SCIENCE, ENGINEERING & THE DEVOLVED ELECTIONS, 2011
Background Paper

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INTRODUCTION

This background paper has been produced in the run-up to the devolved elections of May 2011. It is intended to convey current science and engineering policies and the performance of Scotland, Wales and Northern Ireland in the light of these; to highlight areas of relative strength and weakness and to deliver policy recommendations. It should be read alongside the targeted summaries for each of the devolved nations, and provides the background to them. There will also be regular updates and information on the CaSE website: www.sciencecampaign.org.uk. This paper makes many comparisons across the UK nations, it is useful to bear in mind their relative populations and productivity, shown in Table 1.

Table 1. Population, proportion of total UK population (2009) and Gross Value Added per member of the population, in 2008, shown by UK nation[1,2]

	England	Scotland	Wales	Northern Ireland
Population (000s)	51,810	5,190	3,000	1,790
% UK population	83.8	8.4	4.9	2.9
GVA per head population	£21,049	£20,031	£15,222	£16,240

SCIENCE & ENGINEERING LEGISLATURE & GOVERNANCE: IS IT A PRIORITY?

Recommendations

- **Scotland, Wales and Northern Ireland all acknowledge the vital role that science and engineering should have in the economic recovery, and in improving long-term prosperity. The devolved Governments need strong and long-term policies to give aspiring and working scientists and engineers, and investors, the confidence to locate their careers and spending in the UK. These policies need to be supported with financial investments.**

Investment in science and engineering skills and research gives broad and historically proven economic returns over the short- and long-term[3]. Science and engineering have a crucial role to play in the economic recovery and must be given political attention and support. The devolved nations of the UK need to prioritise science and engineering to the same extent as the UK Government, despite having smaller governance and limited devolved responsibilities. While each of the nations govern in a different range of areas, they all include education and training, economic development and support for industry, health, environment and rural affairs or agriculture. Thus, many of the areas heavily influencing or influenced by science and engineering – research funding, scientific advice, education, industry and innovation – are devolved to an extent.

GOVERNANCE

Recommendations

- **Each of the nations should have a Minister with responsibility for science, engineering and innovation highlighted in his or her portfolio and who is included in the relevant high-level decision-making committees.**
- **All of the devolved nations have developed or are developing strategies for science, technology, engineering and mathematics (STEM) – it is important that all of the parties commit to seeing these through after the May 2011 elections.**

[1] Mid Year Population Estimates 2009, ONS
http://www.statistics.gov.uk/pdfdir/pop0610.pdf
[2] http://www.statistics.gov.uk/downloads/theme_economy/NationalGVA2009.pdf
[3] Securing Our Future with Science and Engineering, June 2010, CaSE

- **STEM policies need to be long-term, of the order of decades not years, as this is the time-frame in which research and innovation occur, external investment decisions are made, and careers are pursued.**

A named Ministerial champion can ensure that policies affected by and affecting science and engineering are beneficial and coherent across departments. This appointment needs to be high level and sends an important signal to aspiring and working scientists and engineers, and investors, of the priority that a Government places on science and engineering. There have been calls for such a position from across the science and engineering community[4],[5],[6].

The Scottish Government names science as one of the ministerial responsibilities of the Cabinet Secretary for Education and Lifelong Learning. Support for industry would come under the remit of the Cabinet Secretary Finance and Sustainable Growth[7]. *Science for Scotland* was produced in 2008 and represents a strategic and cross-cutting framework for developing science in Scotland, from education to enhanced business investment[8]. Scotland could really benefit from appointing a Minister with core responsibility for science, engineering and innovation.

The Welsh Assembly Government appointed a Deputy Minister for Science, Innovation and Skills in 2007. Wales recognises the importance of science and engineering for its future and is showing consistency and coherence in its policy making. It has developed its scientific advice, founded a National Science Academy, published a review of its research and development (R&D) at the end of 2010 to feed into its economic renewal strategy, and is currently updating its *Science Policy for Wales* (first published in 2006)[9],[10]. It is working hard to promote its achievements, for example, detailing them in "*Welsh Achievements in Science and Technology*", last published in 2009 and updated every 3-4 years[11]. Wales has taken a significant step forward in appointing a Deputy Minister for Science, Innovation and Skills, but given the importance of these areas for future growth, and the need to push forward with the STEM agenda, this should be a full Ministerial position.

The Northern Ireland Executive does not name science, engineering or innovation as a specific ministerial responsibility. They are mostly covered by the Departments of Education, of Employment and Learning, and of Enterprise, Trade and Investment[12]. Indeed the first two of these recently collaborated on a STEM review[13]. The Executive's response to this review, proposes to appoint a prominent STEM business person as STEM Champion, who will also lead the STEM Implementation Steering Group (which includes key government stakeholders)[14]. While this is progress, a STEM is needed at Ministerial level.

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[4] STEM securing a prosperous future for Scotland ,The Engineering Policy Group, Scotland
[5] PAWG Scotland policy briefing, November 2010. http://www.amrc.org.uk/news-policy--debate_pawg-scotland
[6] Prospect's Manifesto for Scottish Science, March 2011.
[7] http://www.scotland.gov.uk/About/14944/Scottish-Cabinet
[8] *Science for Scotland*, November 2008, http://www.scotland.gov.uk/Publications/2008/11/24143207/0
[9] R&D Review Panel, Welsh Assembly Government, 2010. http://wales.gov.uk/docs/dcells/publications/100909rdreporten.pdf
[10] Science Policy for Wales, 2006
[11] http://ms.fs4b.wales.gov.uk/publications/campaigns/Innovation/pdf/eng/Welsh_Acheivements_Eng_May09.pdf
[12] http://www.northernireland.gov.uk/index/work-of-the-executive/ministers-and-their-departments.htm
[13] The Report of the STEM Review, Department of Education, Department for Employment and Learning. September 2009.
[14] Success Through STEM, Draft Government Stem Strategy, November 2010, Northern Ireland Executive. http://www.delni.gov.uk/draft_government_stem_strategy-2.pdf

DEPARTMENTAL RESEARCH & DEVELOPMENT

Recommendations

- **Government departmental research and development (R&D) budgets need to be maintained to provide the evidence-base for policy development and the effective delivery of public services. With fewer resources available, government departments need research to ensure that their policies and public services are cost-efficient. Recent cuts in departmental R&D spending should be reversed.**

Government departments must secure the evidence-base for their policies by investing in research to develop new ideas and to evaluate policies already in place. It would be a false economy to cut the work that enables the most efficient and cost-effective policy-making. It is not straightforward to find consistent departmental R&D data – there follows the best that we have available[15]. Given the importance of this spending, it would be helpful if planned and past spending was published more clearly and consistently.

The Scottish Government has an active programme of research into social behavior, the environment, biology and agriculture, health, and the economy[16]. The Scottish Government spent £139m on departmental R&D in 2008-09 (up from £130m in 2004-05), primarily in Rural Affairs and the Environment and in Health and Wellbeing[17].

The Welsh Assembly Government spent £35.5m 2009-10 on R&D in the Department of Health and Social Services (up from £20.9m in 2005-06). The Department for Economy and Transport also spent £9.4m in 2010-11 on departmental R&D (up from £2.4m in 2006-07, in cash terms)[18].

In Northern Ireland, several departments spend on R&D, we have data on the following for 2009-10: Health, Social Services and Public Safety invested £12.5m; Finance and Personnel invested £0.4m; Agriculture and Rural Development invested £7.7m; Environment invested £1.7m; Employment and Learning invested £70.9m (including £54m on the research base); and Education invested £0.3m[19]. Overall spending has increased over the last five years.

SCIENCE & ENGINEERING ADVICE

Recommendations

- **The Northern Ireland Executive should appoint a Chief Scientific Adviser, supported by a Scientific Advisory Committee, to deliver science and engineering advice as well as oversee a STEM advisory system.**
- **Wales and Scotland should maintain and develop their system of scientific advice and include engineering as part of the portfolio of their Chief Scientific Advisors who should have direct access to the relevant Minister and to the head of their national executive.**

Virtually every area of policy-making requires or at least gains from science or engineering advice, or both. Accordingly, the UK Government has a system of scientific advisors in almost every department, as well as a Scientific Advisory Council. There is also an over-arching Government Office for Science led by the Chief Scientific Advisor who overseas the advisory system to deliver the best possible scientific advice for policy development and delivery. It also looks at future issues and supports scientists and engineers in the civil service.

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[15] The CaSE website will be updated with any clarifications: www.sciencecampaign.org.uk.
[16] http://www.scotland.gov.uk/Topics/Research/About
[17] Written answer to a question tabled by Michael Russell, SMP, March 10th, 2011. Source: Government Research and Development Survey, Office for National Statistics.
[18] Members Research Service, National Assembly of Wales, 24th February 2011.
[19] From a series of written questions tabled by Chris Lyttle and other sources.

The Scottish Government has a Chief Scientific Adviser, Professor Anne Glover, and the independent Scottish Science Advisory Council which provides advice and recommendations on science strategy, policy and priorities. In 2009, it produced a thorough analysis of the state of Scotland's Research Base[20]. There are also mechanisms for more specific advice. For example, there is a specific Scientific Adviser for Rural Affairs and the Environment, and a Co-ordinated Agenda for Marine, Environment and Rural Affairs Science (CAMERAS) board, set up to ensure that science supports the Scottish Government goal of increasing sustainable economic growth[21]. The Chief Scientist's Office aims to improve the quality and cost-effectiveness of health services.

In 2009, the Welsh Assembly Government created the post of Chief Scientific Adviser for Wales to provide scientific advice, and to promote STEM and the role of science within the wider knowledge economy. Professor John Harries was appointed to the role in 2010, and the independent Science Advisory Council for Wales was formed soon after that to advise him and help develop the new science policy for Wales. There are other systems for scientific advice, for example, the Chief Medical Officer provides independent professional advice on health and healthcare matters.

The Northern Ireland Executive does not have a Chief Scientific Adviser, although the Departments for Agriculture and Rural Development and of Health, Social Services and Public Safety have science advisers. Apparently, the appointment is being considered and should be confirmed with utmost speed and priority[22].

SCRUTINY & INTEREST

Recommendations

- **Each of the national assemblies should have a specified committee that is responsible for ensuring that current and future policies affecting and affected by science and engineering are duly scrutinized.**

Each of the devolved nations should have a mechanism for scrutinising the governance of science and engineering. This guards against policy areas falling between gaps of oversight and helps policy coherence. It also enables interest and expertise to be built up over time. In the UK parliament, both the House of Commons and the House of Lords have a Science and Technology Committee to scrutinise the relevant Government policies.

None of the devolved nations has a dedicated committee for the scrutiny of science and engineering, so other committees work in these areas. For instance, the Enterprise and Learning Committee of the National Assembly for Wales recently conducted an inquiry on the STEM agenda[23]. In Northern Ireland, the Committees for Education, for Employment and Learning, and for Enterprise, Trade and Investment, Education have been working together to make sure that the recommendations of the 2009 STEM Review are actually implemented.

The number of elected representatives in each of the nations may limit the viability of a dedicated committee (see Table 2); if one is not formed then oversight should be clearly

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[20] International Comparative Performance of Scotland's Research Base (2009) The Scottish Government Office of the Chief Scientific Adviser, evidence ltd
http://www.scotland.gov.uk/Resource/Doc/981/0093770.pdf

[21] http://www.scotland.gov.uk/Topics/Research/About/EBAR/CAMERASsite,
http://www.sasa.gov.uk/

[22] Success Through STEM, Draft Government Stem Strategy, November 2010, Northern Ireland Executive.
http://www.delni.gov.uk/draft_government_stem_strategy-2.pdf

[23] National Assembly for Wales, Enterprise and Learning Committee, The Science, Technology- Engineering and Mathematics (STEM) Agenda 28 January 2011
http://www.assemblywales.org/stem_agenda_report-e.pdf

designated to a specific committee.

