

THE ANSWER IS ROCKET SCIENCE...

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Education and Innovation in the 21st century

INTRODUCTION – THE CASE FOR GROWTH

Every Great Political Speech begins with a truism

This isn't a great political speech – but I'll still begin with a truism –
Growth is Good.

Our future depends on generating greater economic growth. We have, as a nation, as a society, as a planet, to become better at producing the goods and services which drive progress.

And one of the reasons why I so welcome Reform's report today is that it underlines the importance of mathematics in driving economic growth. The report's stress on the need to nurture the mathematics economy is timely and important.

The case for growth – the need to promote dynamism, innovation, economic expansion – should be self-evident.

But, as successive generations have found, there are always seductive voices ready to make the case for policies which can impede, smother or arrest growth.

There are those who argue for economic protectionism and against free trade – and their voices are increasingly influential in this election year in America, as well as across the European Union.

There are those who make environmentalism a religion, and not a prudent response rooted in science. Their motives may be admirable but their arguments can be so fundamentalist they risk not only harming growth but undermining the consensus we need to combat climate change.

And then there are those who do very nicely thank you out of a world in which opportunity is blocked and the status quo is carefully preserved in such a way as to keep their privileged position, at or near the top of the pile, intact.

Some of the most eloquent adversaries of the reforms needed to generate economic growth have often been figures on the Right who have wished to bang an antique drum for Merrie England rather than embrace the emancipating power of growth and change.

All of these reactionary, anti-opportunity, anti-growth forces have powerful contemporary advocates and they need to be confronted – in the name of progress, growth and opportunity...

We need to confront them because every worthwhile good in the future will be secured through growth.

For those of us who believe in greater social justice we can only make opportunity more equal if we generate the growth to invest in public services and better support for the vulnerable.

For those of us who want a better environment – cleaner air, greener open space, a more beautiful country – these goods can only be secured through the scientific progress, the innovation and the public investment which go along with growth.

For those of us who want better education for our children, broader horizons for them as they travel, a better chance of them going to university, a richer choice of jobs when they graduate, a surer path to a family home and more rounded, balanced, cultured life than we have had – then economic growth is the answer

Specifically – we as a nation need to raise the trend rate of economic growth in this country.

Now growth, unlike the boom and bust we've been experiencing, needs to be sustainable. In several ways:

- not built on debt and therefore short term (as now)
- not overinflated and so leading to a crunch (as now)
- not based on damaging the environment
- not based on damaging the social fabric of the nation.

But unless we secure growth we won't secure our future.

INNOVATION – THE ROUTE TO GROWTH

And, as today's paper reminds us, it's innovation, it's intellectual exploration, rooted in rigour and sustained by mastery of academic knowledge, which will drive that growth.

In the past we might have thought that the way to generate growth, the way to compete with those nations poised to eat our lunch was simply to bear down on costs and just make ourselves a cheaper warehouse in which to do business.

Well nobody could be a greater hawk than me when it comes to bearing down on unnecessary expenditure - and eliminating the forest of red tape which currently stands in the way of growth.

But it's not enough for us simply to compete on reducing the burdens of doing business. We have to ensure we're capable of competing up the value chain, that our workforce isn't just competitive on costs, but it's competing, and winning, on ability.

Future economic growth will be driven by Britain competing in an increasingly intellectual marketplace. Lord Leitch's recent report on skills suggested that by 2020 the number of jobs in Britain available to those with no or low skills would be around 500,000. The traditional labouring and service jobs which once gave employment and dignity to millions, to a majority of the male workforce, now just a residual part of our native economy.

Now, I'm very wary, in an open economy, of making predictions about the precise demands for a particular sort of labour in twelve years time.

In fact, as the author of a book called Michael Portillo – The Future of the Right – I'm very wary about making any predictions at all.

But it seems to me undeniable that the trend Leitch identifies is correct. The number of jobs for those without a high level of basic education in this country is diminishing.

And the trend in every one of our major competitors is in the same direction.

This is the point in the speech in which I mention China and India – its obligatory now for almost all politicians to refer to China and India – together – in any speech where they want to seem knowledgeable about the world economy.

And I'm no different.

Because it still seems to me that we haven't yet, as a society, properly appreciated the challenge posed by these nations' embrace of policies designed to generate greater levels of growth – and specifically their emphasis on education. Rigorous, academic, and overwhelmingly mathematical and scientific education in particular.

Sometimes the debate in the west appears rooted in the belief that these countries primarily pose a challenge on the basis of cheaper costs. But these nations are now competing right up the value chain. China is branching out into all the most cutting-edge areas, including nano-technology, genetic engineering, and quantum computation.

