Delivering Diversity

Making Science & Engineering Accessible to All

Campaign for Science & Engineering in the UK

CaSE Policy Document Number 8 May 2008

This document stems from a CaSE *Opinion Forum* meeting on under-represented groups in science and engineering held in October 2007.

CaSE further developed ideas with a range of individuals from companies, universities, government departments, learned societies and others. This policy document may reflect a general consensus, but the specific views are the responsibility of CaSE.

The under-represented groups considered here are disabled people, those from socially-disadvantaged back-grounds, women and ethnic minorities. While some policy suggestions target certain groups, many will benefit all, including groups not directly considered here. The focus is on issues that are particularly problematic in science, technology, engineering & mathematics (STEM), rather than across all disciplines.

This document is one of a series that present CaSE's policy recommendations on current issues in science & engineering.

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Summary of findings & recommendations

1. The desirability of a more diverse science and engineering workforce is generally well-accepted. Many initiatives to improve this diversity are having impact, but it is depressingly slow in some areas and may have plateaued in others. More radical steps must be implemented as policy rather than simply as good practice. **It is time to deliver diversity.**

2. The Government must integrate its commitment to improving diversity in STEM education and employment into all science and innovation policy, and not simply treat it as a self-contained side-issue.

3. Belonging to a group that is under-represented is a disadvantage in itself. This is partly because of the shortage of individuals at higher levels to act as role models, mentors, and reviewers or to provide support networks. Perhaps equally importantly, these groups may be poorly represented on influential committees, governing bodies, interview panels, etc.

4. As well as taking a bottom-up approach to improving diversity, by increasing numbers at early stages, we argue for a top-down approach whereby diversity is implemented at the higher levels to pull others up.

5. All organisations in the scientific and engineering community should demonstrate a representative diversity for the full range of their activities. They must not just show their commitment to diversity, but actual success.
This practice should be self-imposed within the community and it can be driven at the policy level for Government organisations or for those receiving Government funds.

- School outreach programmes should be attended by students representative of that schools intake (before subject selection). Outreach programmes for older students should be targeted at under-represented groups.
- Governance bodies should be representative of the groups from which they draw (within one term of office).
- Prizes, fellowships and funding should be awarded across different groups, and speakers at conferences should be representative of different groups, according to the pools from which they are drawn.

6. It is time to shift from good practice that encourages gentle change to achieving real and rapid results.

7. A national database should be developed for all under-represented groups to help provide role models, mentors, speakers, support networks, etc. The GetSET database managed by UKRC may be a good starting point.

8. All teacher training should address diversity. Teachers should be trained not just to promote diversity but also in how to recognise and eliminate (hopefully unconscious) bias in their own practices. Careers advice should emphasise the possibilities of a STEM career for all.

9. More flexible employment practices should be implemented, providing part-time work, accommodating career breaks, and improving work life balance for all. The proposed Research Excellence Framework must not penalise part-time workers or those returning to work after a career break.

Summary of findings & recommendations

10. More undergraduates are living at home, often for financial, cultural or religious reasons. But closures of many STEM departments means that these subjects are often not available locally. As demand for STEM degrees increases, funding should be provided to encourage new departments to open to increase local provision.

11. There is a dirth of resources for disabled scientists and engineers. The Government should provide funding for a centralised resource centre for disabled people studying and working in STEM. Currently information is available in a piecemeal manner. Much time and energy is wasted as educators and employers work with those with disabilities to find solutions that have been developed elswhere. The STEM community must widen its perceptions of how work can be performed and communicated, introducing more flexible procedures, particularly for assessment and promotion.

12. CaSE wholeheartedly supports the Government's ongoing intention to help disabled people study, continue to work or return to work. CaSE urges the Government to lift the caps on financial support for disabled undergraduate and graduate students to bring it into line with support for employment.

13. Schools in socially-disadvantaged areas are the least likely to have specialist science and mathematics teachers and most comprehensive schools do not teach separate physics, chemistry and biology GCSEs. The Government needs to:

- Target specialist science teachers into the schools where they are most needed.
- Achieve its target for every student with a strength in science to be able to study separate science GCSEs by September 2008. CaSE believes that all schools should offer separate science GCSEs.

14. We should be embarrassed by the inequity in our science and mathematics education and take every opportunity to correct it. While CaSE welcomes recent commitments to improve science education and out-reach, the Government needs to develop a more coherent strategy to focus these resources into the areas where they are most needed.

15. A resource centre should be developed to examine and act upon ethnic minority issues in STEM. The UKRC provides a good model or its remit (and funding) could be expanded to include this area. Much more research needs to be done to understand the factors affecting the representation across different ethnic groups and to identify the most successful initiatives to correct under-representation.

16. CaSE applauds the Government's founding and ongoing commitment to the UKRC. It concretely shows the Government's genuine intent to achieve equality for women in this sector and illustrates to others the importance of striving for this equality.

17. CaSE recommends double-blind reviewing for publications and grant applications.

18. CaSE will improve the monitoring of the make-up of its governing bodies and speakers at meetings. CaSE is committed to improving the diversity of its governing bodies within the term of office.

