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Talented Women for a Successful Wales

a report on the education; recruitment; retention and promotion of women in STEM-related study and careers

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Index of contents

Index of Figures and Tables

Foreword from the co-chairs

Our science, technology, engineering and maths (STEM) sectors are crucial to the success of Wales. Their knowledge-intensive organisations and their highly-skilled people make a major contribution to innovation, economic growth and the quality of our public services. STEM-related professions are generally well-paid and rewarding but many are experiencing significant skills shortages. Women are outperforming men in education overall and are more likely to get a good degree yet, still, more of them work in jobs requiring skills below their educational level. They are significantly under-represented in the STEM workforce: this is a waste of knowledge and talent.

Our report makes recommendations to address the under-representation and poor retention of women in STEM in Wales, based on four major themes – education, recruitment, retention and promotion.

We start by pointing out some steps the **education** sector can take to make the study of STEM subjects something that girls will increasingly see as relevant and rewarding for them. Not attracting a proper proportion of girls into the full range of STEM subjects chokes off the supply of women who can progress into STEM-related careers and continues to waste potential talent.

We next recommend measures to help **recruitment** of more women into the STEM workforce. Having noted the relatively few girls who study STEM subjects post-16 and urged changes, we need to secure their entry into STEM-careers through apprenticeships, graduate routes or otherwise. This is imperative, if future demand for STEM skills at all levels is to be met.

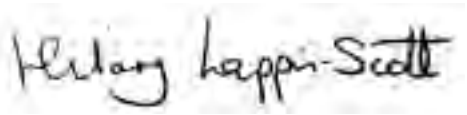
We are also recommending measures for the **retention** of women in the STEM workforce. Women with a STEM degree are less likely to remain in a STEM career than their male counterparts. We need to change this culture.

Finally, we are recommending measures to increase the **promotion** of women in the STEM workforce. Relatively few women hold senior positions in the scientific and technical fields, despite the overwhelming evidence of the benefits of diversity in leadership. Leaders play a pivotal role in any organisation. Their impact is felt in everything from strategic decision-making to organisational and financial performance.

Some of our recommendations are not in the gift or powers of the Welsh Government. These are addressed to other actors, because we want to set an ambitious agenda for everyone with a stake in the future of the STEM workforce – including business, educators and the public sector as a whole. We would like to see the Welsh Government and some other public sector bodies encouraging and facilitating what we recommend others to do, where appropriate.

The under-representation of women in STEM is a complex issue. Producing this report has consequently been a challenging process. We acknowledge the support and advice that many people have provided, especially those stakeholders who responded to our direct questions and attended our focus group. We look forward to a considered response from the Welsh Government.

Professor Karen Holford
FIMechE FICE FInstP FLSW
Pro Vice-Chancellor
Cardiff University



Professor Hilary Lappin-Scott
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Foreword by the Chief Scientific Adviser for Wales

A famous Chinese proclamation declared that 'women hold up half the sky' but in science and engineering they have long been hugely under-represented. While women today are rarely subject to blatant open discrimination in education or the workplace, we still face stereotyping, subtle unconscious biases and structural barriers to our success, in certain sectors. Even in 2015 a mere six per cent of the UK engineering workforce is female and women make up the majority of academic staff in only four out of 23 STEM subject areas, one of which is nursing.

Girls often drop STEM subjects as they progress from GCSEs to A levels, or from A levels to degrees. Yet more young women leave the sciences behind after getting their degree or a postgraduate qualification. In academia and many STEM-related professions, the representation of women falls with every move up the career ladder.

The lack of women in STEM professions matters for their individual life chances. They risk missing out on many well-paid and rewarding jobs. More broadly, however, it limits the talent available to our science base and to businesses in Wales and is therefore a constraint on our wider economic prosperity and social well-being.

This is a complex problem which challenges us to think hard about perceptions of science and engineering and the disincentives – often unintended – that discourage girls and women from participating in STEM. I asked the task and finish group to review all of the evidence and make pragmatic recommendations on what we can do to remove these barriers here in Wales. I welcome the group's well-informed, comprehensive and wide-ranging report, which is challenging and in places radical. It is, however, also very much aligned with the Welsh Government's commitments to a fair and equitable society, where diversity is valued, people do not face discrimination and everyone has the opportunity to fulfil their potential.

I will review the recommendations carefully and work closely with the incoming Ministers on a formal Welsh Government response, over the summer. As everyone knows, the public sector is facing a period of unprecedented financial pressure but the economic and moral case for taking action on this issue is extremely strong.

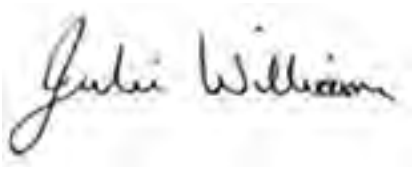
Professor Laura McAllister FLSW
Chair, Sport Wales & Liverpool University

Professor Dame Teresa Rees FAcSS FLSW
Cardiff University

Dr Sophie Buchaillard
Cardiff University

Dr Lucy Knight
Chwarae Teg

In the meantime, I would like to thank all of the members of the task and finish group who worked on this report, under the leadership of the co-chairs, Professors Karen Holford and Hilary Lappin-Scott. Thanks go especially to Professor Laura McAllister, Professor Dame Teresa Rees, Dr Sophie Buchailliard, Christine O'Byrne, Dr Lucy Knight and her Chwarae Teg colleagues.