Elected representatives can keep up to date on various issues by joining cross party groups. The Scottish Parliament and the National Assembly for Wales both have active cross-party Science and Technology Groups for members to engage with current issues and both include external members[24],[25]. There are moves to set up a similar group in Northern Ireland in June. One way for getting a feel for the level of interest in science and engineering is to see how often they are mentioned in debates and oral or written questions as shown in Table 2. In a climate where only science and engineering can solve our long-term sustainability problems the numbers in the Table are unacceptably low.

Table 2. Number of elected representatives and proportion of debates and oral or written questions that mentioned science or technology (or related issues) over the last four years, in Scotland, Wales and Northern Ireland[26].

	Scotland	Wales	Northern Ireland
Number of representatives	129	60	108
Science/engineering mentions			
(i) in debates	5.0%	3.7%	2.0%
(ii) in questions	0.4%	0.8%	--

SUMMARY

Table 3. Variations in the political priority of science and engineering across the UK governments (in this context, science in its broadest sense)

	UK	**Scotland**	**Wales**	**Northern Ireland**
Science Minster	Yes	No	No	No
Deputy Science Minster	No	No	Yes	No
Chief Science Advisor	Yes	Yes	Yes	No
Science Advisory Committee	Yes	Yes	Yes	No
Departmental Science Advisors	Yes	Yes	Yes	Yes
Dedicated scrutiny committee	Yes	No	No	No

EDUCATION – 5 TO 19 YEARS

Recommendations

- **All nations need to ensure that all students have the STEM skills necessary to thrive in our modern world. It is also essential to increase the number of students studying STEM to a higher level to meet future skills needs.**

Everyone needs to achieve the level of STEM understanding necessary to participate and thrive in the modern world. The UK also needs millions of people with a much higher level of these skills in the workforce especially as its competitive future lies in high-skills sectors.

In England, education is delivered through a range of maintained schools including some that are academically selective. In Wales and Scotland state schools are non-selective. Northern Ireland has non-selective schools or selective (grammar) schools and until 2010 all students sat the transfer test. Students older than 16 can study in Further Education (FE) colleges across the UK as well as schools.

[24] http://www.assemblywales.org/memhome/mem-register-cross-party/cpg-science-technology.htm
[25] http://www.scottish.parliament.uk/msp/crossPartyGroups/groups/cpg-sciTech.htm
[26] Data compiled by CaSE from DeHavilland parliamentary monitoring service, data for Northern Ireland were unavailable when this was published, but this document will be updated on the website when the data are available.

Maintained schools in Wales and Scotland and most of them in England are required to follow a nationally-specified curriculum which includes mathematics and science. There has been a trend towards less prescriptive content and fewer statutory tests, partly in response to concerns over the time spent "teaching to test"[27]. While it is generally felt to be positive that external compulsory science testing has been reduced, and that reducing mathematics testing would be equally beneficial, it is important that they are both still prioritised in the curricula.

Northern Ireland is remarkable in not requiring students to study mathematics or science after 14 years. This change, taken in 2007-08, was part of increasing the subject choice (to 24 subjects, with at least one third general and one third vocational), while compulsory study was limited to some cross-curricular skills and "learning for life and work"[28]. Many of these skills do include STEM (e.g., using mathematics and ICT), but there is no need to directly study science or mathematics, despite the fact that this enhances employability[29].

Because of different curricula, timings of educational stages, and means of assessment across the years and the nations, it is not always easy to make meaningful comparisons. Within each nation and period, though, there are systematic trends, for example with certain ethnic minority groups and children eligible for free school meals under-performing. This document focuses on international comparisons and qualifications achieved rather than earlier performance.

TEACHING

Recommendations

- **All nations should ensure that all primary schools have at least one teacher with relevant graduate level qualifications or additional training in mathematics and science (and collect the data to monitor this provision).**
- **Financial incentives for teacher trainees in shortage subjects (physics, chemistry, mathematics) should be maintained in Wales, England, and Scotland, and should be introduced in Northern Ireland.**
- **All secondary schools should have teachers with specialist knowledge in each of biology, physics and chemistry, and sufficient teachers to meet student needs in mathematics. All nations should have systematic data collection to monitor teacher provision. Targets for training teachers should be set in each shortage subject.**
- **Measures should be taken to incentivise teachers to work in the schools where they are most needed.**

The quality of science teaching relates to teachers' qualifications, with a better match improving standards and achievement[30],[31]. Unfortunately, the UK is experiencing damaging shortages of teachers with a background in physics and mathematics and to a lesser extent chemistry. Much has been done in recent years to try to address these problems, including the provision of financial incentives for secondary teachers in these subjects, additional training routes, and challenging recruitment targets. Reversing the trend to train general rather than specialist science teachers has also been helpful. Unfortunately, there are not consistent data on the make-up of the workforce.

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[27] 'State of the nation' report. Science and Mathematics Education, 5-14, July 2010, The Royal Society
[28] http://www.deni.gov.uk/nisr_20070046_en.pdf
[29] Mathematics the *Lingua Franca* of Career Opportunities and a Strong Economy. The Engineering Policy Group Northern Ireland, 2008. http://www.theiet.org/publicaffairs/panels/nireland/math-statement.cfm?type=pdf
[30]Success in science, Ofsted, June 2008.
[31] Physics in Schools and Colleges: teacher deployment and student outcomes. Smithers & Robinson, The Centre for Education and Employment Research, University of Buckingham, 2005

It's estimated that just 3% of teachers in English primary schools have a specialist degree and teacher training in science and 2% in mathematics[32]. Of English non-selective secondary schools, one in four lacked a physics specialist and one in six lacked a chemist; half of all mathematics lessons were taught by teachers without a mathematics degree[33].

Wales recognises similar problems with its teaching staff. For instance, in 2010 across the 222 secondary schools in Wales, there were 158 registered teachers of physics trained in the subject, compared with 198 physics teachers without training in physics (and 50 whose training subject was unknown)[34].

Across all schools in Northern Ireland, 14% of registered teachers have STEM degrees and less than a quarter of these were working in primary schools; of the less than 200 physics teachers, only about a third were working in Ireland's non-selective schools, that make up about 70% of schools.

In order to teach students post-14 in Scotland, teachers need to have studied their subject for two years at degree level - the Government collects data on subjects taught, rather than qualifications, and they should technically be one and the same at the higher levels. However, survey data suggest that there have been some difficulty in finding enough STEM teachers. For example, in 2005, surveys of Scottish secondary schools found that 3 in every 10 local authority schools reported shortages in chemistry teachers and that 70% of schools had difficulty recruiting mathematics teachers[35],[36]. These shortages would have been felt by teachers teaching outside their discipline in the early years of secondary school. In fact, there is currently a reduction in the size of the teaching workforce in Scotland, so any shortages will become less problematic.

Throughout the UK, primary school teachers are generalists and many lack confidence teaching science. Because so few students study mathematics after 16 or 17 years, most primary school teachers will not have studied mathematics for at least 5 years before they start teacher training. The UK government accepted the recommendation of a recent review of provision in English schools that all primary schools should have a mathematics specialist with deep mathematical subject knowledge, from either graduate studies or appropriate professional development training[37]. This goal should be extended to the devolved nations and also to include science teachers. Students start to develop subject preferences and career aspirations in primary school and it is vital that their teachers are confident and inspiring[38]. It is possible that incentives aimed at improving the recruitment of secondary school science and mathematics teachers have done so at the expense of primary schools – such incentives should operate for all schooling levels.

England and Wales provide additional training grants for mathematics, chemistry and physics teachers (£9,000) and a "golden hello" bonus when teachers fully qualify (£5,000) with smaller support for ICT and other sciences[39]. England has seen rises in

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[32] 'State of the nation' report. Science and Mathematics Education, 5-14, July 2010, The Royal Society
[33] CaSE Working Paper on Education & Skills, February 2010.
http://www.sciencecampaign.org.uk/documents/2010/CaSEEducationSkills.pdf
[34] General Teaching Council for Wales, Annual Statistics Digest 2010
http://www.gtcw.org.uk/gtcw/images/stories/downloads/Annual%20Statistics%20Digest/Annual%20Stats%2010%20(E).pdf
[35] The Future of *Mathematics Teaching* in *Scotland*. Scottish Mathematical Council, 2005.
[36] *Snuffing out the Bunsen Burners,* Scottish Chemistry Teacher Survey May 2005, Royal Society of Chemistry Education Division Scottish Committee, http://www.rsc.org/images/ScottishChemistryTeachersSurveyResults_tcm18-28526.pdf
[37] Independent Review of Mathematics Teaching in Early Years Settings and Primary Schools, Sir Peter Williams, June 2008.
[38] E.g., see Learning to Love Science, report by the University of York and Shell, 2008.
[39] Science, Technology- Engineering and Mathematics (STEM) Agenda, National Assembly for Wales, Enterprise and Learning Committee, 2011.
http://www.assemblywales.org/stem_agenda_report-e.pdf

teacher trainees in shortage subjects, although it has just dropped the "golden hellos"[40], and now sets specific targets within the sciences. Wales increased the percentage of teacher trainees in STEM subjects from 38% in 2004-05 to 45% in 2008-09, although the raw number in physics and mathematics declined, with most increases occurring in biology and general science[41]. Since 2010, it has set a combined teacher trainee target for physics and chemistry[42]. Scotland fully funds the fees for teacher training in physics and mathematics, but does not have additional incentives. Northern Ireland recently announced a range of initiatives and intentions to improve teaching (such as supporting training for qualified teachers and a physics network)[43] - it is planning to ensure that places available for teacher training reflect demand, but the problem lies in filling those places and requires real financial investment.

Teaching in a Different Language

Recommendations

- **Research should be commissioned in Wales and Northern Ireland to determine the impact of requirements to teach science and mathematics in a language other than English.**

To a varying but growing degree, some children in the nations do not receive the entire curriculum in English. In Scotland, 0.4% of students received all or some of their curriculum in Scots Gaelic, most of them at primary schools[44]. There are moves to increase provision of materials to promote STEM in Irish medium schools, of which there are 21 (out of 226) – use of English for at least part of the curriculum is encouraged[45].

The issue is much more prominent in Wales. A quarter of secondary schools in Wales are Welsh-medium for at least half their lessons, but there is a particular problem in finding specialist teachers able to teach science and mathematics in the Welsh language. For instance, fewer than 15% of newly qualified physics teachers are able to teach in Welsh[46]. It is important to assess the impact of teaching STEM in languages other than English, especially given the difficulty of finding specialist teachers with the necessary language skills.