Legal Requirements

Public Sector

These duties affect all public bodies, including schools, colleges and universities. They are positive duties; instead of waiting for reported instances of discrimination before taking action, public bodies are obliged to show that they actively promote equality.

The Race Relations (Amendment) Act (2000) came into force in 2002.

The Disability Discrimination Act (2005) came into force in December 2006.

The Equality Act (2006) that came into force in April 2007 covers gender.

Private Sector

Private sector employers are not required to actively promote diversity. However, they are bound by the pre-existing laws on discrimination and as such any complaint can be brought up before an industrial tribunal. Private companies are not bound by the Equality Act to gather workforce characteristics so it is not easy to monitor the make-up of their workforce.

The Race Relations Act (1976) makes it unlawful for employers to discriminate on racial grounds.

The Disability Discrimination Act (1995) makes discrimination against disabled people unlawful, and states that employers have a duty to make reasonable adjustments to the working environment and facilities to prevent disadvantage to a disabled employee. This became an anticipatory duty in 2001.

The Sex Discrimination Act (1975) makes it illegal to discriminate on the grounds of sex when offering employment or education.

Why do we need fair representation?

The science and engineering community prides itself on being a meritocracy. Looking at who achieves in different disciplines, and particularly at who excels, we must either deduce that there are specific groups who are simply not talented, or accept that supposedly merit-based systems are still ridden with barriers and bias. As the evidence points towards the latter, we must work to ensure that success in science and engineering becomes truly merit-based.

The Moral Issue

Our society has a responsibility to ensure that opportunities are equally open to all. This is particularly important for STEM education and employment as workers with these skills are in high demand, as reflected by increased income. Starting salaries average £23,000 a year, against a £19,000 average for graduates and the lifetime income of a graduate in science, engineering or maths is about £80,000 more than the average graduate.[1]

The Business Case

It has been estimated that the UK will need 2.4m STEM workers by 2014 and that the current figure of 45,000 STEM graduates per year must be doubled to reach this target.[2] Under-representation of certain groups suggests that some individuals who are perfectly capable of taking up STEM careers are not doing so, either by choice or because of factors beyond their control. Understanding and addressing the reasons behind this could lead to many of these people taking-up or continuing with STEM careers and would go towards making up the skills shortage.

Diversity and Success

A workforce from a wide range of social classes and ethnic backgrounds, with fair representation of women and disabled people, will be more aware of the range of needs of potential customers and is likely to be more open-minded and innovative. Diversity also enhances the employer's reputation.

The Government Position

The Government openly recognises the importance and value of a diverse STEM workforce. However, diversity seems to be dealt with as a side-issue, under the banner of science and society. Instead, it should be at the heart of Government policy on science and engineering education and employment. Of the two most recent Government documents on science and innovation, the Sainsbury review made only passing reference to under-represented groups and Innovation Nation failed to address this area.[3,4]

The Government must integrate its commitment to improving diversity in STEM education and employment into all science and innovation policy, and not simply treat it as a self-contained side-issue.

The Pipeline

For convenience, the flow of people into science and engineering careers is often visualised as a pipeline. This starts when students in secondary education specialise their subjects. From here most careers progress through undergraduate degrees that may then lead into postgraduate research or scientific and technological industry. A shortage of scientists and engineers at the late stages of the pipeline could be due to one of two factors:

1. A lack of input into the pipeline at the early stages.
2. 'Leaks' in the pipeline at later stages.

Input into the pipeline is affected by many factors, including basic literacy, numeracy and investigative skills at primary level, the teaching and subjects offered at secondary school, the general image of science and engineering and the aspirations of individual students.

'Leaks' in the pipeline refers to the drop-out at later stages, for example students with science A-levels choosing not to take a science or engineering degree, or graduates moving into finance or management.

It is important to know which factors are in effect before attempting a solution.

The failure of the critical mass approach

Let us consider the example of the biological sciences. It might be assumed that under-representation of women was due to low input: too few girls chose science at school, leading to low numbers at university and in biological careers. Such under-representation could be solved simply by achieving critical mass at an early stage. This has now been achieved, in fact, the majority of bioscience graduates are now women. However, as the pipeline progresses to postgraduate study and beyond, women drop-out at a much higher rate than the men. In 1995-6, 41% of bioscience researchers were female and just 6.6% of professors, and this rose to 46% of researchers and 13% of professors in 2005-6 (HESA).

There are clearly factors later in the pipeline that are more discouraging or challenging to women than to men. These are the issues that must be addressed if an equal representation of women in the biological sciences is to be achieved. Super-imposed on that, is that fact that any increased input may take time to work-up through the promotional system unless women are drawn into academia from other sources, such as industry or after a career break.

Common issues

Belonging to a group that has been historically under-represented is in itself a disadvantage, even if all the original causes of that under-representation are removed. This is, in part, because of the shortage of individuals at higher levels to act as role models, mentors and reviewers or to provide support networks. Perhaps equally importantly, these groups may be poorly represented on influential committees or panels for governing bodies, grants, awards, interviews and such like. There is evidence that people typically support those most like themselves, although they may lack insight into their bias.