Professor Julie Williams CBE FLSW FMedSci
Chief Scientific Adviser for Wales

Executive Summary

STEM-related careers are generally rewarding and well paid, reflecting the high level of skills they demand and the value they add to our economy and society. Across the UK numerous STEM occupations – particularly in engineering, healthcare and IT – are experiencing skills shortages, with too few resident workers available to fill existing vacancies. Wales has a chronic shortage of research scientists across a wide range of STEM disciplines, which impedes the success of our research community. This is why educating, recruiting, retaining and promoting women in STEM careers is crucial to the health of our science base and to the performance of the economy as a whole, as well as the life chances of individual women. Currently, less than 10 per cent of engineering employees and STEM professionals overall in the UK are female, compared with three times this proportion in Sweden.

The problem in the UK is that, every year, thousands of women who would make excellent engineers and scientists go into different careers instead. Reasons include tired old stereotypes, such as that science is 'not for girls'; the paucity of famous female scientists and engineers, to act as role models; the absence of flexible working opportunities and assisted paths to return from career breaks and a lack of focused, engaging information and advice about career options.

The causes are many and have been extensively documented elsewhere. This report will focus on proven best practice from across sectors and make recommendations on practicable positive actions that will have an impact on increasing the number of women studying, working and leading in STEM careers. We divide up the challenges that are faced, noting that the theme of leadership flows through much of the best practice and recommendations.

The Challenges

Education

- Girls and women are particularly under-represented in engineering, physics and computer science, from the uptake of these subjects at A-level through to university.
- The current school/college science curriculum does not equip students, male or female, with the skills that universities and employers are looking for.
- Relatively few primary and secondary school teachers have a background in STEM, or specific STEM skills and knowledge and this can make the effective teaching of STEM subjects difficult.
- Children generally enjoy STEM lessons in school yet very few aspire to work as STEM professionals. There are many factors which

influence these decisions including ability (real and perceived), 'science capital', gender stereotyping, lack of awareness of job opportunities in STEM and assumptions made by children, by teachers and by their parents.

- The uptake of STEM subjects at Welsh universities is highly 'gendered': For instance, only 12 per cent of engineering and technology students are women, while they make up 84 per cent of students in medicine-related subjects.
- There are many initiatives to increase the numbers of girls taking certain STEM-related subjects but there has been a lack of longitudinal tracking to determine their impact.

Recruitment, Retention and Promotion

- There is, according to one estimate, an annual shortfall of 40,000 STEM workers in the UK and an industry body claims that the number of engineering graduates needs to double by 2020 to meet demand.
- There is a calculated shortfall of circa 600 STEM academics in Wales, shown in recent research. Realistically, this shortfall can only be met by increasing the number of women already educated in STEM who then enter STEM careers.
- The WISE campaign has estimated that increasing the number of women in STEM could be worth £2bn to the UK economy.
- Greater diversity within the STEM workforce will increase the talent pool, increase the diversity of decision-making perspectives with a more balanced gender dimension, better represent the population and help to fill the shortfall of STEM researchers in Wales.
- The greatest loss of women from STEM careers occurs when they have children. Employment structures still often operate on a full-time, inflexible norm, which makes it difficult for care-givers, typically women, to manage work-life balance and achieve career progression.
- Women are more likely than men to take a career break and are therefore more disadvantaged when applying for promotions due to their interrupted career histories.
- A coordinated strategy and structural change in organisational management are essential to maximise impact.
- Women are under-represented in all types of relevant leadership positions, including secondary school head teachers, STEM professors, fellows of learned societies, FE and HE governors, business leaders and members of STEM-related Welsh Government sector panels.
- Unconscious bias within employment systems and structures is a significant barrier to women's progression.

Our Recommendations:

Education

- The **Welsh Government** should make the achievement of improved gender balance, in STEM subjects and STEM-related training, a theme in appropriate educational policies and programmes – for teacher training; curriculum reform; careers advice; apprenticeships and FE and HE funding, where these concern the delivery of STEM subjects.
- **Teachers** in primary schools' without a STEM background, should be given better awareness of key foundational concepts and issues in STEM, as part of the New Deal arrangements.
- Secondary school **teachers** teaching 'out of field', should seek to be trained in subjects they are teaching (exploring various options, such as summer schools; home learning; e-learning; sabbaticals.
  - ✦ (Supported by **School Heads**. **Education Workforce Council** and **local authorities** should encourage these steps.)
- Relative progression of girls in STEM should be monitored, beyond GCSE (where science is compulsory). Significant under-adoption by girls in any individual school should be investigated, to identify reasons and remedies for any identified problems. **Estyn** should consider any special measures they might impose for this issue.
  - ✦ (**Actioned**, as appropriate, by **Local authorities**, **School heads** and **governors**, **Estyn**.)
- Professor Furlong's **task and finish group** should consider how more effective teaching of STEM subjects, particularly to girls, could be facilitated by changes to teacher training and professional standards.
- **Education providers** should sign up to the 50:50 by 2020 campaign.

Recruitment

- Careers information and promotional materials from **STEM sector bodies** (businesses and otherwise) should be bias-free and include positive role models for girls.
- Models of best practice in the delivery of the Careers and the World of Work (CWW) framework should be identified, disseminated and **schools** encouraged to adopt them.
- All **schools** should commit to obtaining the Careers Wales Mark at the earliest opportunity.
- Imaginative initiatives – challenging gender stereotypes and encouraging girls and boys to consider non-traditional occupations should be encouraged.
  - ✦ (The **Welsh Government** and **local authorities** to encourage these actions).

- Partnership working by **universities**, **businesses** and **third sector organisations** on STEM outreach and engagement should identify and promote the most successful such activity.
  ✦ (The **Welsh Government** to facilitate.)
- Apprenticeship providers should mentor and support those who are following an apprenticeship in gender atypical sectors and occupations.
  ✦ (Actioned by **Apprenticeship providers**, encouraged and facilitated by the **Welsh Government**.)