Continuing Professional Development

Recommendations

- **All teachers should be entitled to funded, subject-specific Continuing Professional Development (CPD). Courses should be available for teachers without a background in physics, chemistry and mathematics to develop their skills and confidence and also for primary school backgrounds seeking to develop a specialism in science or mathematics.**

More so than in most subjects, STEM teachers need CPD to keep up to date with advances in the field. It is also a way to address issues with practical training, and is hoped to improve retention. Provision of CPD to teachers is semi-decentralised – with the

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[40] http://media.education.gov.uk/assets/files/pdf/l/letter%20from%20michael%20gove%20to%20tda%20on%20teacher%20training%20places.pdf 31/1/2011

[41] Written evidence to the Enterprise and Learning Committee Inquiry into the STEM agenda from the Welsh Assembly Government

[42] http://www.hefcw.ac.uk/documents/publications/circulars/circulars_2011/W11%2006HE%20Secondary%20Initial%20Teacher%20Training%20Intake%20targets%202011_12%20v2.pdf

[43] Success Through STEM, Draft Government STEM Strategy http://www.delni.gov.uk/draft_government_stem_strategy-2.pdf

[44] Pupils in Scotland, 2009. A National Statistics Publication for Scotland. http://www.scotland.gov.uk/Publications/2009/11/05112711/0

[45] Success Through STEM, Draft Government STEM Strategy http://www.delni.gov.uk/draft_government_stem_strategy-2.pdf

[46] Science, Technology- Engineering and Mathematics (STEM) Agenda - National Assembly for Wales, Enterprise and Learning Committee, January 2011, Estyn written evidence http://www.assemblywales.org/stem_agenda_report-e.pdf

National Science Learning Centre, located in York, having a UK-wide remit, and offering financial support for teachers. The devolved nations themselves provide many options, although it is not easy to relate data on take-up to individual teachers and schools. In these financial times, long-term funding is at risk, although it seems that Scotland and England are fairly secure. The introduction of the Scottish *Curriculum for Excellence* may require additional CPD.

There are now several schemes for teachers of physics, chemistry and mathematics without a background in these subjects, some of these are available across the UK, but many are focused on England. These courses have the potential to break the cycle of too few specialist teachers to inspire students to go on to further study to create a large enough graduate pool to recruit future teachers from. The subject biases described in the following sections, with male students preferring physics and mathematics and female students favouring biology, are in-line with the proportions of teachers in these subjects[47]. Access to role models, including teachers, and biases in the classroom, may affect the genders differently leading to these trends. Some of these issues could be addressed through CPD.

SECONDARY PERFORMANCE

Recommendations

- **Wales and Northern Ireland must ensure that all schools give students the opportunity to study the three separate sciences at GCSE level and that uptake of STEM subjects improves post-16.**
- **Northern Ireland needs to urgently revise its curriculum to require all students to study mathematics and science up until the age of 16.**
- **While Scottish students show a greater interest in studying STEM as compared with the rest of the UK, there must be no complacency, with new curriculum and qualifications and a possible downward trend in international comparisons.**

In England, Wales and Northern Ireland, most students progressing to HE study GCSEs up until 16 and then take AS levels followed by A levels. There is also a wide range of vocational qualifications, often delivered in FE colleges, many of which can lead to HE. Across the UK, post-16 STEM subjects tend to be physics, chemistry, biology, mathematics, and further mathematics.

Although students that studied two combined science GCSEs can progress to study science A levels, students that study three separate biology, physics and chemistry GCSEs (“triple science”) are more likely to study and do well later at science A levels[48]. It is estimated that possibly over 40% of schools in Wales do not offer the separate sciences at GCSE (compared with 30% in England) and there is no statutory requirement regarding access to studying triple science in other nearby schools or colleges[49].

As noted earlier, recent changes in Northern Ireland mean that students no longer have to study mathematics or science at GCSE (or equivalent). Thus students no longer need to study a balance of science subjects and can take one, two or three of biology, physics and chemistry GCSEs. There is already a worrying impact upon results, with entries into single science GCSE increasing, a decrease in double science, and an increase in biology and to a lesser extent, chemistry and physics GSCEs[50]. This pattern needs to be carefully

[47] 'State of the nation' report - the UK's science and mathematics teaching workforce December 2007
[48] Educating the next generation of scientists, 2010, National Audit Office report.
[49] Science, Technology- Engineering and Mathematics (STEM) Agenda - National Assembly for Wales, Enterprise and Learning Committee, January 2011, Estyn written evidence http://www.assemblywales.org/stem_agenda_report-e.pdf
[50] The Report of the STEM Review, Department of Education, Department for Employment and Learning. September 2009. http://www.delni.gov.uk/es/report_of_the_stem_review.pdf

monitored and there is an urgent need to introduce a requirement for all students to study science and mathematics qualifications post-14.

The Scottish education system is distinct. Most students take intermediate and standard qualifications prior to 16. These will be replaced under the *Curriculum for Excellence*, with new National 4 and 5 qualifications. It is important that these new qualifications do not lead to lower take-up or a narrowing of STEM subjects, given the strength that has come from the breadth of Scottish science education. Most students take Highers and Advanced Highers post-16. It is possible but not usual to progress to HE after taking Highers (at age 17), with many Scottish degrees lasting four years. Alternatively, students can study Advanced Highers at school, sometimes enabling them to skip the first year of HE[51]. Highers are offered in the core sciences, human biology, and broader applied science like environmental science or biotechnology. The Scottish Baccalaureate in Science, introduced in 2009, comprises two science courses, mathematics, and an interdisciplinary project (at least two of the courses to be Advanced Higher level).

International Analyses

The OECD Programme for International Student Assessment (PISA) publishes international comparisons of the knowledge and skills of 15-year-olds in reading, mathematics and science every three years. The mean was set at 500 in 2003, and reached 496 for mathematics in 2009 and 501 in science across all nations. Table 4 shows the PISA data from 2009 by UK nation[52]. The overall UK performance of 492 in mathematics did not significantly differ from average, although inspection of Table 4 suggests that this was unlikely to be true of Wales. The highest performing countries had averages over 550 (Shanghai and Hong Kong-China); Finland scored 541, Germany - 513, and France - 497. The UK's score of 514 was above average in science, but this could not have been true of Wales[53]. The highest performing countries were again above 550 (Shanghai and Hong Kong-China); Finland scored 554, Germany - 520, and France - 498.

Table 4. Mathematics and science scores from PISA 2009 shown by gender and nation (standard deviation in parentheses).

	England	**Scotland**	**Wales**	**Northern Ireland**
Mathematics	493 (87)	499 (93)	472 (82)	492 (89)
Mathematics- Boys	504	506	482	501
Mathematics – Girls	483	492	462	484
Science	515 (99)	514 (96)	496 (95)	511 (103)
Science – Boys	520	519	500	514
Science – Girls	510	510	491	509

Table 4 also shows variation with gender – across all countries in the study, boys scored 12 points higher than girls in mathematics with much smaller and less significant differences in science. In the UK, boys significantly out-perform girls in every nation in mathematics, and in science in Wales.

[51]Chapter 2 of the following provides a helpful overview: Preparing for the transfer from school and college science and mathematics education to UK STEM higher education. A 'state of the nation' report. The Royal Society, February 2011
http://royalsociety.org/State-Nation-Increasing-Size-Pool/

[52] PISA 2009 Results: What Students Know and Can Do: Student Performance in Reading, Mathematics and Science (Volume I). http://www.oecd.org/document/53/0,3746,en_32252351_46584327_46584821_1_1_1_1,00.html

[53] PISA analyses statistically compared overall UK results with other nations, but not those of England and the devolved nations, so these inferences are drawn from inspection of the data.
http://www.oecd.org/document/53/0,3746,en_32252351_46584327_46584821_1_1_1_1,00.html

There were no significant differences in science scores between 2006 and 2009 in any of the nations, although Scottish PISA scores significantly dropped (25 points) in mathematics from 2003 (unfortunately the other nations did not have comparable data for 2003). This trend is consistent with Scotland's performance in TIMMS over the years[54]. The performance of Scotland's 13 year olds declined in mathematics and science between 1995 and 2007, and the 9 year olds' science scores also declined.

Plans for Improvement

Performance in international comparisons and in qualifications gained suggest that Wales is relatively weak in science and mathematics schooling. Although it is tempting to think that this may reflect difficulties because of its size or GDP, PISA comparisons show these factors are not necessarily key predictors of the quality of science and mathematics education.

On a positive note, Wales has recently become much more proactive in science policy areas, including in education. For instance, in April 2010, Welsh Ministers gave the go-ahead for the National Science Academy in Wales to promote the take-up of STEM, under the strategic direction of the Chief Scientific Adviser for Wales and with a £2m budget.

The Welsh Assembly Government has commissioned a pilot of a Further Mathematics Support Programme (which proved very effective in England) and there is also an initiative entitled 'More Maths Grads'. The STEM Cymru project, led by the Engineering Education Scheme in Wales, aims to encourage 12 to 19-year olds to study STEM and participate in industry-linked technological and engineering activities. A recent report by the Enterprise and Learning committee of the National Assembly for Wales made a series of recommendations to improve STEM education[55].

The Northern Ireland Executive initiated a STEM review in 2007, publishing a STEM Report in September 2009, which recognised that STEM holds the key to the future success of the Northern Ireland economy[56]. Particular goals for 2011 include increasing the numbers studying STEM post-16 by 5%. Various committees kept up the pressure on the Executive to implement the recommendations of the report, but it was not until late 2010, that a draft STEM Strategy consultation was launched[57]. Progress is being made, but too slowly, and recommendations need to be backed up by the necessary financial investments.

While the situation may be better in Scotland, there is no room for complacency with a new curriculum and possibly falling standards in international comparisons. The Institute of Physics recommends investing in a "stimulating physics" programme, similar to those in Wales and England[58]. A new Action Plan is being developed by a steering group chaired by the Chief Scientific Advisor, and should address some of these issues.

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[54] Trends in International Mathematics and Science Study: primarily a USA based comparison of the extent to which students have mastered a useful curriculum after 4 years of schooling and at least 9.5 years old, and after 8 years of schooling and at least 13.5 years old
http://nces.ed.gov/pubs2009/2009001.pdf

[55] Science, Technology- Engineering and Mathematics (STEM) Agenda - National Assembly for Wales, Enterprise and Learning Committee, January 2011. http://www.assemblywales.org/stem_agenda_report-e.pdf

[56] http://www.delni.gov.uk/es/report_of_the_stem_review.pdf
The Report of the STEM Review, Department of Education, Department for Employment and Learning.

[57] Success through STEM. Draft Government STEM strategy. http://www.deni.gov.uk/2657p_stem_booklet_v9.pdf

[58] Physics an investment for the future. The Institute of Physics manifesto for the Scottish election of 2011. http://www.iopscotland.org/news/11/file_48530.pdf

Accessing Higher Education

Recommendations

- **The number of students studying STEM at higher level is dependent on the supply of potential students from secondary education. All of the UK nations are weak in international comparisons in this regard, although this was less true of Scotland. All students should have access to the necessary courses, particularly physics and mathematics A level, and be given good career advice. An even more progressive approach could increase the breadth of post-16 study or introduce compulsory study (e.g., of mathematics post-16).**

Recent national analyses examined the size of the pool of students who could potentially study STEM above 18 years[59]. Students in all nations favoured the biological over the physical sciences after 16 years of age. Students taking core science in Scotland also tended to take mathematics and there was an emerging trend for this to be true in the rest of the UK also.

The latest 2010 results showed an increase in the percentage of A levels that were taken in each of mathematics, further mathematics, biology, chemistry, and physics across the UK (not including Scotland)[60]. It is not clear how this relates to individual students – so it could be that fewer students are each taking more science A levels.

Table 5 illustrates the percentage of the student cohort that was taking core science at pre-University level or science and/or mathematics. England and Wales have the lowest rates of participation in science and/or mathematics relative to Northern Ireland and especially Scotland (bearing in mind that these are Highers in Scotland taken at 17, not Advanced Highers). The stronger performance of Scottish students probably reflects their typically broader range of study at Highers; unfortunately, the additional breadth of study available to most students in the rest of the UK at AS level does not appear to benefit them in the same. Worryingly, the proportion of students taking core sciences appears stable in Scotland and Northern Ireland, but is declining in England and Wales, widening the gap between these and the other nations.