As well as taking a bottom-up approach to improving diversity, by feeding people in early in the system, we argue for a top-down approach, whereby diversity is implemented at higher levels to pull others up.

All organisations in the scientific and engineering community should demonstrate a representative diversity for the full range of their activities. They must not just show their commitment to diversity, but actual success at implementing the right strategies to achieve it.

This should be self-imposed as good practice within the community. Where possible it can be driven at the policy level for any Government organisation (e.g., Research Councils) or for those receiving Government funds (e.g., the Royal Society and the BA).

Areas that would be covered include:

- **School outreach programmes - these should be attended by students representative of that schools intake (before subject selection).** For example, in mixed schools, science and engineering after-school clubs will only continue to receive funding if they are attended by equal numbers of girls and boys who are as ethnically diverse as the school's intake. **Outreach programmes for older students should be targeted at under-represented groups.**

- **Governance bodies, interview panels, etc. - these should be representative of the groups from which they draw.**

- **Prizes, fellowships, funding, etc. - these should be awarded across different groups, and speakers at conferences should be representative of different groups, according to the pools from which they are drawn.**

There would be a margin to work within in complying these directives and time-frames would vary according to their nature, for instance, changing the make-up of a Governance body could take a term of office. There would obviously be some exceptions, for example, when activities are specifically targeted at under-represented groups.

It is time to shift from good practice that encourages gentle change to achieving real and rapid results.

These demands may sound intimidating, unachievable, or even, to some, over-accommodating. But it is useful to reflect upon the use of women-only shortlists by the Labour Party in the selection of parliamentary candidates. This controversial policy considerably improved the gender balance of Labour MPs and there is now talk of introducing ethnic minority shortlists. The science and engineering community needs to consider what steps may be appropriate to improve its own diversity.

An illustrative success story within the science community is the implementation of diversity guidelines by the Society for Neuroscience for all their sponsored and non-sponsored events and meetings associated with the annual meeting. The guidelines demand: (1) appropriate representation of women and minorities as invited speakers in relation to their participation in the specific neuroscience subfields of the conference or meeting; (2) a good balance between established and new investigators on the roster; and (3) an attempt for broad geographical representation.

The guidelines seem to have had positive results and the proportion of symposia participants that were women jumped from 18% in 2003 to 32% in 2004 and has not fallen below 33% since then. Further, in the last two years, at least 90% of submissions (each of 4 speakers) included a woman or ethnic minority speaker and those that did not, were encouraged to reconsider their submission. The society's Program Committee helps submitters to come up with alternative speakers if necessary, or suggests, for example, that a post-doc replace a laboratory head.

Similarly, some outreach programmes, like the London Engineering Project, already require and successfully deliver equal participation.

Common issues

Databasing Diversity

Increasing numbers of schemes aim to promote STEM careers to women and certain ethnic groups, but very few, for example, target disabled scientists.

A national database should be developed for all under-represented groups to provide role models, mentors, and support networks.

This database could also be used to help fulfil the directives discussed opposite (e.g., identifying potential speakers). An obvious database to build upon would be the GetSET database managed by UKRC which already monitors ethnicity and disability.

Teaching Diversity

The issues here are the diversity of teachers themselves and bias in the way that they teach. Currently, most children will never be taught by an ethnic minority teacher. Fortunately, the Training Development Agency is working towards a more diverse teaching workforce that provides positive role models for everyone. In 2006-2007, 12% of trainee teachers were from ethnic minorities and this rises to 14% in science and 20% in maths. Recruitment and retention grants help to cover project costs.

As well as making sure that the workforce is diverse, it is important to ensure that teachers do not re-inforce negative stereotypes. All teacher training should include diversity.

Teachers should be trained not just to promote diversity but also in how to recognise and eliminate (hopefully unconscious) bias in their own practices.

To elaborate with the gender example, there is evidence that girls are treated differently from boys generally in school, and especially in science classes.[5] Science teachers devote more time to boys, have higher expectations of them, and give boys more credit than girls for the same performance. Boys are criticised about behaviour more than girls, while girls are criticised about academic performance, and this may negatively affect how girls perceive their abilities and the likelihood of pursuing STEM subjects. Teacher perceptions are also affected by ethnicity (see p. 9). There should be space in the teacher training curriculum for them to understand these biases and how to eliminate them.

Careers advice should emphasise the potential of a science or engineering career for all.

Increased access to more visible role models, through a diversity database, should facilitate this. The new STEM Choice and Careers project will work to promote equality and diversity.

Work Life Balance

Though career breaks are most commonly taken by women having children, there are a multitude of other reasons that a person may need to take time out from full time work. These include illness, accident, bereavement, caring for others, including fathers leaving to care for children, or simply the desire to do something different.

The community must continue to improve good practice in flexible employment, the provision of part-time work, accommodating career breaks and generally improving work life balance for all.