And they are competing on the basis of rapidly expanding the cadre of trained mathematicians and scientists in their economy.

India and China are producing FOUR MILLION GRADUATES every year.

The single largest area of graduate growth is mathematics, science and engineering. 1/3 of graduates in China are engineers – here it's just 8%.

SCIENCE AND MATHEMATICS - THE MOTHER AND FATHER OF INNOVATION

I've mentioned China and India – one political cliché – and looking at their performance prompts me to mention another.

Often when politicians are urging a course of action on others which we consider self-evident, and we wonder why people won't accept our simple logic we're inclined to say, "well it's not rocket science"

But looking at China and India's performance – indeed looking at the principal drivers of growth and innovation across the globe it seems increasingly clear to me that the answer to our problems, more often than not, is rocket science.

It's rocket science – mathematics, engineering, physics and the other hard sciences which are driving innovation globally, and generating growth for the future...

I love the arts – and Britain's attractiveness as a nation is built on our artistic heritage and cultural leadership.

Design is important – not just as a way of adding value but as a process which makes our life at once easier and richer.

And an emphasis on service is crucial – in a world where time is precious and the public square seems more impersonal, coarser even, anything which makes individuals feel more valued, their needs respected, and which strengthens relationships, is vital.

But the real innovation which will ultimately drive growth in the economy is going to be generated and sustained by science, technology, engineering and mathematics.

To the question – how do we make our futures richer – the answer genuinely is rocket science.

The hard sciences are the foundation of growth.

They enable growth like nothing else.

Whether its new software

New applications for consumer electronics

New methods of getting us from a to b

New methods of limiting damage to the globe

New methods of getting capital to where its needed

New financial instruments

Better tennis rackets

Trainers which are – literally- cooler

New cures for life-threatening diseases

New learning platforms

New versions of Grand Theft Auto

New graphics in the latest Spielberg blockbuster

New hope for the childless

Or sight for the blind and hearing for those in a world of silence

- it's mathematics and science which will generate these innovations
– and keep our economy on the path of growth and opportunity.

BUT STANDARDS ARE SLIPPING

Which is why it's so worrying, as Reform's work underlines, that we're doing so badly.

In the most recent international league tables we slipped from fourth to fourteenth in science and 8th to 24th in mathematics.

The fantastic work done by John Marks for Reform's paper today reinforces the cause for concern about standards.

He points out that questions are less rigorous,

He shows us that exams lead candidates to solutions instead of requiring independent mathematical reasoning,

He demonstrates that traditional algebra and geometry, as well as proper proofs are no longer so central,

and by drawing attention to the fact that it's now possible to secure a C grade – a pass – with just 20% of questions answered correctly John has blown the whistle on Government claims of relentless improvement.

But his work, and that of Reform's more broadly on mathematics, is only one part of the picture.

There are real concerns about the quality of the rest of the STEM curriculum as well.

As the Sunday Telegraph reported last week there are widespread concerns among scientists about the Key Stage Three tests which 14-year-olds sit.

Asking students which part of a rider's anatomy a riding hat protects, or where the energy comes from in a solar-powered mole scarer are hardly rigorous tests of scientific reasoning.

In fact they're hardly anything to do with science at all – they're just basic tests of English comprehension.

At GCSE there are real concerns as well about the rigour of examinations. Asking students, as one exam board did last year, whether we look at the stars with a microscope or a telescope is not really equipping the next generation to compete with the products of Singaporean or Taiwanese schools.

Indeed the whole thrust of the new science curriculum – which aims to empower students to be “consumers of science” and which concentrates on engaging students in debate about GM foods or climate change – is a shift away from preparing students to be scientists.

I’m the first to support the wider spread of scientific literacy among the population. We’d have a more enlightened discussion of issues such as the reliability of the MMR vaccine or the promise inherent in GM foods if scientific knowledge was more securely embedded in our society.

But the way to build understanding of science is to train students to be scientists – to give them a grounding in scientific knowledge – from the structure of hydrocarbons to the laws of thermodynamics – which enables them to conduct experiments, deploy reason, test propositions, operate empirically

The new science curriculum at GCSE hasn’t inspired confidence in our finest schools – Martin Stephen, the High Master of St Paul’s, and another distinguished Reform author – has warned that it has a “terrifying absence of proper science”.

Indeed the Qualifications and Curriculum Authority itself – the Government’s own standards body – has actually celebrated the fact that the science curriculum at Key Stage 4 – for those over 14 – has “reduced content and factual recall”.