Table 5. The percentage of the post-16 student cohort that was studying (i) core science at pre-university level or (ii) studying mathematics with or without science, shown by nation for 2005 and 2009.[61]

	Year	England	Scotland	Wales	Northern Ireland
% cohort taking core science	**2005**	28.9	49.4	32.2	37.6
	2009	27.7	49.7	26.6	37.4
% cohort taking core science and/or maths	**2005**	35.8	60.7	38.2	43.1
	2009	37.1	60.1	34.1	44.3

Since the 1990s, there had been ongoing problems with the falling popularity of physics. More recently, the number of physics entries has been rising, by 6% in England and

[59] Preparing for the transfer from school and college science and mathematics education to UK STEM higher education. A 'state of the nation' report. The Royal Society, February 2011 http://royalsociety.org/State-Nation-Increasing-Size-Pool/

[60] Fantastic A-level News for Sciences and Maths. CaSE Press Release, 19/08/2010

[61] Preparing for the transfer from school and college science and mathematics education to UK STEM higher education. A 'state of the nation' report. The Royal Society, February 2011, Table 3.1 & 3.2. http://royalsociety.org/State-Nation-Increasing-Size-Pool/

Wales, 4% in Scotland, and a negligible amount in Northern Ireland between 2005 and 2009. However, this masks a very worrying trend. The *proportions* of institutions entering students into physics decreased by 2% in each of the nations over this period, falling to 90% in Scotland, 88% in Wales, 82% in England, and just 57% in Northern Ireland.

A similar pattern emerges in mathematics – its A level and particularly further mathematics A level, experienced a dramatic period of decline. Between 2005 and 2009, however, entries increased by 40% in England, 4% in Scotland, 46% in Wales, and 22% in Northern Ireland. Just as with physics, the proportion of institutions entering candidates into mathematics fell to 93% in Scotland, 92% in England, 95% in Wales, and 67% in Northern Ireland.

It has been argued that the decline in institutions offering physics and mathematics reflects the chronic shortage of specialist teachers in these areas (see earlier). Note how these declines occurred in Scotland as well as the rest of the UK, suggesting that there may indeed be issues with teacher provision there. In addition, FE colleges may financially struggle to offer physics to small class sizes.

An international comparison of 24 countries found that England, Wales and Northern Ireland were the only ones in which fewer than 20% of students take mathematics at upper secondary (typically post-16) level (not counting retakes of GCSEs etc.). The figure is nearer to half for Scotland, but still below average. Three quarters of the countries surveyed, but none of those in the UK, had compulsory mathematics for at least some students[62].

Numbers of students studying STEM are complicated by interactions with gender and school type – for instance in Northern Ireland every grammar school entered a student into physics A level, compared with less than a third of non-selective schools. Furthermore, 67 of 226 schools in Northern Ireland are selective, and 47 of them produce 70% of all STEM A levels[63]. Northern Ireland also greatest difference between the low- and high- performers in science in PISA 2006 and the spread of attainment was also greater that that of the UK in mathematics. In all the nations for post-16 study, female students showed a stronger preference for biological sciences, but males were more likely to study physics and mathematics.

FURTHER & HIGHER EDUCATION

The future STEM workforce will be vital to sustain the economic recovery and the demand for STEM skills is expected to grow faster than that in other sectors. Over nine out of ten UK businesses employ people with STEM skills, but two thirds of all employers report difficulty recruiting enough of these workers, particularly at the graduate and pos tgraduate level[64]. Most STEM workers have at least FE and HE qualifications. It can be hard to manage the match of skills and demand at local levels and this becomes more important the smaller the nation; migration also affects the flow.

Scotland has 14 universities, 5 HE institutions and 43 FE colleges. Of the 29 UK universities ranked in the top 200 in the world, 5 are Scottish and the rest are English[65].

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[62] Is the UK an outlier? An international comparison of upper secondary mathematics education. The Nuffield Foundation, November 2010. http://www.nuffieldfoundation.org/sites/default/files/files/Is%20the%20UK%20an%20Outlier_Nuffield%20Foundation_v_FINAL.pdf

[63] The Report of the STEM Review, Department of Education, Department for Employment and Learning. September 2009. http://www.delni.gov.uk/es/report_of_the_stem_review.pdf

[64] Emerging stronger: the value of education and skills in turbulent times. CBI/Nord Anglia, 2009.

[65] THE World rankings 2010/11: http://www.timeshighereducation.co.uk/world-university-rankings/2010-2011/top-200.html#score_OS|sort_rank|reverse_false

Wales has 11 HE institutions, with an additional 5 FE institutions engage in some directly funded HE delivery and a higher number deliver HE programmes through collaborative working. There are plans to rationalize provision to no more than 6 universities in 2013. HE in Northern Ireland consists of Queens University, Belfast and the University of Ulster, as well as Stranmillis University College and St Mary's University College and there are 6 FE colleges. All of the UK nations also have a branch of the Open University.

VOCATIONAL TRAINING

Recommendations

- **Northern Ireland and Wales need to make sure that they are providing enough apprenticeships and offer more support for small businesses to participate in vocational training schemes.**

National Vocational Qualifications (NVQs) and Apprenticeships in England, Wales and Northern Ireland, along with Scottish Vocational Qualifications (SVQs), provide work-based learning in a range of industry and employment sectors, including engineering. Foundation degrees also offer vocational education at HE level, equivalent to the first two years of an Honours course. Vocational qualifications are currently subject to a review by the UK Government and in Northern Ireland, which may update the range of qualifications available; it could certainly do with some rationalisation.

Scotland has rapidly increased its provision of apprenticeships, reaching around 20,000 in 2009-10[66]. Participants have good progression, with about 70% of leavers gaining a qualification, job, or moving onto additional training. In order to translate this effectively into increased productivity, it is important that there is a good match between placements and current and future skills needs. There has been an impressive shift to having more women joining the programme.

The recent strategic skills and growth strategies coming from Wales, highlight the importance of flexible, responsive and high-quality apprenticeships[67]. Some programmes are in the pilot stages and the successful ones should be implemented with the necessary number of placements.

Northern Ireland is now emphasising the importance of apprenticeships, and had set out a target for 10,000 apprenticeships by 2010. This is now an all age provision and the Government recognises the need to improve completion rates[68]. Business representatives (the CBI and Federation of Small Businesses) have urged the Government to set better targets and provide more support (including funding) for the programme[69]. Northern Ireland may be having difficulty with placements because of its large proportion of small businesses – with many struggling to find the time and money to participate.

HIGHER EDUCATION IN FLUX

All of the devolved nations are reviewing their HE & FE provision, aiming to implement changes for 2012-13. The Browne review and the UK Government's response to it are overhauling HE funding in England. There is much uncertainty still about the actual mechanisms and the impact they will have on the numbers of students and levels of

[66] *Towards Ambition 2020: skills, jobs, growth for Scotland*, UK Commission for Employment and Skills, February 2010. http://www.ukces.org.uk/publications-and-resources/browse-by-title/towards-ambition-2020-skills,-jobs,-growth-for-scotland

[67] E.g., Investing in Skills consultation, January 2010. http://wales.gov.uk/docs/dcells/consultation/100310investingskillsen.pdf

[68] The updated strategy - *Success through Skills 2: The Skills Strategy for Northern Ireland*, June 2010, http://www.delni.gov.uk/success_through_skills_2_-_the_skills_strategy_for_northern_ireland-consultation_document.pdf

[69] E.g., http://www.cbi.org.uk/Pdf/20100930-CBI-response-to-Success-through-skills-Strategy-for-NI.pdf

funding per student and entering the system as a whole[70]. As the new system will be shaped by market forces it may take years to stabilise.

The Scottish Parliament is currently engaged in a far-reaching consultative consideration of the future shape of HE – how it is organised and accessed as well as funding. It is considering much more flexibility in the way in which courses are taken and credited, with greater recognition of partial degrees. There is also some duplication between the sixth year of school and first year of university, and ways to eliminate this redundancy are being explored. The consultation should finish in April, enabling party responses to be debated as part of the election campaigns.

The Welsh consultation on HE closed in February and Wales looks set to follow the same general changes as England, with a rise in the cap of the tuition fee and better access to funding for part-time students[71]. In order for universities to charge higher fees, they will probably have to explain how they will support the goals laid out in the recent HE strategy, *For our Future,* which stressed the importance of STEM subjects and supporting innovation[72].

Northern Ireland is also consulting on its HE Strategy for the next decade, ending in April 2011. The strategy will recommend how the sector can maximise its economic, social and cultural contribution, considering research, fair access and teaching quality[73].

Each nation's system will be shaped by changes in those immediately around it. And in our increasingly globalised world, with many students travelling overseas, it is important to consider the world stage. Many overseas universities are offering courses in English and promoting themselves to UK students. Past funding and performance are presented in the following sections, but they may be a less reliable indicator than usual of how things will be in the future. Also bear in mind that small changes in course uptake for smaller courses can create large fluctuations year to year.

Higher Education – Funding

Recommendations

- **Tertiary education needs to be funded in a sustainable and internationally competitive way, without risking departmental or course closures in STEM subjects. If a nation decides not to charge fees, then the relative shortage of income for teaching must be made-up from elsewhere.**
- **If variable student fees are introduced for different courses they must not discourage students from studying the STEM subjects that are vital to the UK's future.**
- **Groups of students already under-represented must not be systematically less able or inclined to study STEM subjects because of new funding arrangements.**

Universities receive public funding for teaching for each student in a block grant (that takes into account many factors) from each of the national Funding Councils or directly from the Department for Employment and Learning in Northern Ireland (DELNI). This element of public funding is either being cut or at risk of being cut, sometimes dramatically, in each of the nations.

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[70] Securing Sustainable Higher Education Browne Report, The Independent Review of Higher Education Funding and Student Finance, October 2010. http://www.bis.gov.uk/assets/biscore/corporate/docs/s/10-1208-securing-sustainable-higher-education-browne-report.pdf

[71] Higher education funding and student finance 2012/13, Consultation Document, Welsh Assembly Government, January http://wales.gov.uk/docs/dcells/publications/110114studenten.pdf

[72] *For Our Future - The 21st Century Higher Education Strategy and Plan for Wales,* Welsh Assembly Government*, November 2009, http://wales.gov.uk/docs/dcells/publications/091214hestrategyen.pdf*

[73] Consultation document on the development of a Higher Education Strategy for Northern Ireland, Department for Employment and Learning, January 2011. http://www.delni.gov.uk/higher-education-strategy.pdf

In 2007, the UK as a whole invested 1.3% of GDP in higher (tertiary) education, 0.7% of GDP was from the public purse[74]. The European average was also 1.3% of GDP, but with 1.1% coming from public sources, while the OECD average was 1.5% of GDP with 1% from public funds. Thus the UK is not investing heavily in higher education compared to other countries, and makes a smaller public contribution.

The various funding council websites report that, in 2010-11, the teaching grant totaled £4,782m in England, £660m in Scotland, £149m in Northern Ireland, and £286m in Wales. Of course, a different proportion of people access higher education in each of the nations.

The newly formed Learned Society of Wales has highlighted the consistent funding shortfall of Welsh students and raised serious concerns over future funding plans[75]. In 2000-01, a Welsh student received £20 less public funding compared with an English student and £780 less than a Scottish student but in 2008-09 a Welsh student received £900 less funding than an English student and £2276 less than a Scottish student.

Universities also charge tuition fees directly to the students – there are loans available to cover these fees from student finance companies in each student's home-domicile and bursaries available to offset them. Universities in England and Northern Ireland charge a tuition fee of £3,000 to all UK students. Scottish universities do not charge Scottish students, but charge students from other UK nations less than £2,000 a year. Welsh universities charge Welsh students just over £1,000 a year, and UK students from other nations, £3000 a year.