Returning to work after a career break is particularly challenging in academia due to the need to publish regularly and the competitiveness of applying for grants, and in science and engineering because of the importance of keeping skills current. There is also a shortage of part-time work.

There are currently a number of schemes running to help returners, some of which have been very successful. They help people find part-time work, fund childcare and refresh their skills. However, it is also important that prior to taking a career break people are made aware of all the actions they can take to keep up their knowledge, skills and contacts. Advice and assistance should be made available at every stage in the process.

Particularly helpful to both people looking after young children and disabled people, part-time opportunities should become more prevalent. At the moment, there is a perception that you cannot be a senior scientist or engineer on a part-time basis. While there are obviously challenges involved, it is ridiculous to say that this is impossible given the number of academics who spend only a proportion of their time actively running a lab, while other time is spent, for instance, on sabbaticals, teaching, or in administrative roles.

The proposed Research Excellence Framework (REF) for allocating university funding on the basis of academic performance must include a mechanism that does not penalise part-time workers or those returning to work after a career break.

These employees should not simply be excluded from the process. At the moment, there has been no explanation of how the REF will accommodate them.[6] Departments promoting flexible working should reap rewards rather than risk being penalised.

Common issues
Local Study

More undergraduates are choosing to study at local higher education institutions (HEIs) while living at home. The closure of many STEM departments since the 1980s means that more students cannot study these subjects locally. For example, in 2001, of 13 HEIs in the southwest of England, Exeter was the only one with a physics department. Similarly, Cambridge had the only physics department in East Anglia.[7]

Clearly, poor local provision limits the ability of under-graduates living at home to pursue a STEM career, often hindering specific groups such as the socially-disadvantaged, who are constrained by financial reasons, or certain ethnic groups, such as Pakistani, Bangladeshi and Indian students who are more likely to live at home.[8]

As demand for STEM degrees increases, funding should be provided to encourage departments to open or re-open to increase local provision.

University departments are increasingly involved in outreach schemes for local students and supporting local teachers.They are also encouraged to collaborate with local industry, most recently in the White Paper, *Innovation Nation*, planning local "partnerships for innovation" among universities, business and venture capitalists.[4] It is vital that the swathes of the country lacking STEM departments do not miss out. Plans for 20 new HEIs should increase local provision and it is vital that this provision includes the critical STEM subjects, otherwise we are at risk of introducing large geographic divides in these sectors in the UK.[9]

Table 1. The percentage of students receiving Disabled Students' Allowance by STEM are

STEM area	% receiving DSA
Mathematics	2.4
Physical sciences	4.5
Biological sciences	4.1
Computer science	4.0
Engineering & Tech	4.3
Medicine	2.0
Allied to Medicine	3.6
Agriculture	5.4

Source: HESA, 2007

Specific issues
Disability

Disabled people are currently under-represented in SET occupations, making up just 3.8% of the workforce, as compared with 5.9% in other sectors.[10] Achieving fair representation of disabled people in STEM requires a culture change because of attitudes and perceptions that disabled people cannot perform laboratory practicals or cannot meet academic requirements. Practical work can be an additional challenge that other subjects do not have, but creative solutions and different ways of working can overcome many issues that at first seem barriers. People need to be in an environment that makes them feel comfortable disclosing their disability, expecting a supportive response, and without fear of discrimination. Many improvements for disabled scientists are simply examples of good practice for all such as flexible work practices, local university courses, more visible role models etc., as discussed earlier.

There is a dirth of resources for disabled scientists and engineers. The Government must provide funding for a centralised resource centre for disabled people studying and working in STEM. Currently information is available in a piecemeal manner. Much time and energy is wasted as educators and employers work with those with disabilities to find solutions that have been developed elsewhere.

Disability as covered by the Disability Discrimination Act (DDA) is defined as "a physical or mental impairment which has a substantial and long-term adverse effect on a person's ability to carry out normal day-to-day activities". The proportion of students who describe themselves as disabled decreases from 6.4% at undergraduate level to 5.1% at post-graduate. Overall, the most common disability is dyslexia (43%) followed by unseen disabilities (18%).

HESA statistics report that 4.1% of all full-time first degree students receive Disabled Students' Allowance (DSA, see p.7).[11] Interestingly only 2.1% of part-time students received DSA. The proportion of students receiving DSA varies across subjects as shown in Table 1. Thus most of the STEM subjects attract an appropriate number of disabled students relative to the student population, although medicine and mathematics do less well.

Certain aspects of most courses will require reasonable adjustments and anticipatory measures for disabled students, such as lectures, seminars, reading lists and assessment. Most STEM subjects will have a practical element to them, which may require additional consideration of an individual's needs such as making lab equipment usable and safe for people with a range of disabilities. There is currently no best practice guide

Specific issues
Disability

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for an accessible laboratory and lab equipment, and labs that are tailored to accommodate those with disabilities often have to be constructed and tested from first principles, as discussed in a case study by the University of York.[12]

All new builds must have disabled access and facilities as the DDA covers both the buildings themselves and the fixtures and fittings. Education providers must anticipate reasonable adjustments and the needs of future students. Therefore new builds should be designed to meet the needs of current and future users with disabilities. Installing a hearing loop and fitting basic equipment designed to accommodate people with a range of disabilities, such as variable height benches and fume cupboards, are anticipatory measures that should be taken under the duties of the Act.