Operating on the basis that students should know less to do better completely misunderstands how science, and indeed mathematics, works.

It’s only by accumulating knowledge, and understanding how theories and models rest on assembling that knowledge in a particular logical pattern, that scientific understanding advances.

The failure of the existing curriculum and qualification offer to command confidence is dramatically shown up by what happens abroad and what is happening in the independent sector.

In Singapore, a country which has close historic links to our own, and which performs superbly in maths and science their students sit the old O-level, not the GCSE which our students sit.

In the independent schools which dominate access to Russell Group universities heads increasingly offer the independent IGCSE, not the state's own GCSE, and more and more are tempted to offer the Cambridge Pre-U rather than the existing A-level.

When it comes to the new qualifications the government are piloting then professional concern is even greater

The Advisory Committee on Mathematics Education has warned that the maths element in the Government's new diplomas won't be testing enough.

Professor Adrian Smith, chair of ACME and a former Government maths adviser, has argued that the proposed maths element of the diplomas would not go beyond GCSE-level in many areas.

Given that these qualifications are aimed at people up to the age of 19 and are intended to prepare people for university-level study in subjects such as engineering or architecture this is a profound concern.

"A higher level of maths will inevitably be required in those diplomas which are obviously 'numerate', argued Sir Adrian, and, he pointed out, the current level of qualification "will leave UK school and college leavers lagging still further behind their European counterparts," he said.

AND OUR KNOWLEDGE BASE IS SHRINKING

So we're failing to guarantee high standards.

And, as well as performing more poorly than our competitors, we're also producing fewer students in these vital areas.

The number doing physics A level has fallen by over 50% over the past twenty years.

The number of maths A levels has fallen by 15% in the past decade.

We have fewer than 3,000 physics undergraduates.

The number of physics and chemistry graduates has fallen by over 25% in a decade.

Between 1994 and 2004, more than 30 per cent of the physics departments in Britain disappeared.

And all this has been happening at a time of university expansion overall. So even as more and more people are going to university, fewer and fewer in absolute terms are pursuing these hard science subjects.

In engineering and technology the number of undergraduates following these courses, as a proportion of total undergraduates, has fallen by 32%.

Now some people might object to this focus on numbers – although I would have hoped that in a room full of mathematicians there might be some sympathy for this approach – but some commentators would argue that we shouldn't try to increase the number of scientists as though we were trying to meet tractor production targets.

I disagree – not because I'm a fan of targets – I'm not - but because I'm a student of networks.

Network theory teaches us that when it comes to innovation, to the generation of new ideas, there is a relationship between numbers and the creativity which those of us who believe in the open society so value.

The more talented, creative, academically trained, scientifically disciplined, individuals there are in a society, in contact, the more innovative that society will be – and the relationship isn't just linear.

The more the potential connections, the greater the number of potential combinations, the greater the likelihood of people sharing ideas, sparking off one another, establishing links, the more likely that each, and all, will generate more new ideas.

The work of thinkers on network theory such as Albert-Laszlo Barabasi, the arguments of polemicists like James Surowiecki, the author of the *Wisdom of Crowds*, the case made in books such as *We-Think* by Charles Leadbetter and *Here Comes Everybody* by Clay Shirky all underline the enormous potential for intellectual dynamism which comes from maximising the number of academically-creative people in contact with one another.

Nothing will drive innovation – and growth – more than growing and developing our own networks of mathematical and scientific innovators in this country. So expanding the number of people going into higher education and, critically, increasing the number doing STEM subjects, is crucial to our future well-being as a society.

AND WE'RE NOT GENERATING THE TRAINED MINDS TO TRAIN THE MATHEMATICIANS SCIENTISTS OF THE FUTURE

Which is why it's so worrying that we have such a big problem attracting properly qualified people into teaching these subjects.

The Royal Society has shown that students' success in science and mathematics is very closely associated with being taught by specialist science and mathematics teachers.

But we simply don't have the people in place to deliver the improvements we need. Out of the nearly ten thousand graduates training to become primary school teachers in the last year for which we have figures only 227 had any sort of science or maths degree.

When maths and science form two-thirds of the curriculum tested at the end of primary school these figures are worrying in themselves.

But when placed in broader context the problems we face are even more significant.

At secondary school a quarter of maths teachers have no specialism in the subject.

The University of Buckingham have reported that nearly two-thirds of those teaching physics at GCSE and A level do not have physics as the main subject of their qualification.

Indeed the CBI have revealed that a third of those teaching physics at GCSE don't even have an A level in the subject.

And a bad situation is getting worse.