Retention

Welsh universities should:

- encourage research departments to provide STEM researchers returning after a career break protected time in their workload and targeted mentoring to enable them to lead on research funding applications;
- sponsor dedicated academic fellowships for researchers returning from a career break (with **HEFCW**);
- provide coaching, mentoring and training for employees in workload management, career development and managing work/life balance;
- develop 'keeping in touch' strategies to help researchers maintain and update their scientific knowledge and skills while on maternity or parental leave;
- create a 'Women in STEM: industry and education' network, promoting cross-sector learning and best practice – working with industry;
- cause the 'Women in STEM; industry and education' network, when established, to host a STEM employers' conference, for STEM employers to share best practice and develop and publicise opportunities for women returners.

✦ (The **Welsh Government** to encourage and facilitate the actions above.)

- The **'Business Wales'** service should provide further advice, guidance and support to employers on equality and diversity issues.
- **Employers** to adopt models of best practice in retaining women after career breaks.
- Businesses should be provided with specific advice on how to attract, retain and support women in the STEM workforce.
- **Men and women** working in STEM professions should exercise their right to request flexible working and shared parental leave.

✦ (The **Welsh Government**, **anchor companies** and **employer bodies** to advise, encourage and facilitate the actions above.)

Major STEM businesses should:

- sign up to the WISE 'Ten Steps for sustaining the pipeline of female talent in science, technology, engineering and manufacturing';
- develop 'keeping in touch' strategies to help employees maintain and update their scientific knowledge and skills, while on maternity or parental leave and develop initiatives to encourage such people to return to STEM roles after career breaks – embedding these in their strategic equality plans.

✦ (The **Welsh Government** to encourage and facilitate the actions above.)

- The Welsh Government should review its support for childcare and consider how it can further support a wider range of parents with the costs of childcare – with the long-term aim of developing a universal offer of high-quality early childhood care and education.

Promotion

Welsh universities should:

- take account of candidates' breaks for maternity / parental leave when short-listing for academic and research posts or when considering for promotion;
- demonstrate their commitment to equality in STEM by achieving an Athena SWAN institutional award or ensuring they have publicly-stated equivalent standards in place (with **HEFCW** encouraging);
- consider how they might, working with **HEFCW**, create an all-Wales mentoring scheme, following the model of the Women in Universities Mentoring Scheme, specifically to support women in STEM;
- use alumni records to identify STEM mentors for women in business.

✦ (The **Welsh Government** to encourage and facilitate the actions above.)

- **Businesses** should support campaigns to eliminate the gender pay gap, such as that element in the 'Women Adding Value to the Economy' (WAVE) project.

Major STEM businesses should:

- sign up to the 50:50 by 2020 campaign.
- provide coaching, mentoring and training for employees in workload management, career development and managing work/life balance.

- provide unconscious bias training: firstly for staff involved in recruitment and promotion, then all line managers, in due course.

✦ (**Welsh Government** to encourage and facilitate the actions above).

Introduction

The under-representation of women in science, technology, engineering and mathematics (STEM) is a long-standing and global phenomenon. While some science subjects engage higher numbers of women, for example medical and biological sciences, women make up a small share of students in other STEM disciplines and the proportion of women working in the STEM workforce is low, despite growing recognition that recruiting, retaining and promoting talented women in STEM professions would bring considerable benefits to business and the Welsh economy. The aim of this report is not to revisit the extensive body of evidence that illustrates the issue, but rather to focus on some of the causes and make recommendations for action, informed by existing best practice from all sectors.

For the purpose of this report, STEM is defined as: 'disciplines and industries that fall broadly into the areas of science, technology, engineering and mathematics.'

The overwhelming evidence that women are under-represented in STEM subjects, coupled with a recognition of skills shortages in many STEM-related occupations, has led many governments and employers around the world to acknowledge the need to increase the number of women in STEM. There are now emerging clusters of best practice and successful policy initiatives to learn from.

The Welsh policy context

'Science for Wales' has been the Welsh Government's science strategy since 2012. It sets out a vision of a strong and dynamic research base that supports the economic and social needs of Wales. The strategy stresses that success depends not just on government, but also on the research, business and education communities. Within the theme of 'increasing the science and engineering talent pool', action to increase the number of girls and women in STEM is a key focus.

'The National Science Academy STEM enrichment Strategic Plan 2015-18'

The National Science Academy (NSA) is the Welsh Government's main vehicle for encouraging greater participation in STEM. The NSA principally supports outreach activities, by giving grants to organisations engaging children, young people, teachers, parents and guardians, with a view to increasing the future workforce of scientists and engineers. The Welsh Government recently conducted a strategic review of the NSA, examining its focus, impact and reach. Following the conclusion of that review, its priorities are:

- supporting projects which target children aged 7-14 and their parents/guardians;
- supporting projects that seek to break down barriers to studying STEM subjects, especially subjects where girls are underrepresented; and

- providing long-term stability for programmes seen to be performing well.

'STEM in Education and Training: A Delivery Plan for Wales'

Published in March 2016, the Welsh Government's STEM Delivery Plan outlines current and proposed initiatives to enhance young people's experience of STEM. The importance of increasing the number of girls in STEM is highlighted throughout the plan, which states:

> 'If we are to meet future demands for the STEM skills we know Wales needs for sustained economic growth, we need to increase the supply of STEM skills through greater numbers of young people pursuing STEM as an option. To achieve that, we simply cannot ignore half the population.'