It is important to remember that physical disabilities form only a small segment of the issue. The most common disability is dyslexia, followed by unseen disabilities (e.g., diabetes & epilepsy). The current scientific culture is based on some deeply seated precepts, including the high value placed on academic independence and traditional ways of working. Disabled students often challenge these precepts and work in different ways and still demonstrate they are good scientists and engineers. Academic requirements must be founded on competence standards and although reasonable adjustments must be made to allow a student to demonstrate the competence, the standard itself cannot be altered. For example, a deaf student may find that no sign exists for specific research terminology in sign language so they create new signs with their interpreters to communicate specific concepts (although www.sciencesigns.ac.uk, for example, has a useful database). A competence standard of completing lab notes could be met through handwriting in a lab book, or a dyslexic student may use a Dictaphone. A viva is challenging for any student, but a student with Asperger's Syndrome may need additional support and clear questions in order to demonstrate their abilities. And, returning to mobility issues, a wheelchair user may need more organisational support to arrange attending an international conference.

Current attitudes place many non-essential activities on a par with scientific excellence. One researcher with mental health difficulties reports being told, "If you can't give a talk you have no future in research."

The scientific and engineering community must widen its perceptions of how work can be performed and communicated, introducing more flexible procedures particularly for assessment and promotion.

Increasing the provision of part-time work may also especially help disabled people given that 29% of them work part-time compared with 23% of people without disabilities.

Financial Issues

Most UK higher education students can apply for DSAs to cover any extra costs incurred while studying because of their disabilities. These cover four areas:
1. Specialist equipment (computer equipment, specialist software, furniture or training etc.) capped at £5030 for the entire course
2. Non-medical helpers (e.g., interpreter) capped at £20,000 pa (up from £12,000 last year)
3. General expenses
4. Travel

At post-graduate level, Research Council funding includes a provision for disabilities covering, for example, a full-time interpreter or assistant for a post-graduate student. However, students who do not receive Research Council funding are dependent on their local authority for assistance and their provision is capped at just £10,000 for the entire period of study.

CaSE applauds the Government's increasing support in this area. Unfortunately, the cap of £5000 for specialist equipment for an entire undergraduate course may be problematic for those studying practical science and engineering and the cap for non-medical help could be limiting. The greater shortfall is likely to come from the low level of funding for post-graduate study, which is much less generous that that for under-graduates.

Once in the workplace, employers have a duty to make reasonable adjustments to the working environment and facilities to accommodate a disabled employee and can receive funding for this from the Access to Work scheme to cover expenditure under similar categories to those in the DSA above.

CaSE wholeheartedly supports the Government's ongoing intention to help disabled people study, continue to work or return to work.

It is inconsistent that the DSA and post-graduate schemes are capped but the Action to Work scheme is not. It is not clear why the Government offers more support to disabled people in employment but not in the education that could result in that employment being more fruitful and satisfying.

CaSE urges the Government to lift the caps on financial support for disabled students to bring it into line with support for employment.

Specific issues

Social disadvantage

Social disadvantage can seriously limit the ability to study STEM subjects, in the teaching provision and subject choice offered at school, and later in the degree subjects available.

Children should be taught science and mathematics by specialist teachers (with a degree or additional teacher training in the subject). Ofsted has shown that being taught by specialist teachers improves student motivation and performance. Yet, there is a national shortage of science and mathematics specialist teachers and this is particularly evident in schools in socially-disadvantaged areas.[13]

Children attending mainstream rather than independent schools are more restricted in subject choice. Currently about a tenth of secondary school children take three science GCSEs leading to separate exams in biology, chemistry and physics, the majority take two science GCSEs and a minority take one. Unsurprisingly, pupils are more likely to study and do well at science A levels if they had previously taken three rather than two science GCSEs. However, shockingly, just 26% of mainstream schools offer three separate science GCSEs and 58% of science specialist schools do so, as compared with 66% of grammar schools and 72% of independent schools.[14]

It is not surprising then that only about a tenth of students take at least one science A level in main-stream or science specialised schools, as compared with about a third at grammar and independent schools.[15]

The Government must:

■ **Target specialist science and mathematics teachers into the schools where they are most needed.** It could do this with financial incentives to encourage teachers into schools with persistent vacancies in these areas. Including whether schools have these specialists in school attainment tables might encourage head teachers to use the incentives available to them to assure recruitment and retention of the necessary staff.