Table 6. Percentage of HE students studying in their home-domiciled nation, and percentage of students in each nation that come from EU and Non-EU countries, 2009-10 (excluding The Open University)[76]

	Undergraduate			**Postgraduate**		
	% home-domiciled	**% EU**	**% non-EU**	**% home-domiciled**	**% EU**	**% non-EU**
England	97	3.7	6.6	96	8.0	26.9
Scotland	93	6.7	6.0	86	8.9	27.8
Wales	79	5.1	6.9	68	6.1	36.6
Northern Ireland	76	5.2	1.5	71	19.2	9.2

The variation of student numbers in the different nations is undoubtedly affected by the different fee regimes. The number of first year undergraduates studying in their home-domiciled nation in 2009-10 varied as shown in Table 6. Like other areas of the UK, the total number of full-time students is capped in Northern Ireland, but this cap is at a relatively low level. Unfortunately, about a quarter of STEM students studying abroad do not return to work in Northern Ireland after graduating, and the Government is developing scholarships to try better to retain them[77]. The Executive has set a goal to increase the proportion gaining graduate or postgraduate qualifications in STEM by 25% - 30% by 2020[78].

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[74] Education at a Glance, 2010, OECD indicators, Table B2.4. http://www.oecd.org/dataoecd/45/39/45926093.pdf
[75] Comments Of The Council Of The Learned Society Of Wales On The Welsh Assembly Government's Support For The Universities In Wales (1 March 2011)
[76] Higher Education Student Enrolments and Qualifications Obtained at Higher Education Institutions in the United Kingdom for the Academic Year 2009/10, Tables 1a & Table 4.
[77] http://www.delni.gov.uk/es/report_of_the_stem_review.pdf
The Report of the STEM Review, Department of Education, Department for Employment and Learning.
[78] Success Through STEM, Draft Government Stem Strategy, November 2010, Northern Ireland Executive.

It is possible that tuition fees will rise dramatically for many students (except in Scotland), perhaps up to £9,000, and universities have the freedom to vary them across subjects. It seems inevitable that variable subject fees will affect student choice of what to study, and must not work against the need to increase uptake of strategic subjects. If universities use fees to reflect costs, then the high-cost STEM subjects may be charged at higher rates. This may reduce overall numbers of STEM students.

Furthermore, students from certain ethnic minorities and from socially-disadvantaged backgrounds are already under-represented in STEM – higher fees may accentuate these problems[79]. It is vitally important that these issues are considered in policy development and when fees are set, that data are carefully monitored, with compensating actions ready if necessary.

An interesting model is Northern Ireland's universities that already offer certain scholarships targeted for STEM subjects[80]. In addition, the University of Ulster operates a highly successful "Step-Up" Programme that delivers tutoring, summer schools, induction into HE, and mentoring to socially-disadvantaged STEM students with the aim of increasing the proportion progressing to and succeeding in HE.

Scotland stands alone in seeming unlikely to introduce fees. It is essential that the relative loss of teaching income that will occur if it does not follow the rest of the UK nations, estimated to be between about £100m and £200m, is made up some other way.

HE & FE Performance

Recommendations

- **All of the nations must ensure that enough STEM graduates and postgraduates are trained and also improve numbers of people studying STEM from groups that are currently under-represented.**
- **Increasing the number of international students could benefit each of the devolved nations from providing a critical mass (for otherwise under-subscribed courses), a breadth of perspectives, and significant financial support. Specific strategies should be developed to promote universities more effectively overseas.**

Table 7 shows the distribution of HE qualifications awarded in 2009-10. Over all subjects, Scotland and Wales have a rate of undergraduate and graduate degrees slightly above their population share, but a lower rate of other qualifications. Northern Ireland is lower than would be expected.

The proportion of qualifications within each nation that were in STEM subjects (using quite a broad definition) varies quite markedly – making up about half of those at undergraduate level in Scotland and Northern Ireland, compared with nearer 40% in Wales and England. These differences are to some extent sustained at post-graduate level with an overall decline in the percentage of STEM qualifications at postgraduate level. The first degree data are illustrated in Figure 1.

Qualifications in the core STEM subjects (and excluding medicine) make up just 24-29% of undergraduate degrees and 14-24% of postgraduate degrees (and 32-29% of other qualifications).

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http://www.delni.gov.uk/draft_government_stem_strategy-2.pdf
[79] CaSE Working Paper on Education & Skills, February 2010. http://www.sciencecampaign.org.uk/documents/2010/CaSEEducationSkills.pdf
[80] The Report of the STEM Review, Department of Education, Department for Employment and Learning. September 2009.

Figure 1. Percentage of post-16 students taking at least one STEM subject and percentage of undergraduate degrees that were broad STEM or core STEM, shown by nation for 2009[81]

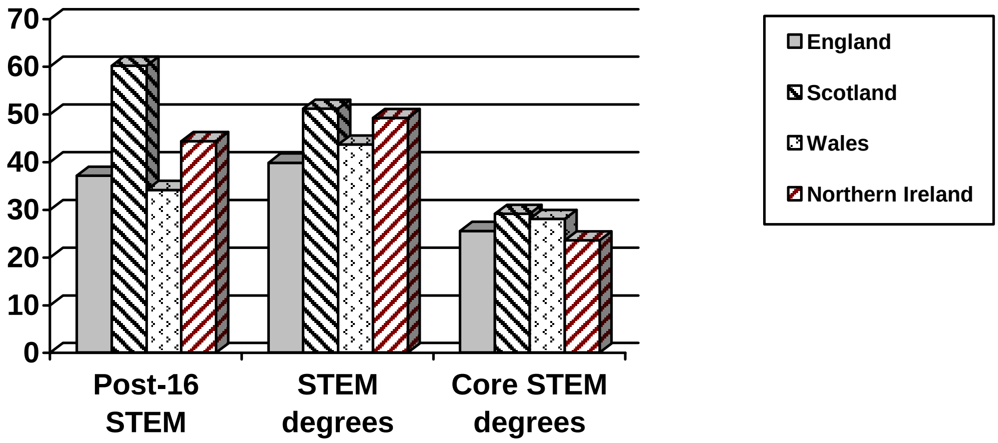

Table 7. Undergraduate, postgraduates and other HE qualifications awarded in 2009-10, shown by UK nation for number in all subjects, percentage of UK for total and the percentage of all subjects that were broad STEM or core STEM. Also shown are percentage of all, STEM or core STEM qualifications that were awarded to women[82]

	England			Scotland			Wales			Northern Ireland		
	PG	UG	Other	PG	UG	Other	PG	UG	Other	PG	UG	Other
All Subjects (000s)	188	292	126	21	31	6	13	19	6	4	8	2
% UK total	83.1	83.3	89.9	9.3	8.8	4.5	5.8	5.5	4.0	1.8	2.3	1.6
% subjects that were STEM	34.3	39.8	44.7	36.5	51.1	53.2	29.0	43.6	41.9	39.6	49.2	44.1
% subjects that were Core STEM	21.6	25.5	33.4	23.5	29.1	34.5	14.1	28.0	31.2	17.9	23.5	38.9
% all subjects that were female	53.4	56.3	63.0	53.1	57.7	53.3	47.3	56.5	51.9	59.5	61.0	70.7
% STEM that were female	44.5	49.3	61.2	42.8	53.5	46.5	48.0	51.4	35.3	57.1	55.7	82.2
% core STEM that were female	35.4	40.5	15.7	33.9	39.9	27.4	33.7	40.0	19.9	46.6	43.2	4.6

[81]Higher Education Student Enrolments and Qualifications Obtained at Higher Education Institutions in the United Kingdom for the Academic Year 2009/10, Table 7a (percentages were calculated). Core STEM subjects: biological sciences, physical sciences, agriculture, mathematical sciences, computer science, engineering & technology. All STEM (as defined by HESA) also includes: medicine & dentistry, subjects allied to medicine, veterinary science, architecture, building & planning.

[82]Higher Education Student Enrolments and Qualifications Obtained at Higher Education Institutions in the United Kingdom for the Academic Year 2009/10, Table 7a (this includes students from all countries, percentages were calculated). Other includes Foundation degrees, HNDs, National qualifications framework levels 4 and 5, etc., see HESA for full list. See above footnote for more detail.

Table 7 also shows the impact of gender. Looking down each of the columns in the lower half of Table 7, shows that women gain a good share of all qualifications, often over 50%, but a smaller share of STEM qualifications (in the broadest sense), and a much lower share of core STEM qualifications.

The gender distribution varies markedly with specific STEM subject, with women heavily over-represented in subjects allied to medicine but under-represented in computing, engineering and mathematics. Notably, the profile of gender distribution across the subjects varies across the nations. For example, women secured 14.6% of postgraduate degrees in engineering in Wales, compared with 25.6% in Northern Ireland.

Across the UK, international students play an important role in opening up universities to global networks and collaborations, training students who stay on as part of the UK workforce, or take their experience and contacts on to benefit other nations (and build up their ties with the UK). International students also support UK universities and the wider economy through fee income and living expenses. It is essential that the Westminster Government does not reduce these benefits by introducing overly restrictive visa regulations.

Universities in England and Northern Ireland charge EU students a tuition fee of £3000, Welsh universities charge EU students just over £1000 a year, and Scottish universities do not charge EU students (although it may seek to do so in the future). All UK universities charge non-EU students much higher fees. Table 6 shows the variation in proportion of HE students that are from EU and non-EU countries at undergraduate and graduate level. Non-EU students spent £1.9bn across the UK in 2008/09, £127.9m in Scotland (6.7% of the UK total), £51.4m (2.7%) in Wales and £11.7m (0.6%) in Northern Ireland[83].

The Scottish government is planning to build on its internationalism by promoting Scottish universities under a single banner, hoping to attract more students and having more Scottish universities setting up overseas campuses.

RESEARCH BASE

Recommendations

- **The research base can magnify public investment by drawing in additional skills from overseas and funds from other sources (e.g., research charities, private companies and EU funding). It is vital that each of the nations, and especially Wales and Northern Ireland, delivers strong financial support to its research base and develops its critical mass in order to be competitive for external funding.**
- **Scotland has a strong research base, both in terms of its performance and in its ability to attract additional funding from all sources. Wales and Northern Ireland have weaker performance and do not secure their share of external funding. Northern Ireland particularly struggles, probably because of the smaller scale of its research base. Policies should seek to build up research through collaboration possibly with overseas researchers or businesses.**

Research carried out in universities and research institutes is referred to as the “research base”. It is heavily dependent on education policies to deliver skilled researchers and also on public funding to enable a core mass of research to be performed and infrastructure, maintained. When policies deliver well in both these areas, then the research base can

[83] Consultation document on the development of a Higher Education Strategy for Northern Ireland, Department for Employment and Learning, January 2011. http://www.delni.gov.uk/higher-education-strategy.pdf

magnify investments by drawing in additional skills from overseas and funds from other sources (e.g., research charities, UK Research Councils, private companies and EU funding). On the other hand, insufficient public funding for a solid base of infrastructure and skills makes it hard to compete for external funding. Thus even a relatively small disadvantage in locally delivered public funding can put a nation at a much larger disadvantage in overall research funding levels.

The numbers of publications and citations (in which those publications are referenced) are measures of productivity of the research base, while citations per paper can indicate impact and quality. The UK performs well on these measures, especially Scotland and England (see Table 8)[84].

Table 8. The numbers of publications, citations, and citations per paper (2000-2010) and increase in each of these numbers from 2000-2004 to 2006-2010, overall rank for citation/paper, and citations per thousand of population, shown by UK nation (percentage of UK total in parentheses).