According to the Royal society recruitment to teacher training courses in 2005/6 fell short of Government targets by 10% in science and 18% in maths.

What makes it worse is that drop-out rates from teacher training were 15.7% among prospective science teachers and 17.8% among prospective maths teachers – so the number of teachers who actually qualify are substantially lower than those in training.

And half of the science and maths teachers who qualified between 1994 and 1999 are no longer teaching.

Unless we reverse this shocking trend our country is destined to fall further and further behind.

PLUS KNOWLEDGE IS BEING RATIONED TO THE RICH

And for those of us who're concerned about social justice it is a particular cause for concern that the poorest are suffering most from this trend.

Access to a truly stretching curriculum which will prepare students for a career in science, technology, engineering or mathematics is increasingly being restricted to the wealthy.

- Only 1 in 20 state school pupils take the three separate sciences – physics, biology and chemistry at GCSE

Four times as many students in the independent sector take that combination of subjects. And that's because the opportunities are greater.

- The three separate sciences are only available in 26% of comprehensive schools.

Some will say that it's old-fashioned to express a preference for studying the sciences as separate GCSEs rather than as part of a general "double science" GCSE.

But the best universities want students to study the separate sciences, it's the best preparation for a STEM degree or career and when schools are free to choose and have the resources to offer the best they unhesitatingly offer the three separate sciences.

As Dr Hilary Leever of the Campaign for Science and Engineering, has pointed out, "we know students taking three separate science GCSEs are more likely to go on to take science A-levels and do well.

If, however, you come from a poorer background, or live in a more deprived neighbourhood, your chances of studying a physics, chemistry

or biology GCSE, and thus getting on the path to the best jobs around, are radically curtailed.

Just 2% of pupils eligible for free school meals are entered for physics, chemistry and biology as separate GCSEs. In the ten most deprived boroughs, just 3% of pupils did GCSE physics and in Islington, not a single state school pupil sat biology, chemistry or physics GCSE in 2005/6.

So in the heart of one of the world's richest cities access to the knowledge which liberates is denied the poorest – it's a standing disgrace.

WHAT IS TO BE DONE

So

We need economic growth to make our society richer, fairer, more open, meritocratic and green

And

Innovation – particularly of the kind generated by maths and the hard sciences – is central to guaranteeing that growth.

While other countries are forging ahead and generating more and more science and mathematics graduates, we are falling behind in international league tables.

Our curriculum and qualifications are less and less attractive and competitive.

Our university science departments have been closing and undergraduate numbers have been in long term decline.

Our teaching base has been eroded and we lack qualified teachers where it counts.

And the poorest are suffering most from a rationing of educational opportunity.

This dire state of affairs prompts me to ask Lenin's question -

“What is to be Done?”

More often than not, with this Government, if you ask Lenin's question, you get Stalin's solution...

Targets, Centralisation, and Shooting the traitors.....

But we believe in a different approach – an approach which reflects what’s happening in the world in which we live, and, crucially, which reflects the circumstances fuelling innovation across the globe.

AN EDUCATION POLICY BASED ON MODERN SCIENTIFIC PRINCIPLES

We are living in what David Cameron has called a “post-bureaucratic age”.

It may not be a perfect soundbite. And it may not help that it was coined in a speech he gave at the Google Zeitgeist conference – thus instantly inviting a cynical response from the hardbitten citizens of the Westminster village

But David put his finger on the crucial social, cultural and economic transformation of our times.

We’re living in an age when the big bureaucratic models are collapsing and the old bureaucratic ways of delivering clearly no longer work.

David described three stages in social organisation.

The pre-bureaucratic age was essentially the feudal, pre-industrial period when authority was local, familial and clannish and society was organised in traditional hierarchies.

The Great Leap Forward, which enabled the birth of the modern age, was the establishment of societies in which authority, and information, could be centralised and services delivered by bureaucracies.

Whether it was the establishment of Bismarck’s welfare state

Or FDR’s New Deal and the managerial state described by James Burnham

Or the United Kingdom governed by the men in Whitehall, with their colleagues in the BBC, the nationalised industries and the parallel inspectorates and bureaucracies.

The twentieth century was the high point of the bureaucratic age.

But we're now living in a period where these bureaucracies are increasingly outmoded.

Individuals are less deferential towards authority and more demanding in the services they use.

They won't accept one size fits all and demand a tailored solution to their needs.

They can instantly compare performance and prices online, whether it's insurance, fuel, clinical outcomes or educational achievements.

The large organisations which promised a guaranteed level of delivery – in the private and public sector – have been found wanting.