■ **Achieve its target that every student with a strength in science can study separate science GCSEs by September 2008.** The Government's goal is only for all science specialist schools to offer separate sciences - students at other schools may need to travel to them or share teachers with them. While this might be a necessary first step, **CaSE believes that all schools should offer separate science GCSEs.**

Last year, the Programme for International Student Assessment (PISA) released its detailed survey of the science and mathematics knowledge and skills of 15-year-olds in 2006.[16] Of the 57 countries surveyed, 12 ranked higher than the UK in science, although the UK scored above average. The UK ranked lower than 15 other countries in mathematics and was comparable with the OECD average. Overall countries, coming from a higher socio-economic background increased student's performance and their appreciation and enjoyment of science. These relationships were disappointingly strong in the UK which also demonstrated an unusually broad distribution of performance. Finland performed much better than all the other countries and has one of the least divisive education systems, with little impact of social background.

We should be embarrassed by the inequity in our science and mathematics education and take every opportunity to correct it. CaSE welcomes recent commitments to improve science outreach and education but recommends that the Government develops a more coherent strategy to focus these resources and finances into the areas where they are most needed.

Finally, as mentioned earlier (p.6), socially-disadvantaged students may be financially restricted to studying at local universities while living at home. These students are unlikely to be able to select from the full range of STEM subjects. A recent survey of secondary school or college students (in urban areas in the Midlands) considering higher education found that 31% reported that minimising debt had much or very much affected their decision of where to study.[17] Overall, 56% of them were considering studying locally and of these, 75% were planning to live at home with 72% rating minimising debt as an important or very important factor in their decisions. Students from lower income backgrounds with low to medium grades were much more likely to study locally. Unfortunately, most respondents were not aware of range of bursaries on offer, felt that they would not be sufficient to off-set their costs and made their choice of university before investigating the bursaries.

In the future, if variable fees are introduced, it is crucial that these do not result in higher fees for science and engineering than other subjects as this would obviously only further increase the social divide in access to a science and engineering education.

Specific issues

Ethnic minorities

The representation of different ethnic groups in STEM is a complex issue. During most stages of education, some ethnic groups are under-represented in these subjects, while some are over-represented, however, by the time you consider senior STEM workers, all are under-represented. The reasons for this, however, are not entirely clear, involving a combination of social and cultural factors.

When considering STEM achievement by ethnicity during secondary education, distinct patterns emerge.[18] Indian and Chinese students on average achieve far higher in the sciences than their white counterparts, while Black Caribbean students are the lowest achieving. This is not specific to science. It is notable that young people from Black Caribbean, Pakistani, Bangladeshi and Black African backgrounds are less likely to achieve highly at school and to continue in education post-16, probably due to a combination of socio-economic factors and self-fulfilling expectations. Gender interacts with ethnicity, such that Chinese and African women are best represented, Bangladeshi women are particularly under-represented, while among the black Caribbean populations, it is the men that appear to be disadvantaged. There is a correlation between ethnicity and income, such that students from some ethnic minorities are more likely to attend schools in socially-disadvantaged areas, and we have seen in the previous section the impact that this can have on a science and engineering education.

Research from a multinational project to assess the engagement of 15-year-olds with science has shown that developing and developed countries have very different attitudes to science.[19] Young people from developing countries are more likely to believe that science and technology are important and beneficial for society and they are also more likely to aspire to a job in science or technology. These data suggest that at least first generation immigrants from cultures that have these positive attitudes may have a greater desire to take up science. A recent PISA report showed that students from an immigrant background in the UK were indeed more likely to value science highly and to enjoy and want to pursue it.[16] It is unfortunate indeed that these students do not seem to be able to capitalise upon their enthusiasm in our current system.

The impact of teaching has been discussed earlier (p. 5). Groups that lack a history of excelling in certain areas are likely to have limited aspirations to them, but may also find that teachers do not expect them to perform in those areas and encourage them to take less challenging courses. These effects are evident in different ethnic minority groups, with, for example, higher teacher expectations of Asian children but many Black Caribbean children being encouraged into more vocational courses.[20]

In two recent reports, Ofsted analysed the good practice of schools with high achievement of ethnic minority students who typically under-achieve.[21, 22] An important element was careful monitoring of patterns of performance and participation by different groups which enabled staff to identify problem areas and make sure, for example, that they were including all groups at appropriate levels. In this way teachers were able to counter any unconscious bias in their approach and counter inhibited aspirations in specific groups. Ofsted recommends a very open discussion of race and ethnicity and school performance and the transparent development of strategies with staff, teachers and students with clear objectives. Ofsted also recommends the provision of high quality training or all staff so that the needs of minority ethnic pupils can be tackled with confidence. CaSE supports these objectives.

There are many new initiatives aimed at improving the uptake of science among certain ethnic groups. For instance, the Government Science in Society Program enables schools with a high proportion of Afro-Caribbean, Bangladeshi, or Pakistani pupils to bid for funding for extra-curricular science learning activities (providing £1.5 million from 2005-2008).

CaSE applauds such initiatives but it should be established that the money would not be better spent simply making sure that schools with a high proportion of ethnic minority students have specialist science teachers and offer appropriate STEM options.