	England	Scotland	Wales	Northern Ireland
Papers	679,394 (81.5%)	106,160 (12.7%)	35,707 (4.3%)	17,464 (2.1%)
% increase in papers	7.7	6.8	13.2	7.4
Citations	9,979,737 (81.5%)	1,622,708 (13.2%)	434,969 (3.6%)	201,859 (1.6%)
% increase in citations	42	41	59	58
Citation/paper	14.7	15.3	12.2	11.6
% increase in citation rate	32	32	41	47
Rank for citation/paper	6	5	16	19

Table 8 also shows the increases in outputs from 2000-2004 to 2006-2010.[85] All of the nations increased their output of papers, by 7-13%, with much higher increases in citations and in citation rate per paper – illustrating an overall trend for papers to have more citations. Northern Ireland, while coming from a relatively low base of paper publication, increased its publication rate by 7% but has increased its citation rate per paper by an impressive 47%. Scotland's relative performance is noticeably above those of the other nations.

The different nations have different areas of strength. Scotland has a range of citation rates, with good impact in agriculture, biological sciences, physics and space science, and relative weakness in chemistry, social sciences, geosciences, and engineering.

Wales has a large range of impacts but is noticeably high impact in plant and animal science and also does well in computer sciences, and has high productivity in social sciences, psychology and psychiatry. Northern Ireland also has a large range in its productivity and impact across disciplines; it is high impact in chemistry and geoscience, but weak in mathematics.[86]

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[84] ScienceWatch.com "Top 20" using data from ISI Web of Knowledge, Essential Science indicators, Thomson scientific journals. Listings based on publications from January 1, 2000-October 31, 2010 and nations with at least 10,000 papers in Thomson Reuters-indexed journals.

[85] Calculated from the ISI Web of Knowledge, Essential Science indicators, Thomson scientific journals, January 1, 2000-October 31, 2010

[86] ISI Web of Knowledge, Essential Science indicators, Thomson scientific journals, January 1, 2000-October 31, 2010

FUNDING THE RESEARCH BASE

Public funding for the base of research in universities and research institutes is delivered by a dual support system through the UK-wide Research Council and the devolved Funding Councils or DELNI, with additional funding drawn in from other sources.

Research Council Funding

The UK Government sets a Science Budget that allocates money to seven different Research Councils for research projects, studentships, and national research facilities – the different UK nations compete for this money across the UK. In the October 2010 Spending review, the UK government froze resource funding for the Research Councils in cash terms – this delivers project funding for grants on the basis of peer review and is highly competitive. In December, it announced that the capital funding delivered through the Research Councils that maintains infrastructure as well as new builds, would be halved[87].

The Research Council also delivers capital funding to universities in proportion to their share of the competitively won grants. It is intended to ensure that the "full economic costs" of research are covered - helping institutions fund the physical infrastructure required for high quality research (e.g., buildings and equipment for research, libraries, IT infrastructure). Thus differences in success of winning Research Council grants are scaled up when this capital element is taken into account.

Table 9. Spending from UK Research Council and on Research Institutes (including BIS spending on the Public Sector Research Exploitation programme) in the nations from 2005-6 to 2009-10 (% of UK total shown in parentheses)[88], [89]

		England	Scotland	Wales	Northern Ireland
Research council Spending (£m)	2005-06	1,648.5 (85.3%)	222.3 (11.5%)	51.3 (2.7%)	11.6 (0.6%)
	2006-07	1,798.5 (85.6%)	230.7 (11.0%)	56 (2.7%)	14.8 (0.7%)
	2007-08	2,108.8 (85.6%)	273.8 (11.1%)	64.5 (2.6%)	16.3 (0.7%)
	2008-09	2,286 (85.2%)	311 (11.6%)	67.3 (2.5%)	20 (0.8%)
	2009-10	2,489.9 (84.7%)	347.5 (11.8%)	78.1 (2.7%)	24 (0.8%)
Spending on research institutes (£m)	2005-06	552.6 (90.2%)	49.7 (8.1%)	9.7 (1.6%)	0.8 (0.1%)
	2006-07	566 (89.8%)	53.4 (8.5%)	10.8 (1.7%)	0.2 (0.0%)
	2007-08	581.7 (88.9%)	59.0 (9.0%)	13.2 (2.0%)	0.2 (0.0%)
	2008-09	625.3 (88.5%)	68.5 (9.7%)	12.3 (1.7%)	0.5 (0.1%)
	2009-10	696.3 (87.4%)	90.8 (11.4%)	8.9 (1.1%)	0.8 (0.1%)

[87] Capital Spending – a closer look, CaSE blog, 20/12/2010. http://sciencecampaign.org.uk/?p=2606
[88] Hansard, parliamentary written questions, George Freeman, 39690, February 16th, 2011
[89] Hansard, parliamentary written questions, George Freeman, 39691, February 16th, 2011

Table 9 shows the amount of funding won from the Research Councils in each of the nations over the last 5 years. Research Council funding is meant to follow excellence without taking geography into account. Different nations therefore have to invest in the quality of their research bases in order to win these grants. The pattern of funding is fairly stable, with England receiving an amount slightly above its population share, and Scotland performing particularly well (11.8% of funding for 8.4% of the UK population). In contrast, Wales and Northern Ireland reap less than they should. The pattern of distribution is similar to that of citations per paper, as would be expected. Some but not all of the variation in the distribution of Research Council funds reflects the location of public Research Institutes, none of which are located in Northern Ireland.

Scotland's HE review of considers the organization of the research base: whether research should be more concentrated, encouraging more pooling, and whether funding should be focused on Scotland's strategic priorities[90]. The Scottish research base is amongst the best in the world and is arguably not in need of serious reorganisation. Strategies should focus on areas with a proven need for improvement, such as increasing industry investment in R&D (see section on Innovation and Industry).

Smaller national universities may find it harder to win funding because of the insufficient scale of their research units. Wales recently reviewed R&D spending as part of its economic strategy, and will be implementing strategies to secure a greater share of Research Council income. These include building closer partnerships between the Research Councils and HE within Wales and showcasing existing research collaborations to external funders[91],[92]. The creation of research collaborations to achieve critical mass may help and has been successfully advocated in Wales by the Reconfiguration and Collaboration Fund.

Northern Ireland's recent consultation on STEM focused more on education and business, rather than the role of the public sector in building up the research base to attract additional investment and provide the products for innovation[93]. This vital component needs to be given more priority.

Higher Education Funding for Research

Universities receive general research money via the national Higher Education Funding Councils and DELNI, depending on a number of factors – some of this is prioritised towards knowledge transfer but most is quality related, "QR" funding, allocated on the basis of prior research performance. The key data for the QR formula reflect the size of research groups and the quality of work as judged by the Research Assessment Exercise (RAE) conducted jointly across the UK. The most recent RAE was in 2008, but it will be replaced by the Research Excellence Framework, which will take account of the impact as well as the quality of research.

The RAE ranks research on the basis of its originality, significance and rigour as one of:

4* - world-leading;
3* - internationally excellent;
2* – internationally recognised;
1* – nationally recognised;
or unclassfied.

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[90] Building a Smarter Future: Towards a Sustainable Scottish Solution for the Future of Higher Education, 2010 http://www.scotland.gov.uk/Publications/2010/12/15125728/11

[91] R&D Review Panel Report, July 2010, Welsh Assembly Government. http://wales.gov.uk/docs/dcells/publications/100909rdreporten.pdf

[92] *Economic Renewal: A New Direction, T*he Welsh Assembly Government, July 2010 http://wales.gov.uk/topics/businessandeconomy/help/economicrenewal/programmepapers/anewdirection/?lang=en

[93] Success Through STEM, Draft Government Stem Strategy, November 2010, Northern Ireland Executive. http://www.delni.gov.uk/draft_government_stem_strategy-2.pdf

The 2008 RAE classified 18% of research submitted from England as world-leading, compared with 15% for Scotland, and 14% for Wales[94]. Half of the assessed research in Northern Ireland was 3* or 4* and both universities improved their performance from the RAE 2001[95].

The amount and distribution of QR money is determined within each nation. The Scottish Funding Council spends through its Research Excellence Grant, which includes £5m targeting STEM subjects in support of the *Scottish Government Science Framework*. Scotland is the only nation that funds 1* research, partly to support early career researchers, and it allocates its funds in the following proportions: 0.125 units to 1*, 1 to 2*, 3.375 to 3*, and 8 to 4*. It also scales the distribution to take costs into account, awarding 1.2/1.6 times more funding to most STEM subjects[96].

Wales and Northern Ireland allocate their QR money in the following ratios: 1 unit to 2*, 3 to 3* and 7 to 4* (Wales has also focused a further £6m focused on 4* research)[97]. Within each band, different subjects get different ratios to reflect costs, with most STEM subjects receiving 1.3/1.6 the rate of others[98].

The most comparable information on quality related funding includes support for charitable investment in research (see below) and also for postgraduate research teaching. For 2009-10, England spent £1,515m in these areas (equivalent to £29.24 per person)[99], Scotland spent £240.5m (£46.34 per person) [100], Wales spent £83.2m (£27.74 per person)[101], and Northern Ireland spent £53.9m (£30.11) [102].

Charitable Funding of the Research Base

Recommendations

- **All political parties should commit to continue to cover the indirect costs of charitably funded research to encourage this investment stream.**

All of the UK nations encourage charitable support for research by allocating an element of the money distributed by their Funding Councils (or DELNI) to cover indirect costs. Although some charities do make discrete grants to some of these areas, like new builds, libraries and staff training, blanket support for them fall outside charitable objectives. If public money did not cover this element, then universities would lose out financially when they accept charitable funding. If one nation delivered less support, then it would be likely to draw in proportionally less charitable funding, and if this support were weakened across the UK, then it might affect the way in which charities determine how to spend their funds[103]. The different nations have slightly different mechanisms for calculating the charity support element, but they all aim to be consistent with each other in the proportional level of support given.[104]

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94 Review of Higher Education in Wales Phase 2 Report (the Jones Report), 2009 http://wales.gov.uk/docs/dcells/publications/090622hephase2en.pdf

95 http://www.delni.gov.uk/index/further-and-higher-education/higher-education/role-structure-he-division/he-research-policy/recurrent-research-funding/quality-related-research-funding.htm

96 http://www.sfc.ac.uk/web/FILES/Circulars_SFC112010_GeneralFundGrantLetter/SFC1110_General_Fund.pdf

97 http://www.hefcw.ac.uk/documents/policy_areas/research/qr%20funding%20method.pdf

98 http://www.delni.gov.uk/index/further-and-higher-education/higher-education/role-structure-he-division/he-research-policy/recurrent-research-funding/quality-related-research-funding.htm

99 http://www.hefce.ac.uk/pubs/hefce/2009/09_08/

100 http://www.sfc.ac.uk/funding/universities/funding_streams/generalfund/research_funding/funding_research.aspx

101 http://www.hefcw.ac.uk/documents/working_with_he_providers/data_collection/QR_model_200910.pdf

102 http://www.delni.gov.uk/index/further-and-higher-education/higher-education/role-structure-he-division/he-research-policy/recurrent-research-funding/quality-related-research-funding.htm

103 PAWG Scotland policy briefing, November 2010. http://www.amrc.org.uk/news-policy--debate_pawg-scotland

104 For 2010-11: the Scottish Funding Council allocated £21.5m to support charity-funded research in the 2010-11 academic year as part of the volume element of its QR distribution; HEFCW confirmed £3.1 m allocated within QR in proportion to charitable income and also as a minor volume measure (0.25) within the QR funding formula; Northern Ireland allocated £4.2m as part of its block grant.