Whether it's IBM's Big Blue or Old Labour's Dark Brown the machines which appeared to function so well in the past seem crashingly, clunkingly, inappropriate to the needs of today's flexible, decentralised, networked age...

The idea that a single benign controller will provide for us all is obsolete.

In broadcasting the advent of Skyplus means each of us now wields the power only Michael Grade or Alan Yentob used to – we are our own schedulers and channel controllers.

In music production and distribution, the advent of social networking sites such as MySpace and Bebo has meant that artists like Lily Allen have been able to reach their audiences direct without having to go through the old style industry bureaucracy of A and R men and patronisingly restrictive contracts.

In medical science the clinical breakthrough which identified how to counteract SARS was generated by scores of different scientists in dozens of different labs in many different countries all alternately competing and collaborating freely with one another with no single directing intelligence driving their efforts. And they generated an answer in days.

The post-bureaucratic age is an age of innovation, of creativity, of constant adaptation and learning.

And since all those virtues are central to education that's why our approach to education is distinctively post-bureaucratic.

We want to introduce the liberating and creative dynamic of new providers and new ways of working into state education.

At the moment, in too many parts of the UK, education is provided by a bureaucratic monopoly. We would do as they have in Holland, New York and Sweden and allow new providers into the state system to challenge the complacent and the failing.

We would lower the barriers to entry, reforming planning law to make it easier for new schools to be established and to grow. We would put power in the hands of citizens not bureaucrats by giving parents the chance to take their children out of failing schools and place them in good new ones.

At the moment accountability in education is all one way – all upwards – all towards the Secretary of State and the targets he sets.

We want accountability to be to parents, and we want to give heads and teachers the freedom to respond to the needs of those they teach not targets set to satisfy politicians vanity.

At the moment schools struggle to show their pupils are getting five good GCSEs and many are desperate to improve their league table performance. For some the temptation to offer students less rigorous qualifications, in which passes are thought to be easier and coursework less arduous, is strong. Others choose to offer qualifications which are definitely less academically stretching, but which are nominally equivalent to GCSEs, to bolster league table performance.

Students are being presented for qualifications which do not equip them best for future study or the world of work because of the need to hit government targets.

If, however, schools were accountable to parents first then parents could, and would, demand the most rigorous, the most satisfying and the most marketable qualifications.

With maths and science graduates earning hundreds of thousands pounds more than their equivalents in other disciplines and industry desperate for scientifically literate and numerate school leavers then a school system

which genuinely responded to pupil and parent wishes would naturally see more students opt for maths and science.

And a school system such as we envisage – with greater freedoms for headteachers – would mean in-demand professionals with maths and science qualifications would be able to command much higher salaries for their skills.

We would allow heads to pay higher salaries and bonuses to specialist teachers from day one – within budgets over which they had greater control.

We would also allow heads to enter their students for exams which the Government currently doesn't allow to count in league tables – such as the IGCSE – so parents and pupils have the opportunity to pursue courses they consider more rigorous and satisfying.

We would reform teacher training to make it easier for scientists, mathematicians and people of real ability to get into the classroom without having to jump through the current academic and bureaucratic hoops.

For those people – like this Government - who say that the only way to drive up standards is to invest more power and control in the hands of bureaucrats we have to ask why should we reinforce failure?

Consider just one other fact about our current malaise – fact gleaned from the Government's own report into maths education in primary schools. Local authorities, town hall bureaucracies, employ 400 “mathematics consultants” – that's nearly three full time professionals for each local authority area.

And yet, according to the Government's own report, “the depth of subject knowledge of many consultants is insufficient for them to operate effectively as coaches and mentors for practitioners in schools”. And remember we're talking about primaries here.

So the majority of the education bureaucrats employed by other education bureaucrats to consult on maths teaching don't even know enough about maths to help primary teachers keep up to speed when teaching 6 year olds.

There has to be a better way – and there is – by following the path which any mathematician or scientist would follow.

When a particular experiment has failed it's time to learn from your errors.

When others have succeeded through innovation learn from them.

When given the choice between a closed system which repeats a failing pattern and an open system which generates new solutions and constantly adapts, choose the open system...

We need a Government which is ready to be as radical in reforming education as the governments of the eighties in Britain and the US were in reforming the economy

David Cameron has made it clear that our programme for Government will be built on reforms in social policy every bit as ambitious as the radical improvements, the changes towards greater liberalism, in economic policy we brought in the past

I began with a truism, let me end with one – for Conservatives – change is our ally – and nowhere do we need change more than in education....

2 June 2008