Moving onto the undergraduate level, every ethnic minority group is over-represented. However, within specific subjects worrying patterns can be seen. There are clearly cultural effects determining the choices students make. For example, within a general bias towards medicine-related subjects, Indian students are highly over-represented in Opthalmics and Dentistry. Overall, most ethnic groups are over-represented in computer science and engineering, and under-represented in the physical sciences.

The distribution of students across subjects could reflect cultural values and preferences, but could also result from bias and lack of opportunity. The various correlations between ethnicity and income continues to have impact. Student loans and other borrowing are less likely to be a main source of income for ethnic minority students, who are more likely to receive

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Specific issues
Ethnic minorities

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parental contributions (especially those from an Asian background) or rely on income from term-time working (particularly for Black students). Overall, ethnic minority students are more likely to work longer hours than white students at new but not old universities. Pakistani, Bangladeshi and Indian students are more likely to be study from home. Once family and social backgrounds, prior qualifications and education, and entry routes into HE study are taken into account, many of the differences between ethnic groups diminish.[8] Nevertheless, it is clear that many more personal and interpersonal factors affect the pattern of study. Sadly a recent survey found that black and ethnic minority students in the northwest of England perceived racial discrimination to be the biggest barrier to a STEM career, driving some students to apply for work under adopted names that sound less like they originate from an ethnic minority.[23]

Further along the STEM pipeline, under-representation of ethnic minority groups becomes more severe, and over-representation less likely.[18] While most ethnic minority groups are not averse to postgraduate study, they are much more likely to move out of chemistry and physics and into other disciplines. Around 85% of chemistry researchers, 95% of lecturers and 99% of professors are white.

A resource centre should be developed to examine and act upon ethnic minority issues in STEM. The UKRC provides a good model for this, or the UKRC's remit (and funding) could be expanded to include this area. Much more research needs to be done to understand the factors affecting the pattern of representation across different ethnic groups. It is important properly evaluate the success of initiatives in eliminating under-representation.

Other policy recommendations in this area have been covered under common issues. In particular, achieving ethnic diversity on powerful committees, interview panels and in the public eye will help to eliminate bias and the shortage of role models. Furthermore, eliminating the problems experienced by those from socially-disadvantaged backgrounds will help many ethnic-minority groups.

Specific issues
Gender

The focus of work on under-represented groups has been on women. Recent initiatives have followed from the Greenfield report commissioned in 2002 by Patricia Hewitt when she was both Secretary of State for Trade and Industry and Women's Minister.[24] The Government responded in 2003, publishing its Strategy for Women in Science, Engineering and Technology (SET)[25], and then with the launch of the UKRC in 2004. The under-representation of women in STEM is estimated to cost the country £15-23 billion, or 1.3-2.0% of UK GDP.[26]

CaSE applauds the Government's founding and ongoing commitment to the UKRC for Women in SET. It concretely shows the Government's genuine intent to achieve equality for women in this sector and illustrates to others the importance of striving for this equality.

Most of the policies outlined under common issues would benefit women and actually originate from policies targeted at doing so. For instance, increasing provision of part-time work would particularly help women given that 43% of women work part-time in Britain as compared with just 8% men.[27] There is now a wide range of schemes, run by UKRC, Women in Science Engineering and Construction (WISE) and other organisations, targeting these issues. These include mentoring, improving work life balance, net-working, helping women return back to work, and celebrating and publicising women's achievements in STEM. We will outline the current situation and elaborate on some of the issues.

Much effort has been expended to achieve the appropriate representation of women in STEM education and employment. The situation is improving in some areas, but appears resistant in others, often those most in need of change. From 1997 to 2007, the proportion of girls taking STEM A levels rose from 41.3% to 44.9%, but the proportion of girls taking physics A level only rose from 21.7% to 22.0% (fluctuating to a high of 23.1 in 1999). Similarly, between 2003 and 2006, the proportion of female undergraduates studying STEM subjects rose from 34.8% to 36.8%, but the proportion of those that studied engineering and technology only rose from 14.0% to 14.3%.[28]

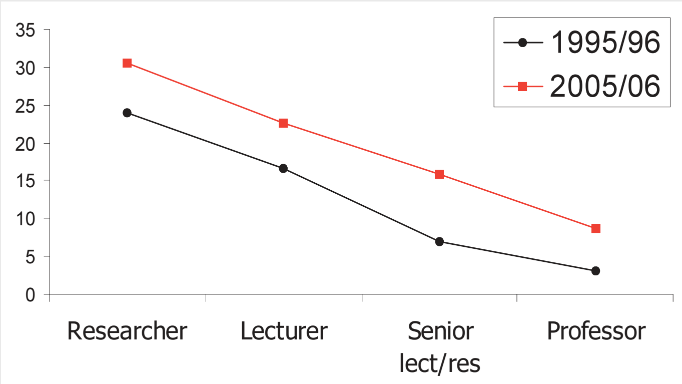
At later stages, as women drop out at a higher rate than men, under-representation becomes more pronounced. The proportion of STEM workers that are female only rose from 18.4% in 2001 to 18.5% in 2006. Only 25% of women with STEM degrees are employed in STEM, compared with 40% of men.[29]

Specific issues

Gender

Figure 1 shows the declining percentage of females with academic level in STEM subjects in 1996 and 2006. More women entered the system at researcher level and were promoted to every subsequent level in 2006 than in 1996. However, in an equal world, the graph should have little or no slope, showing that women do not become increasingly under-represented higher up the system. In the real world, there is no sign of the rate of increasing under-representation abating. Interestingly, the pattern is similar over all the STEM subjects with just a few exceptions. In IT and mathematics, despite little increase in the percentage of female researchers the percentage of professors that were female doubled.