The topic of women in STEM was also a focus for a recent inquiry by the National Assembly for Wales' Enterprise and Business Committee. Their Follow-up Inquiry into STEM's recommendations to the Welsh Government included:

- Based on proven good practice, target more interventions at an early age through to interventions over the long term until there is a gender balance in those subjects.
- Work with STEM employers to develop support structures for providing more flexible and family-friendly working environments and support the work of the Chief Scientific Adviser in this area.

Why do we need to take action?

> 'A more diverse STEM workforce is not simply desirable in terms of equality, but necessary if we are to maximise individual opportunity and meet economic need. […] Currently the UK STEM sector is facing a shortfall of skilled employees with some estimating that the annual shortfall in supply is around 40,000. Other estimates suggest that we need to double the number of graduates and apprentices in engineering alone to meet demand by 2020.'
>
> Campaign for Science & Engineering (CaSE), 2014

In a report published by the WISE campaign in November 2014 – "Not for People Like Me?" – under-represented groups in science, technology and engineering', they suggest that increasing the number of women in STEM could be worth £2bn to the UK economy.

In Wales, there is a projected shortfall of some 600 STEM researchers in our universities. This is preventing Wales from securing a higher share of competitively-awarded research grants from the UK Research Councils and other such providers. Closing this gap could be worth

up to £8m per year to the HE sector in Wales (Halligan and Bright, 2015).

Addressing these shortfalls is critical to Wales' future development as an innovative economy, with a strong science base. Increasing the number of women who study the STEM subjects at more advanced levels and pursue related careers will help to close the gap. Greater diversity in the STEM workforce will make the best use of people's talent and potential and can bring a host of additional benefits to businesses. Studies show that companies which 'deliver on diversity perform better financially, recruit from a wider talent pool, reduce staff turnover and increase creativity and problem solving capability' (WISE, November 2014).

Economic growth:

The engineering sector contributed an estimated £455.6 billion of the UK's £1,683 billion GDP in 2014 (that's 27.1%)

(Source: Engineering UK Report 2015)

Increasing the visibility of women in the STEM sector could also help to challenge gender stereotyping, which contributes to occupational segregation. In 'Gendered Horizons: boys' and girls' perceptions of job and career choices' (Chwarae Teg, 2013) role models they can relate to are identified as a key influence in the way children and young people perceive work and careers, along with aspects of social behaviour.
Policy-makers, educators, careers advisors, parents and leaders across the public and private sectors must work together to address the barriers that are preventing girls and women from accessing the full range of opportunities, so that they can reach their full potential.

The crucial issues to address are in education, recruitment, retention and promotion in both the academic and the business worlds. Clear strong leadership is required to make the practical and cultural changes we need to see. This report considers each of these areas in succession, assessing the current situation and what can be done to recruit, retain and promote women in STEM. Chapter 1 explores the experience of girls and women in the education sector in Wales Chapter 2 focuses on how best to recruit and retain women as they enter, remain or re-enter STEM-related careers. Chapter 3 completes the picture looking at promotion and the role of leadership and role models in changing the landscape for women in science.

Education in STEM – the first step

Pupils from Abertillery School conducting experiments at The Royal Institution Young Scientist Centre, London.

Where do we need greater parity?

Girls perform better than boys at GCSE in every core subject other than mathematics. Figures from exam boards in 2014 show that 73 per cent of girls' exams were graded at least a C, compared with 64 per cent for boys. The gap – nearly nine percentage points – represents the biggest gulf between the two groups since 2003.

However, at A level, girls are under-represented in most of the STEM subjects, with the exceptions of Biology and some vocational award A levels, as shown in Figure 1.

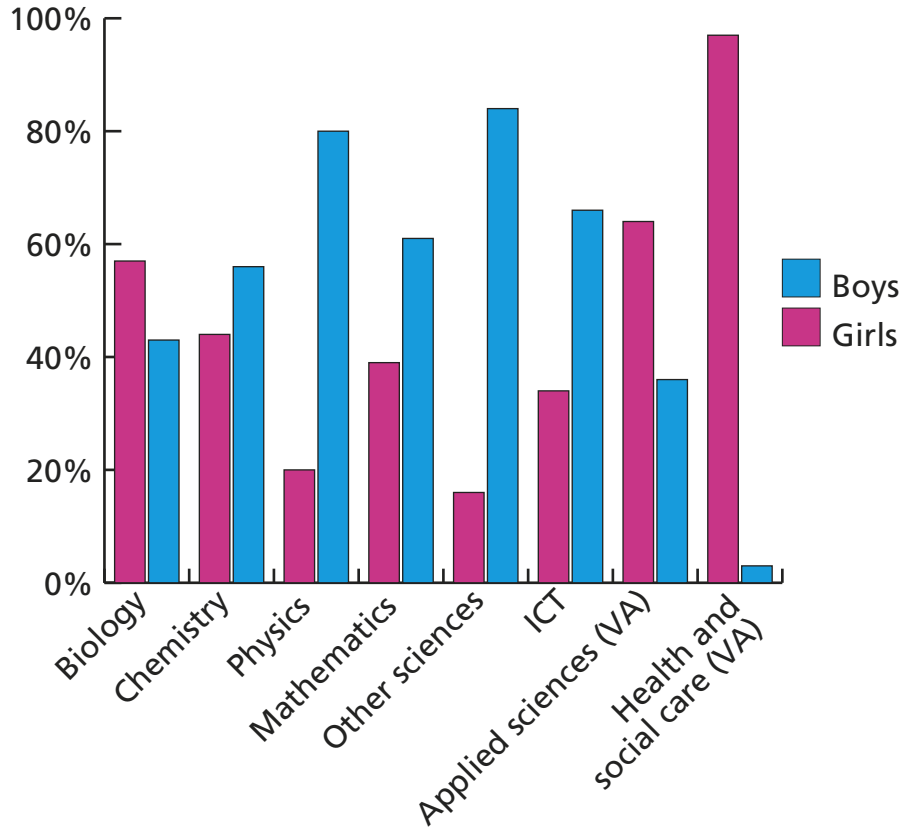


Fig. 1: Proportion of girls and boys taking certain A level subjects in Wales, 2013-2014. (Data source: Welsh Government Annual Examination Results and Schools in Wales: Examination Performance Releases)

Physics and Computing are important A level subjects for pupils wishing to pursue well paid careers in jobs growth industries, yet girls remain significantly under-represented in both. The proportions have remained largely static in Wales since 2009, as illustrated in Figure 2 below.