The majority of UK research funding comes from members of the Association of Medical Research Charities (AMRC). In 2009-10, they invested a total of £1,227m in research, 73.7% of it in England, 11.9% in Scotland, 1.6% in Wales, and 0.6% in Northern Ireland (with 5.7% abroad and 6.5% on capital)[105]. AMRC charities spent £966m in 2008-09 with a similar distribution. There is more information on the distribution of charity funding won by open competition for HE in Table 10.

Table 9. HE income for 2008-09 from UK-based charities (by open competition) and from UK-based business, shown by nation with share of UK in parentheses[106].

	England	Scotland	Wales	Northern Ireland
Charities: Open Competition	664,704 (86.1%)	79,529 (10.3%)	19,736 (2.6%)	7,764 (1.0%)
Industry	229,656 (73.5%)	65,714 (21.0%)	13,735 (4.4%)	3,409 (1.1%)

Business Funding of the Research Base

Table 10 shows the amount of income from industry into HE across the UK. Scotland secures a high share compared to its population and also other sources of income. Wales gets almost a proportionate share for its population, but Northern Ireland gets less.

The extent to which universities are responsive to business needs and are able to draw in private investment may relate to the involvement of business people in their governance. In 2007-08, 37% of HEI governors in England had a commercial background, as compared with 34% in Scotland, 31% in Wales, and 21% in Northern Ireland. Tighter links between academia and industry also help the communication that underlies innovation (see later section on innovation.) Northern Ireland's review of HE recognises the need for increased employer engagement with HE and closer collaboration with local industry, particularly SMEs and potential investors – this will help to identify and address skills gaps but might also bring in more private funding[107].

European Funding of the Research Base

As of March 2010, the UK had attracted €1,834m or 14.4% of the total budget of the Framework Programme 7: 75.4% of this went to higher or secondary education, 1.1% to research organisations, and 3.1% to other public bodies.

The distribution of funding is shown in Table 11. It can be seen that Scotland is good at winning European money for the public sector, Wales is slightly below what would be expected for its size and Northern Ireland wins less than half of its share by population. To improve upon this, the Welsh Assembly Government plans to influence the next framework programme, learn from those with prior success, and build capacity for larger bids[108]. Northern Ireland is also working in this direction and is seeking to maximize opportunities for collaborative research with its nearest neighbour – the Republic of Ireland.

[105] Charity UK and international research expenditure, AMRC, 2011. There has been some fluctuation over the last 6 years, with Scotland ranging between 12.3 and 13.8%, Wales between 1.3 and 1.8%, and Northern Ireland between 0.4 and 0.7%.
http://www.amrc.org.uk/maintain-the-uk-as-a-global-leader-in-science_champion-uk-medical-research-at-home-and-abroad_charity-uk-and-international-research-expenditure

[106] 2008/09 HESA Finance Record

[107] Consultation document on the development of a Higher Education Strategy for Northern Ireland, Department for Employment and Learning, January 2011. http://www.delni.gov.uk/higher-education-strategy.pdf

[108] Meeting of the Cabinet Committee on Economic Renewal (July 2010
http://wales.gov.uk/about/cabinet/cabinetsubcommittees/er/12july10/mins/?lang=en

Table 11. Financial Contribution requested from Framework Programme 7 until March 2010 (€m), shown by sector and devolved nation with share of UK in parentheses[109]

	England	Scotland	Wales	Northern Ireland
HE or other public	€1,256.9 (85.4%)	€161.6 (11.0%)	€34.0 (2.3%)	€18.5 (1.3%)
Private commercial	€340.8 (93.8%)	€13.2 (3.6%)	€4.5 (1.2%)	€4.7 (1.3%)

INNOVATION & INDUSTRY

Recommendations

- **Business investment in R&D is relatively low in the devolved nations compared to other countries, as is the case across the UK. Governments must actively and urgently improve this situation.**
- **Smaller nations struggle to match the pool of talent coming from FE and HE to local business needs. Governments may need to manage supply and demand for skills and to facilitate communication between educators and employers, especially when there are many small businesses.**
- **Governments should do more to benefit businesses through their public-sector procurement and investment strategies. They can also support the work of the research base through supportive policy-making, such as by streamlining research approval times with the NHS.**

Industry investment in R&D is vital for nations to fully exploit the fruit of their research, yielding beneficial products, services, employment and manufacturing. It is estimated that the gains that private companies reap from their investment in R&D are about half of the gains that "spillover" to other private companies and the wider society from that R&D[110]. Direct support, regulation and incentives to enhance private R&D investment are thus well justified.

Table 12 shows the pattern of industry employment and investment in R&D across the nations. About a quarter of employed people work in industry in Scotland, Wales and Northern Ireland, with the rates varying between 14% and 31% in different areas of England. The rate of business and enterprise investment in R&D (BERD) was more variable across the nations. England has a much higher rate of private investment, reaching the equivalent of £290 per head, compared with £106 in Scotland, £81 in Wales, and £96 in Northern Ireland.

Overall, the UK has a low level of industry investment and the UK Government has argued that this is, in part, because of the profile of the economy. More than four fifths of UK industry sales occur in sectors that are low or very low investors in R&D, like oil and gas, and 75% of GDP comes from the service sectors[111]. Obviously the same argument can be applied to the devolved nations. But we also know that public investment encourages private investment and governments have a very important role to play in building up public spending and making sure that the right skills are available. New attempts to rebalance the economy prompted by the recent financial crisis should actively encourage a broader range of industry and investment in R&D.

[109] Welsh participation in EU research, innovation and lifelong learning programmes. February 2011, National Assembly for Wales, European and External Affairs Committee. http://www.assemblywales.org/eur_3_eu_funding_final_report-e-4.pdf
[110] Griffiths, R. (2000). How important is business R&D for economic growth and should the government subsidise it? Institute of Fiscal Studies.
[111] CaSE Working Paper on Research Funding, February 2010. http://www.sciencecampaign.org.uk/documents/2010/CaSEResearchFunding.pdf

In Scotland, BERD spending totals £547m and is strongest in chemicals (£160m), electrical machinery (£109m) and services (£92m), with other spending in mechanical engineering (£19m) and extractive industries (£34m). European economic analyses identified Eastern Scotland and the Highlands to be specialised in agriculture, North Eastern Scotland to be specialized in industry and agriculture and South Western Scotland to be balanced across services, industry and agriculture[112].

Table 10 shows that industries in Scotland fund a relatively high proportion of their R&D (£66m) in universities, presumably reflecting the strength of the research base. Interestingly, this outsourcing of industry research is a model which many sectors are moving to and it is likely to provide an increasingly important source of university income. Table 11 shows that Scottish business wins above its share of European funding compared to the rest of the UK – impressive given that its total BERD is not high.

Table 12. People employed in industry, percentage of people in employment working in industry, business and enterprise investment in R&D (BERD, with % of UK total in parentheses), and BERD per head, shown by UK nation.

		People employed in industry 2008 (thousands)[113]	% employed people working in industry 2002[114]	BERD 2008 (£m)[115]	BERD (£/per head)
England		139		14,935 (94.0%)	290
	North East	4	27.2	325	
	North West	16	26.0	2,290	
	Yorkshire and the Humber	7	27.1	426	
	East Midlands	12	30.2	991	
	West Midlands	12	30.5	892	
	East	29	25.0	4,140	
	London	10	13.9	1,058	
	South East	35	22.3	3,438	
	South West	15	23.7	1,374	
Scotland		7	23.5	547 (3.4%)	106
Wales		3	26.1	243 (1.5%)	81
Northern Ireland		4	25.9	171 (1.1%)	96

BERD spending in Wales totals £243m and is spread across the chemicals (£38m), mechanical engineering (£23m), electrical machinery (£50m) and services (£47m) sectors. In Northern Ireland, spending totals £171m mostly on chemicals (£16m), electrical machinery (£22m), services (77m), and mechanical engineering (£21m).[116] European economic analyses identified Wales and Northern Ireland to be specialised in agriculture.[117] Table 11 shows that businesses in Wales and Northern Ireland do not

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[112] Eurostat national yearbook 2010: Labour market (tables and graphs)
[113] http://www.statistics.gov.uk/downloads/theme_commerce/BERD-2008/National.pdf
R&D in UK Businesses, 2008 Data sets, ONS, Table 17
[114] table 2.3 Economic statistics: National Trends 38 ONS
http://www.statistics.gov.uk/statbase/ssdataset.asp?vlnk=7648&More=Y
[115] http://www.statistics.gov.uk/downloads/theme_commerce/BERD-2008/National.pdf
R&D in UK Businesses, 2008 Data sets, ONS, Table 17
[116] R&D in UK Businesses, 2008 Data sets, ONSTable 15
http://www.statistics.gov.uk/downloads/theme_commerce/BERD-2008/National.pdf
[117] Eurostat national yearbook 2010: Labour market (tables and graphs)

receive their share of European funding compared to the rest of the UK – but the rate is comparable to their BERD investment.

The recent Northern Ireland STEM consultation emphasized the lead that business has to take in building up STEM skills – communicating the growing demand for workers in these areas, supporting education, enrichment and careers advice[118]. It noted that the high proportion of smaller businesses makes engagement more difficult. The Government is establishing a business subgroup, to coordinate this work along with Sector Skills Councils and others. This sort of work will be vital to growing high-tech industry in Northern Ireland, but should not be seen as a replacement for public involvement, investment and leadership.

Promoting Innovation

The 2006 European Innovation Scoreboard broke down performance on 25 innovation indicators by region[119]. The performance of England's nine regions ranked 12th-78th, Wales ranked 80th, with Scotland at 89th, and Northern Ireland at 113th.

The Technology Strategy Board promotes innovation through various collaborative projects and knowledge transfer activities, working as a hub linking business, universities and government in strategic areas. The Technology Strategy Board funds innovative projects, drawing in additional industry funding. The distribution of funding to industry and HE partners across the UK is shown in Table 13. It can be seen that all of the devolved nations received less than their share by population, especially with respect to industry partners. Again, Scotland does better than Wales which does better than Northern Ireland. Notably, the Scottish research base does not secure a proportion of funding that might be expected given its strength, possibly because of a limitation of potential industry partners.

Table 13. Number of partners funded and distribution of funding (£million) from Technology Strategy Board from 2007 to current, % of UK total in parentheses[120].

	No of academic partners	Total grant to academic partners	No of industry partners	Total grant to industry partners	Total grant awarded
All UK	1141	£278	5299	£823m	£1,101m
Scotland	71	£14.4m (5.2%)	246	£31.5m (3.8%)	£45.9m (4.2%)
Wales	50	£14.2m (5.1%)	120	£7.1m (0.9%)	£21.3 (1.9%)
Northern Ireland	3	£1m (0.4%)	22	£6m (0.7%)	£7m (0.6%)

The Scottish Funding Council funds knowledge exchange in two ways - Scottish universities each receive £70,000 from the General Fund to support knowledge exchange and a fraction of the Horizon Fund (£118m for 2010-11), based on prior performance. A further fund, Strategic Priority Investments in Research and Innovation Translation (SPIRIT) stood at £3.8 million for 2009-10 and delivers project funding in key industry sectors identified in the Scottish Government's economic strategy[121]. The current HE review will look at how to improve knowledge exchange between HE and industry[122].

