stark analysis of the decline of physics in Britain's state schools by Alan Smithers and Pamela Robinson of the University of Buckingham.

Most recent debate on education has focused on structural and administrative issues. Like its Tory predecessors, the Blair government argues that schools will perform better if they have more autonomy and if parents have more choice. Yet if schools cannot find maths, physics and chemistry teachers, and if students keep on opting for easier subjects, British education will remain sub-standard, regardless of the level of competition or choice.

"Physics will definitely not die out in state schools," Andrew Adonis, the schools minister, assured Guardian readers in the wake of the Smithers report, pointing out that the number of graduates starting teacher training in science at secondary level had risen sharply in recent years. Adonis is doubtless right that physics will not literally disappear, but in what other country would an education minister have to give such an assurance? Moreover, although the number of science trainees has risen under Labour, science is not the same thing as physics. As Gareth Roberts noted in his 2002 report on the supply of people with scientific skills, buoyancy in the supply of biologists, computer scientists and IT specialists has masked a simultaneous decline in the numbers studying (and so qualified to teach) maths, physics, chemistry and

engineering. And the decline in the numerate disciplines has coincided with increased demand for people with such talents, especially from the financial services sector.

Perhaps the most damning single statistic in the Smithers report is that 23 per cent of schools without a sixth form do not have any teacher who has studied physics beyond A-level. The authors also note severely adverse demographic trends: the proportion of physics teachers aged 51 or over is now double that aged 30 or under. Although recruitment to teacher training courses has picked up, it remains far below the level needed to correct the deficit. Smithers and Robinson argue that Britain needs about 750 physics teacher trainees a year, an increase of nearly two thirds from the present level of 450.

The decline of physics accelerated after the Thatcher government introduced the double-award GCSE science as a replacement for the separate subjects of physics, chemistry and biology. This manoeuvre allowed schools to begin substituting biology teachers for physicists and chemists. In state schools today, more teachers of physics in their twenties hold a degree in biology than in physics. Yet physics and biology are very different disciplines: a grasp of one does not imply a grasp of the other. Entries in physics at A-level have fallen by over a third in the past 20 years despite a big expansion of post-16 education which has seen overall entries rise 23 per cent, partly, it seems, because few biology teachers are able to inspire enthusiasm for a subject they neither understand nor wish to teach.

As Adrian Smith's official inquiry revealed in 2004, maths is in a similarly fragile condition. Maths A-level entries have fallen by 13 per cent just over the past five years—a rate of decline four times as great as that for physics in the same period. Britain has greater difficulty than most other rich democracies in recruiting and retaining qualified science teachers. Smith estimates that almost 25 per cent of maths teachers in the state sector have weak or no qualifications in maths, and that one in seven lessons are taught by people without the appropriate knowledge. The age profile of maths teachers is similar to that of physicists: those over 50 are twice as numerous as those under 30.

A combination of financial incentives and on-the-job training for maths graduates has boosted recruitment since 1998, but Smith reckons there is still a shortfall of specialist maths teachers of around 3,400 in England alone. To make good this deficit, the teaching profession would need to siphon off more than 40 per cent of the annual British output of maths graduates for the next several years—an impossible task given the more attractive pay and conditions in competing occupations. And ironically, the campaign to revive maths is hurting physics: a quarter of teacher trainees with degrees in physics are now training to teach maths.

The root cause of the shortages is the failure of generations of students to study subjects like maths and physics beyond the compulsory phase of education, which ends at 16. Schools cannot attract well-qualified teachers because the pool of highly numerate graduates is so limited. For instance, only 10 per cent of students continue with maths beyond 16, and fewer than 10 per cent of those go on to take a maths degree. Yet maths is not just another subject, to be treated as equivalent to sociology or media studies. It is the only universal language (music aside) and provides the vital underpinning of the knowledge economy that Labour is so keen to promote. As Smith notes, it is a prerequisite for the physical sciences, technology, financial services, many aspects of business and much of ICT. It is also of ever growing importance in biology, medicine, psychology, economics and other social sciences. How paradoxical, then, that Labour ministers refer endlessly to the importance of innovation while presiding over an education system that produces only a trickle of mathematicians and physicists.

The long-run priority must be to increase the pool of numerate graduates. This will require more radical changes to the sixth form curriculum, especially for academic students, than foreshadowed in the 2005 white paper on 14-19 education. The main focus of that paper was on raising the quality and standing of vocational and technical education through a series of diplomas loosely modelled on continental European practice. If Labour delivers on this pledge, it will have achieved a great deal. But it was wrong to imply that the A-level system for the top 40 per cent is working fairly well and requires little more than fine-tuning.

Two facets of the A-level system go a long way towards explaining the eclipse of maths and physical science. It enshrines premature specialisation: England—Scotland has always favoured greater breadth—is all but unique among large affluent democracies in allowing students to take final school examinations in just three subjects (four in the case of some able students). This is absurd in itself, but the folly is compounded because students are given a free choice of subjects. Nowhere else in the rich world can the most able students drop maths, science, the language and literature of their own nation, and all foreign languages, and devote their time to soft options such as psychology, which this year had two thirds as many entries again as physics. Even media/film studies is a more popular A-level than physics.

Nor have successive Tory and Labour governments understood the consequences of allowing free choice of subjects while also encouraging greater competition within both secondary education and the university system. There is plenty of evidence that maths, physics and chemistry are harder than social sciences or the humanities. Both schools and pupils regard them as high-risk, and with league table results in mind all but the most able are discouraged from taking them. The Roberts review noted that 34 per cent of university entrants in maths had an A-level points score of 30 or more

compared with 10 per cent of entrants in biology and less than 2 per cent of entrants in sociology. There could not be starker evidence of the relative difficulty of different subjects.

But the answer does not lie in making maths or the physical sciences easier—as Roberts noted, the content of today's maths A-level is already inferior to that of 15 or 20 years ago. It lies in measures to broaden sixth form education and to limit students' freedom of choice. The 14-19 white paper accepts the abiding importance of maths and English, but implies that good GCSE passes at 16 constitute a sufficient base for all but specialists. In the case of the academically able, this is emphatically not true. As the Smith inquiry into maths argued, every student ought to continue studying maths until the age of 18, and most university entrants should expect to advance considerably beyond GCSE. This only sounds draconian in a country where much of the political class suffers from maths phobia: it has always been normal for able students in the US and continental Europe to study maths beyond 16.

We need to look again at the international baccalaureate, which requires breadth and deliberately restricts choice in the interests of a balanced education. All candidates have to study six subjects, including maths, a science, their mother tongue, and a foreign language, although they can choose whether to take them at a "major" or "minor" level. Such a reform would mean that around 40 per cent, rather than less than 10 per cent, of young people would study maths beyond GCSE. And although many students would still opt for biology, the pool of physical scientists would also expand. Far from being a gold standard, A-levels are akin to an anarchic system of floating exchange rates.

The only way to ensure a greater supply of the key skills nurtured in maths and the physical sciences is to make a broad, balanced curriculum compulsory. People need to study more maths and physics, but not at the expense of poetry and foreign languages. Ending premature specialisation offers the best hope of nurturing the skills needed for a knowledge economy while also combating philistinism. As such, it is surely a policy on which liberal humanists and utilitarian economists ought to be able to agree.