Around 20 per cent of students studying A-level Physics in Wales are female; this is a symptom of poor girl progression from the present Key Stage 2 to Key Stage 4 in science. By contrast, the Institute of Physics notes that schools in England with more girls taking A level Physics tend to have a better gender balance across other subjects too, suggesting that gender equity within STEM-related subjects

is likely to depend on the whole-school environment rather than specific STEM interventions (IoP, 2013).

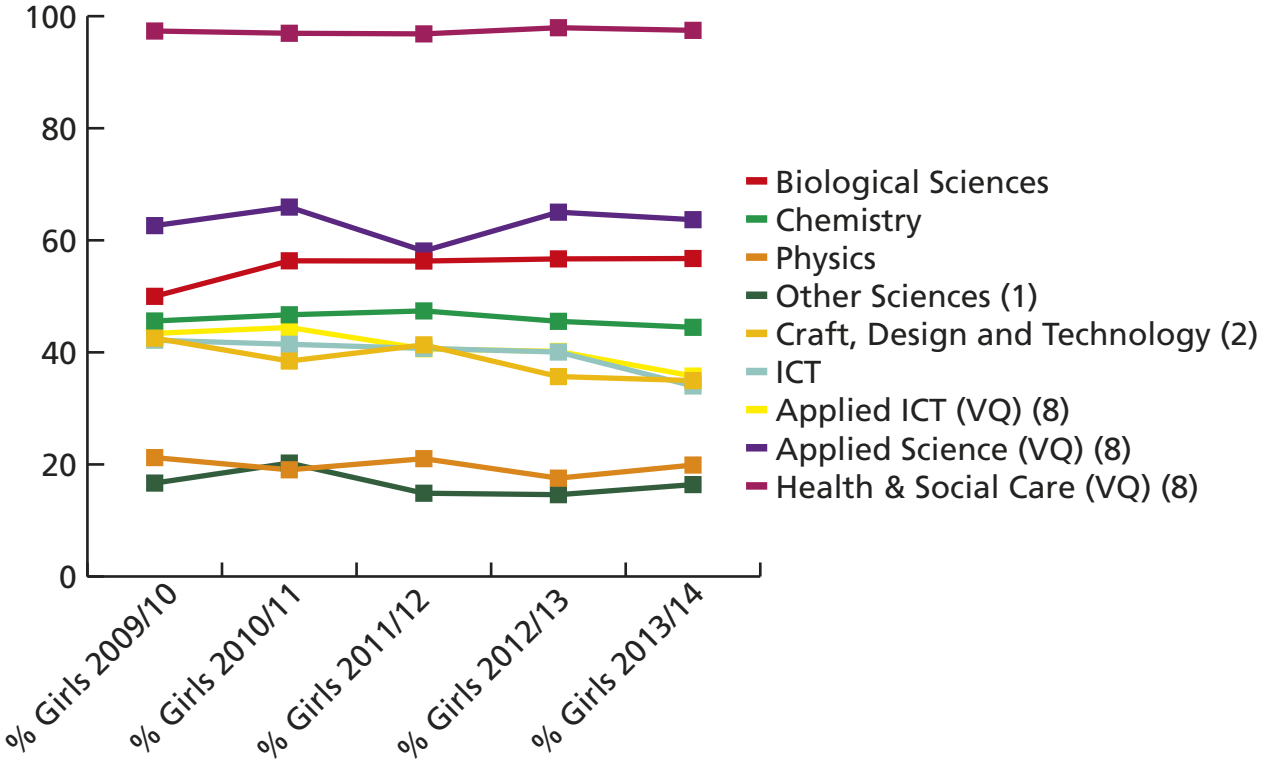


Fig. 2: Proportion of girls studying various subjects at A level from 2009 to 2014. (Stats. Wales, 2014)

Girls and boys achieve almost equal A*-C grades in physics at GCSE level but girls only constitute one fifth of A level physics students.

(Source: http://www.engineeringuk.com/Research/Engineering_UK_Report_2015/)

UCAS records that in 2013-14 only 45 women were accepted onto a Physics degree in Wales from a total of 305 entrants.

We need to double the number of young people studying GCSE physics as part of triple science and increase physics A level study, particularly involving girls.

(Source: http://www.engineeringuk.com/Research/Engineering_UK_Report_2015/)

In Wales, there are stark gender differences between pupils taking A level ICT (the use of computers) and pupils taking A level Computing (how computers work and programming).

In 2013, 610 boys took A level ICT compared with 495 girls (45 per cent), whereas 230 boys and only 30 girls took A level Computing (12 per cent), although Wales fares better than the UK average (E-skills, 2014).