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[119] Success Through STEM, Draft Government Stem Strategy, November 2010, Northern Ireland Executive. http://www.delni.gov.uk/draft_government_stem_strategy-2.pdf
[120] Data supplied by Technology Strategy Board March, 2011.
[121] *Higher Education – Business and Community Interaction Survey 2007/8 (July 2009), HEFCE.* http://www.hefce.ac.uk/pubs/hefce/2009/09_23/09_23.pdf
[122] Building a Smarter Future: Towards a Sustainable Scottish Solution for the Future of Higher Education, 2010 http://www.scotland.gov.uk/Publications/2010/12/15125728/11

The Welsh Deputy Minister for Science, Innovation and Skills recently chaired an R&D Review Panel looking at steps to increase the relatively low level of BERD[123]. This fed into the 2010 publication, *Economic Renewal: A New Direction,* which gives strategic priority to "making Wales a more attractive place to do business"[124]. It recognises the importance of encouraging innovation, stating that "Wales must move towards a more R&D intensive and knowledge-based economy where the right conditions exist for innovation to flourish." This includes: working with academia to build capacity in the key business sectors, encouraging collaboration with universities to increase capacity and success of bids for higher value research contracts, and promoting the importance of BERD.

Business support in Wales will be more targeted and sector based[125]. The Higher Education Funding Council for Wales has been asked to make sure that it can deliver on these national strategic priorities and these same areas are reinforced in the HE strategy, in which providers of FE and HE are asked to ensure that skills needs are met. This cohesive approach to research, and the skills it depends upon, to build high-tech growth lays important ground for Wales' future.

In Northern Ireland, knowledge transfer is funded through a HE innovation fund, jointly from the Department for Employment and Learning and the Department of Enterprise, Trade and Investment (through Invest NI)[126]. Activities must take account of departmental strategic priorities and reflect the Northern Ireland National Innovation Strategy. There is also an HE and FE collaboration fund ('Connected') to coordinate the knowledge transfer needs of businesses, running at £3m over 3 years.

The Northern Ireland Executive set up a Science Industry Panel (MATRIX) in 2007 to develop policies to promote an innovation-based economy. It identified five key STEM sectors with recommendations for maximising the commercialisation opportunities within them[127]. It also recommended the now ongoing establishment of "Industry led Innovation Communities" within knowledge based sectors involving business and academia[128]. The current review of HE aims to increase knowledge exchange.

The devolved nations can also offer more direct support for business through their spending policies for public-sector procurement and by developing, and investing in, venture capital funds to support innovative start-ups[129]. Across the UK, public sector procurement is worth £220 billion. The Technology Strategy Board runs the Small Business Research Initiative, funded by government departments, in which companies compete to come up with innovative solutions to public challenges[130]. Similar programmes should be developed within each of the devolved nations.

There are other areas of public policy that can promote innovation throughout the research base and in business. The National Health Service has great potential to facilitate research. Recent steps across the UK have aimed to improve the NHS as an

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[123] R&D Review Panel Report, July 2010, Welsh Assembly Government.
http://wales.gov.uk/docs/dcells/publications/100909rdreporten.pdf
[124] *Economic Renewal: A New Direction,* July 2010, Welsh Assembly Government
http://wales.gov.uk/topics/businessandeconomy/help/economicrenewal/programmepapers/anewdirection/?lang=en
[125] Focusing on: digital economy; low carbon economy (including climate change mitigation and adaptation); health and biosciences; and advanced engineering and manufacturing.
[126] Higher Education – Business and Community Interaction Survey 2008-09, HEFCE July 2010
http://www.hefce.ac.uk/pubs/hefce/2010/10_14/
[127] The sectors are: life and health sciences; ICT; agri-food; advanced materials; and advanced engineering (transport) http://www.matrix-ni.org.
[128] Success Through STEM, Draft Government Stem Strategy, November 2010, Northern Ireland Executive.
http://www.delni.gov.uk/draft_government_stem_strategy-2.pdf
[129] Physics an investment for the future. The Institute of Physics manifesto for the Scottish election of 2011.
http://www.iopscotland.org/news/11/file_48530.pdf
[130] CaSE Working Paper on Research Funding, February 2010.
http://www.sciencecampaign.org.uk/documents/2010/CaSEResearchFunding.pdf

academic and business partner, yet a recent report identified unnecessary delays, bureaucracy and complexity. For instance, it can take nearly two years to go from funding a proposal to recruiting the first patient[131]. Scotland's strength in health research is supported by a new initiative, NHS Research Scotland, which ensures that the approval times for R&D are now fast and coordinated across the nation. Scotland's new approach is being cited as the benchmark for other parts of the UK[132]. In addition, a new electronic record system is streamlining researcher access to patient records. A similar scheme is being piloted in England. To maximize the potential of medical research, regulation needs to be coordinated across the UK.

DIVERSITY IN SCIENCE AND ENGINEERING

Recommendations

- **Targets for increasing uptake of STEM subjects should be refined to enhance equality. Strategies to improve uptake may be most beneficial and cost-effective if they are targeted at under-represented groups.**
- **Each of the nations should develop a clear and funded strategy to improve diversity in STEM – not only for reasons of fairness, but also to make the most efficient use of resources and harness the widest innovative potential for the UK.**

Distinct groups of people are under-represented in certain areas of science and engineering such as women, people from certain ethnic minority groups or socially-disadvantaged backgrounds, and disabled people. This represents an enormous loss of potential in terms of the sheer numbers of scientists and engineers there could be. Innovation is also enhanced by having a wide range of perspectives, so limiting participation affects innovative potential. It is also a waste of investment. For example, only 30% of women with STEM degrees are employed in STEM compared with 50% of men[133].

Diversity is only slowly being improved despite various interventions aimed at bringing more under-represented groups into STEM education and work. As can be seen from the education section, the under-representation of girls and women varies with UK nation - understanding these differences should help us develop strategies to improve representation.

Unfortunately, the UK government is planning to dramatically cut the dedicated funding for the UKRC Resource Centre for Women in SET. It is vital that the plans to "mainstream" diversity work are clearly articulated, well-funded and look at all under-represented groups.

CORE COMPARISONS ON RESEARCH FUNDING

Figure 2 illustrates much of the data discussed in this paper around investment levels in science and engineering. It provides the percentage of the UK population as a baseline for each of the devolved nationS, and then illustrates the percentage of the UK total on a range of other measures.

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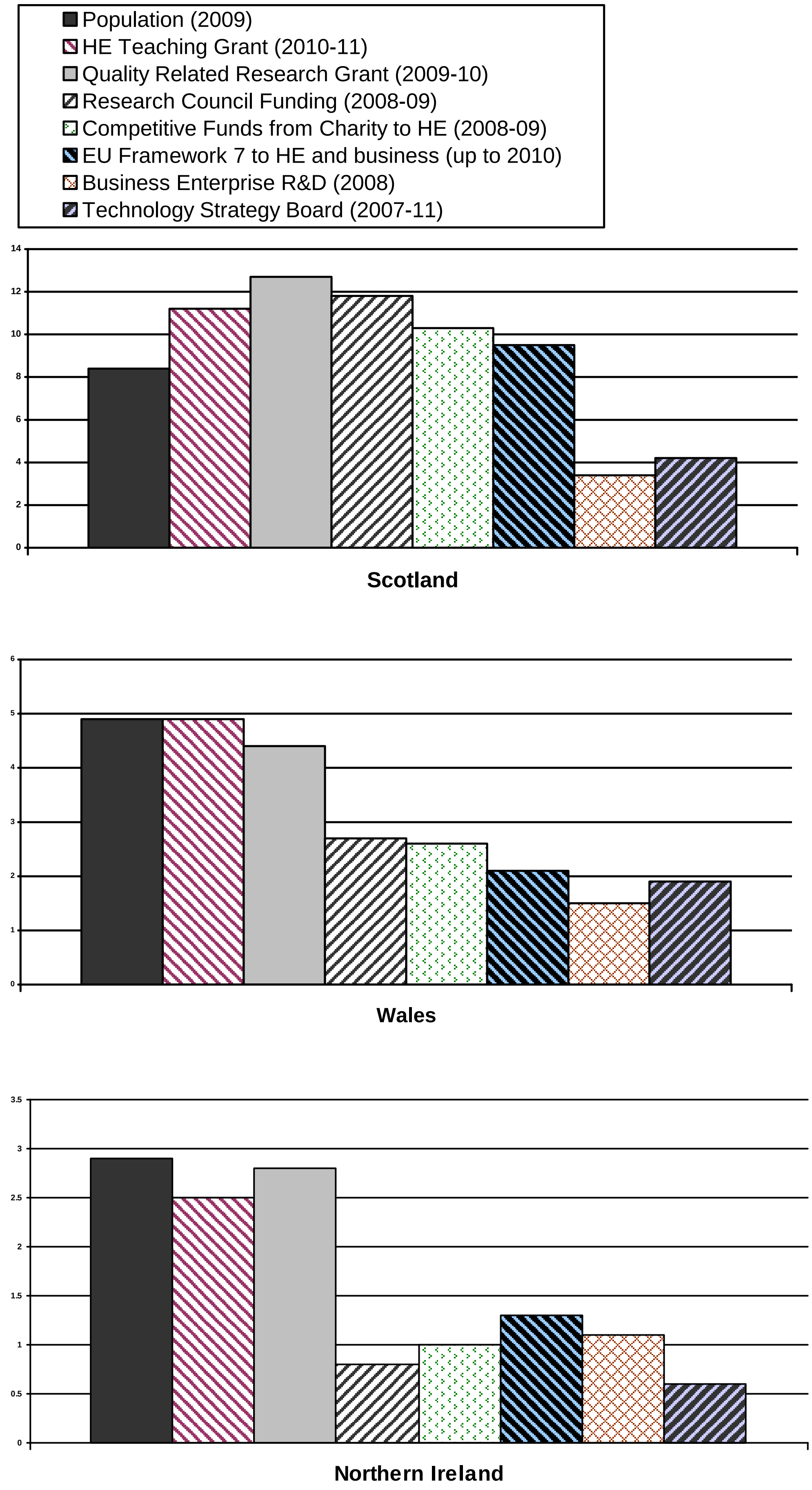
[131] A new pathway for the regulation and governance of health research, January 2011. The Academy of Medical Sciences.

[132] PAWG Scotland policy briefing, November 2010.
http://www.amrc.org.uk/news-policy--debate_pawg-scotland

[133] Women and men in Science, engineering and technology: the statistics guide 2010. The UKRC resource centre for women in SET.

Figure 2. Percentage of UK for a range of measures relating to STEM in Scotland, Wales and Northern Ireland.



Although it is not possible to attribute causality, inspection of Figure 2 shows that Scotland invests well, above its population share in both higher education and the research base. It has a quantifiably excellent research base (e.g., as measured by citation rates or top ranking universities), which enables it to secure more than its expected rate (by population share) of competitive funding from the UK Research Councils, research charities and the EU. This extra income more than covers the higher rate of public investment. Scotland's relative weakness is in business R&D and it needs to develop ways to increase levels of investment in this sector.

Wales invests in higher education at an appropriate rate for its population (although it has a high rate of participation), with research funding slightly below what might be expected. Unfortunately, it seems to be unable to use this public investment to win its share of competitive funding and similar relative levels of investment are seen for R&D in the private sector. Wales may be struggling to find critical mass. The new STEM focus in Wales should start by addressing the relatively low rate of public investment in teaching and research, as well as building collaborative partnerships.

Northern Ireland invests in higher education and research at a level below that expected for its share of UK population. The small size of the research base, and its distance from the rest of the UK, probably combine with the funding shortfall to mean that it wins only a small share of competitive research funding. It also has relatively low levels of business investment in research, possibly reflecting the high number of smaller businesses. Northern Ireland's emerging focus on STEM needs to be accompanied by significant improvements in investment as well as collaborative work to build research partnerships.

FURTHER INFORMATION

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