Figure 1. Percentage of STEM academics that were female in 1996 and 2006



Source: HESA at UKRC, 2008.

As well as employment, we should consider other measures of achievement, such as prestigious prizes, being a fellow of the Royal Society or other learned societies, or being key-note speakers at conferences. Things have improved in these areas, but for the most part, women are not represented at levels that would be expected. For example, The Biochemical society has worked hard to improve its awarding of prizes after realising that just 3.2% of prizes had gone to women from 1963. In the decade up to 2006, this rose to 7%, still much lower than estimates of the pool of 23% that the prizes should draw from. Notably, only 8% of the applicants were female.

Stereo-types and bias

Women and men have stereotypical social roles, with science traditionally in the male realm. Research has shown that subconsciously (and sometimes consciously) both men and women still have stereo-typical attitudes to gender.[30] For instance, parents of young children and assessors at interview make incorrect assumptions about ability based on gender and teachers treat girls and boy differently (see p. 5).

This stereotyping probably influences girls throughout their schooling, resulting in low uptake of many STEM subjects. There is also evidence that men are more likely to receive grants. Such bias can extend onto interview panels, grant committees and such like and even into the peer-review process. A 2005 survey of STEM workers in Higher Education, found that 41% of men had been interviewed by all male panels compared with 27% of women.[31] This illustrates the importance of making sure that interview panels are appropriately diverse (as recommended on p.1 & p.4).

Regarding peer review, a recent analysis found that in the four years after the journal Behavioural Ecology switched to using double-blind review, 8% more female first-authors were published compared to the previous four years, with no such increases in other similar journals.[32]

CaSE recommends double-blind reviewing (or single blind reviewing with an undisclosed author) for publications and grant applications.

Assuring that publications reflect research quality will become increasingly important if the final REF relies upon bibliometric indices.

Work-life balance

Why are flexible work practices so important to attracting and retaining women? Men and women have distinctly different attitudes to work-life balance, especially after a career break. Women have little choice but to put their careers on hold if they wish to have children. An ATHENA survey of STEM workers in higher education (2004) found that 31% of women had taken a career break compared with just 6% of men.[31] Unfortunately, two-thirds of women do not return to STEM work after a career break.[29]

This does not make women less suited to science. It merely makes them less suited to the current scientific culture, geared towards extreme competitiveness and requiring almost obsessive commitment. Many opt out and choose other career paths.

Despite much research and many resources targeted at understanding and improving the representation of women in STEM, there is still a long way to go. CaSE supports initiatives in this area but argue that more pressure must be applied to speed up delivery of results. In particular we recommend that it is no longer considered acceptable for organisations to simply aim to improve their diversity or even to actively promote it, they must demonstrate appropriate levels of diversity within stated and reasonable time frames.

CaSE is committed to improving its own diversity

CaSE will improve the monitoring of the make-up of its governing bodies and speakers at meetings. CaSE is committed to improving the diversity of its governing bodies within the term of office.

Advisory Council: 11 out of 47 members are women. Term of 5 years.
Executive Committee: 2 out of 15 members are women. Term of 4 years.
CaSE staff: 2 out of 4 are women

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29 Tavistock Square
London
WC1H 9QU
Tel: 020 7679 4995
Fax: 020 7916 8528

Campaign for Science & Engineering in the UK

CaSE is a pressure group aiming to improve the health of science & engineering in the UK.

Our objective is to communicate to Parliament and the nation as a whole the economic and cultural importance of scientific and technological research and development and the vital need for the funding of this research by Government and industry.

CaSE represents the interests of the science and engineering community through:
- Meeting and corresponding with government ministers, MPs and peers, and senior civil servants in the UK and devolved governments
- Commenting in the media about science policy issues
- Organising meetings to bring the science and engineering community together with policymakers to discuss topical issues
- Producing reports and responses to consultations and inquiries
- Establishing and circulating the science policies of political parties prior to an election

CaSE works in four main areas:
- Science and Engineering Base
- STEM Education
- Private Sector Investment in R&D
- Government Department Funding and Use of Science

CaSE is a membership organisation comprised of individuals, private companies, research charities, universities, learned societies and others. CaSE's work is supported by it members because it is a proven champion of science and engineering in the UK. CaSE membership also includes:
- Invites to Opinion Forums, Annual General Meeting and Lecture and launch events
- Copies of our newsletter, policy reports, and monthly updates
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