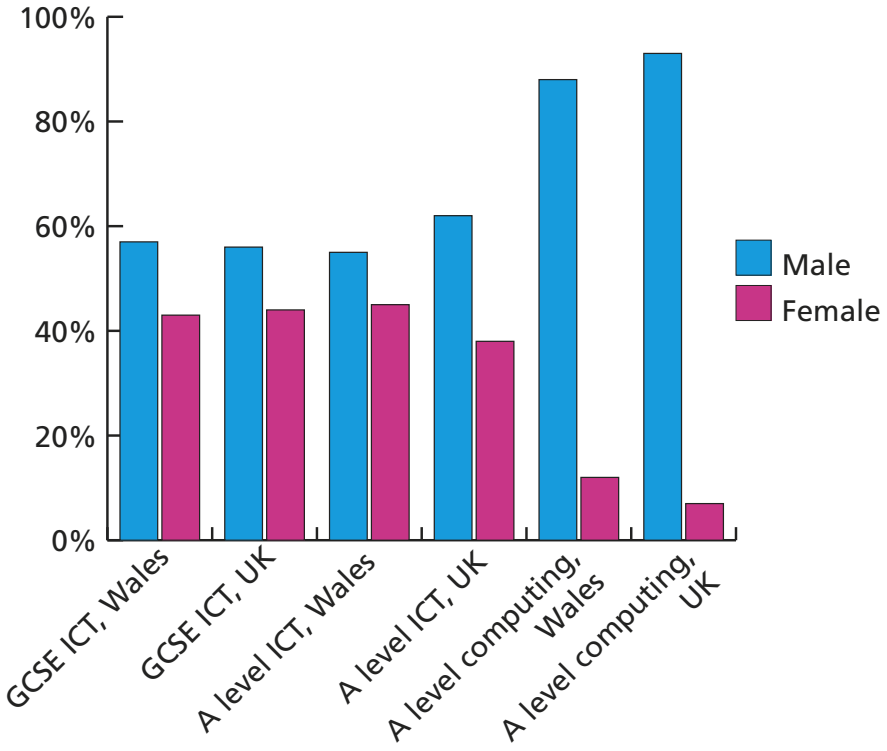


Fig.3: Proportion of boys and girls taking A levels in ICT and computing in Wales and UK, 2013.

These figures show differences that might affect the future prospects of girls. Studying A level Computing equips students with the technical skills necessary for higher-level and better-paid jobs in computing, such as software engineering or web design. Women will remain under-represented in these fields, if the uptake of A level Computing remains low among girls.

School and college teachers

Primary school is the first place where children learn science and their early experience plays a vitally important role in informing their future subject and career choice. Yet few primary schools have access to scientific expertise and research suggests that strategic leadership in STEM at this level is not satisfactory, which is a concern for the future of STEM provision (Wellcome Trust, 2013). Teachers need sufficient knowledge to facilitate learning at Key Stage 2 with confidence. This can be developed through in-service training to very effective levels and should be encouraged more widely.

The situation in secondary schools is different, with a higher proportion of science specialists. In Wales in 2014 there were 14,597 registered secondary school teachers, of whom 4,137 (28 per cent) specialised in STEM subjects. In the same year 198 out of 607 (33 per

cent) newly-qualified secondary school teachers in Wales specialised in STEM subjects.

A large number of secondary school STEM teachers in Wales, however, are not currently trained in the subjects they teach, particularly in Physics, where the proportion is over 50 per cent, as shown in Figure 4. It is essential that secondary school STEM teachers are trained in the subjects they teach, either through initial teacher training or in-service training, if they are to be confident enough in those subjects to engage learners successfully (GTCW, 2014).

Research by the ScienceGrrl campaign (2014) shows that girls' attitudes to the STEM subjects are influenced by:

- Stereotypical images of scientists as a super-intelligent, 'geeky' men working in laboratories
- Assumptions by some teachers that boys are more able in science, which has an adverse effect on girls
- Some longstanding misconceptions about ability, such as men having better spatial awareness and women being more nurturing.

Girls in single-sex schools fare better in their experience of STEM. According to the Institute of Physics, 2.4 times more girls in the UK from single-sex schools take A-level Physics than those from coeducational schools (IoP, 2012). This suggests that there is a gender divide in coeducational classrooms that makes physics less accessible or desirable for girls. Training in gender-inclusive teaching methods and a review of resources were shown to have an impact with the success of the IoP's Stimulating Physics Network (SPN) pilot in England, which generated notable improvements in girls' progression to A level. An interim report from March 2015 provides an evaluation of the most recent strands of this work.

'The core activity of the SPN programme is to work with teachers in a cohort of 400 'Partner Schools'. These schools are identified on the basis of historically low progression rates to AS-level Physics, low attainment in science at GCSE and/or high levels of pupil disadvantage. On this basis, SPN Partner Schools are invited to join the project and receive a two-year programme of support based around bespoke, in-school Continuing Professional Development (CPD) for all teachers of physics. Teachers without a specialist background in physics also have access to a four-day residential Summer School. The CPD is led by a coach employed by the IoP. The SPN also works with 37 'Link Schools' to provide termly CPD events for local networks of schools, coordinating with Teaching School Alliances and Science Learning Partnerships. In 2014-15 the SPN generated 42,993 teacher-hours of physics CPD.

As part of the SPN, work is being done in 20 pilot schools to investigate the most effective approaches to improving girls'

participation in A-level Physics through the 'Improving Gender Balance' (IGB) project. Project officers are undertaking three distinct interventions: working with pupils to improve girls' resilience and awareness of gender issues; with teachers to develop gender-sensitive teaching in the physics classroom; and whole-school initiatives to develop awareness of gender balance, equity and entitlement across all subjects. Findings from this pilot will be integrated into the wider activities of the SPN programme, to drive up the number of girls studying physics at A-level and beyond.' (Source: IoP)

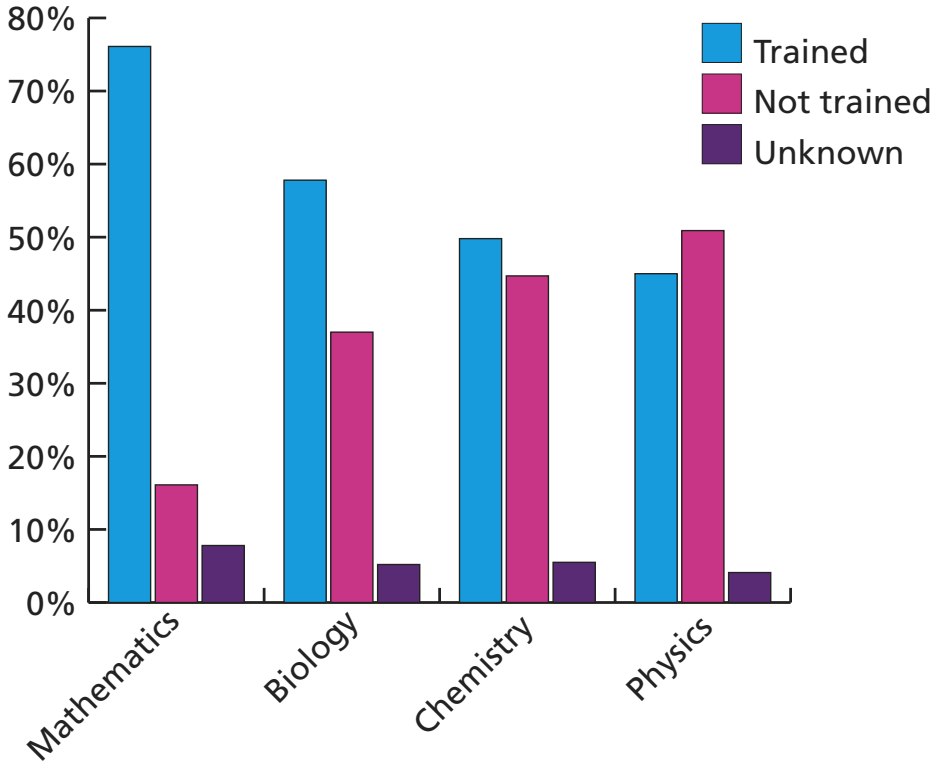


Fig. 4: Proportion of secondary school STEM teachers in Wales trained and not trained in their subject in 2014. (Source: GTCW 2014)

Recommendations:

- The **Welsh Government** should make the achievement of improved gender balance, in STEM subjects and STEM-related training, a theme in appropriate educational policies and programmes – for teacher training, including initial teacher training; curriculum reform; careers advice; apprenticeships and FE and HE funding, where these concern the delivery of STEM subjects.
- **Teachers** in primary schools without a STEM background, be given better awareness of key foundational concepts and issues in STEM as part of the New Deal arrangements.
- Secondary school **teachers** teaching 'out of field' should seek to be trained in subjects they are teaching (exploring various options, such as summer schools; home learning; e-learning; sabbaticals). (Supported by **School Heads**. **Education Workforce Council** and **local authorities** should encourage these steps).

Careers advice and science communicators

Career aspirations and enjoyment of science among children of school age are generally very high. The ASPIRES project run by King's College London (2013) studied the science aspirations of children aged 10-14. It found that 70 per cent of children aged 10-14 feel they learn interesting things in science lessons and 75 per cent believe scientists make a difference in the world. Rather than this positive experience of science teaching being the key factor, for building a higher level of 'science capital', it is exposure to a scientific role model, usually within the immediate family which is the key factor determining whether children aspired to become a scientist. Despite high career aspirations and high enjoyment of science lessons, relatively few would like to pursue science as a career, with fewer than 20 per cent of children showing aspirations to become scientists.

A study by Science Grrl (2014) suggested that the three main influences on children's decisions to pursue STEM are:

- the perceived relevance of STEM to personal identity
- ability in STEM subjects, both real and perceived
- the level of science capital

STEMNET points out that children without familial science capital are unlikely to acquire it at primary school because of the low numbers of teachers with a science degree. More needs to be done to increase the science capital of children in Wales, including more STEM professionals making inspirational visits to schools, such as the STEM Ambassador scheme; STEM professionals providing support to teachers; interventions that involve parents who are often key opinion

formers; improved careers education and advice and increasing children's awareness that an education in STEM is beneficial, whether or not they wish to have a career in a related occupation.

> Longstanding assumptions among teachers, parents and children about girls and STEM need to be challenged, if more girls are to pursue the STEM subjects where they are currently under-represented.

There is a subconscious link between masculinity and science among some girls. The ASPIRES project (2013) found that girls who define themselves as 'girly' were less likely to aspire to a scientific career than girls who do not think of themselves as 'girly'. Many girls and boys are also unaware of the job opportunities within STEM industries. A Girl Guiding survey revealed that 35 per cent of girls think it would be difficult to get a job in STEM, 43 per cent say they don't know what jobs you could get with STEM qualifications and 16 per cent report they cannot afford to study STEM and need to get a job (other than STEM) as soon as they leave school.

It is the responsibility of schools to deliver careers education to young people, as set out in the Careers and the World of Work (CWW) curriculum framework. It is part of the basic curriculum for all learners aged 11 to 16. In 2012 Estyn's thematic inspection of Careers and the World of Work 'Informed Decisions' found that the implementation of CWW was variable. While nearly all schools gave pupils good information to help them to choose subjects in Year 9 (ages 13-14), there was no single model of best practice in the delivery of CWW and there was little rigorous evaluation of how effectively pupils made their subject choices.

The Welsh Government accepted Estyn's recommendations to:

- work with schools to track evidence against the CWW framework;
- remind school governors of their duties to ensure CWW is appropriately delivered and supported;
- work with Careers Wales to develop more informative destination data for school leavers;
- encourage more schools to work towards the Careers Wales Mark award, a quality award which supports and accredits schools' commitment to continuous improvement in CWW.

There is a statutory duty on Welsh Ministers to provide an impartial careers information, advice and guidance (CIAG) service to young people in schools and further education colleges. This independent and professional service is delivered by Careers Wales and there is significant involvement of other partners in the wider 'careers family' including learning coaches; schools; colleges; training providers; university careers services; Jobcentre Plus and other agencies. CIAG

services are, however, built on the foundations that require the provision of suitable careers education by schools and colleges as set out in the Careers and the World of Work Curriculum Framework and its supplementary guidance and supporting documentation.

Careers Wales has produced a guide, 'Spotlight on STEM'. This is a useful starting point for anyone looking for information on STEM careers. Although it does not specifically promote these occupations to girls, associated website videos feature women as well as men and Careers Wales use non-stereotypical pictures and gender-neutral language. We would like to see all bodies involved in providing information about, or promoting careers in, STEM-related sectors make the same commitment and take similar actions.

Careers Wales formerly supported or facilitated a number of imaginative initiatives to challenge gender stereotypes and encourage girls and boys to consider non-traditional occupations. Most have ceased, however, following changes in Careers Wales' priorities, directed by the Welsh Government. This has resulted in changes to Careers Wales' structure and reductions in its budget and ability to continue activity which supported/promoted STEM in schools. The National Science Academy (NSA) is charged with funding and facilitating inspirational learning but this is not tied formally to the curriculum, so it does not substitute for former Careers Wales activity. While we understand the financial pressures on careers services, we urge the Welsh Government to make support for these kinds of activity a priority.

Careers Wales remit, as issued to it by the Welsh Ministers, now focuses on a number of priority groups. Mainstream clients are expected to self serve from the careerswales.com website, Freephone Careers Wales Connect telephone service and web chat services or receive short interventions from careers advisers.

Careers Wales continues to work with professional trade bodies, learned societies and Sector Skills Councils (SSCs) to provide up to date information on careers in these sectors on their website. This includes links to these sector specific bodies websites for specialist advice or information. Careers Wales also works with these bodies to provide up-to-date labour market intelligence (LMI) on jobs, roles and careers in these sectors including qualification requirements, entry methods and progression routes, pay scales, numbers of people in the sector, locations and likely future demand for such roles. This LMI is provided in a user friendly fashion with links to possible courses, the Apprentice Matching Service, Jobs Growth Wales opportunities and searching for vacancy information.

It is the role of the professional trade bodies, learned societies and SSCs to promote their sectors and professions. It is the role of Careers Wales to provide independent careers information, advice and

guidance to the client that is suitable to their aspirations and needs at the time the advice is given. Careers Wales does not have a role in promoting any single sector or career path.

Around Wales many organisations provide science enrichment and communication opportunities which, if better coordinated, could provide the necessary critical mass to ensure real impact.

Dedicated science centres and companies such as Techniquest, Techniquest Glyndŵr, the Wales Institute of Mathematical and Computational Science (WIMCS), the National Botanical Garden of Wales and the Centre for Alternative Technology (CAT) have provided science enrichment activities for large numbers of children such as:

- WIMCS' Further Mathematics Support Programme, which has an emphasis on girls' progression and teacher support.
- Techniquest worked with almost 150,000 pupils in school groups in 2014-2015, 50 per cent of which were girls. Gender awareness and inclusivity is at the heart of Techniquest's development and delivery activity.
- In the same year, 6,522 school pupils from Wales visited Techniquest Glyndŵr and the centre provided outreach activities to 20,135 Welsh school pupils, including female-only workshops for 402 girls, together with the 'Switched On' event to promote physics and computing careers.
- Get On With Science: (2012-13) – A project run by Chwarae Teg (in partnership with ContinYou Cymru) and Fair Foundations, a strand of the flagship Agile Nation project. This saw 28 schools involved, with one teacher from each attending the training days. These involved training in gender awareness in the classroom. Some 980 pupils from year 6 and 600 pupils from other year groups (years 4-8) participated directly. There was a roughly equal split of girls and boys, since the project was aimed at primary school and early years of secondary school and all pupils in selected year groups were involved. The emphasis of the project was to make science lessons and extra-curricular STEM activities gender inclusive and therefore more attractive to girls, rather than the project being aimed only at girls. The outcome of this project has been made available to all schools in Wales.
- Science Made Simple delivered specific projects focused on gender to 22,200 girls in the last four years as part of their 'Who wants to be a superhero?' show to KS2 students.
- Sustainable Science take touring science shows to schools and have reached around 10,000 students per year since 2007, with a specific emphasis on promoting the topic to girls.
- Public engagement company On Show worked with Bosch UK to produce a touring science show based around Bosch technology.

Called the 'All Around You' Roadshow it was developed in consultation with Kate Gentle at Bosch's communications centre. While the show is designed to enthuse people about engineering, the presenters worked hard to ensure that the female members of the audience were encouraged to participate, to try and address the imbalance and lack of female engineers.

- The EESW Formula One challenge attracts 50 per cent female participation and they run a National Science Academy-funded 'Girls into Engineering' project.
- Technocamps, computing workshops for young people delivered by a joint partnership of six of the eight Welsh universities, have to date reached 15,000 participants, 43 per cent of whom were girls.
- Discover Science Saturday Club for Girls for girls in year 9 run by several Welsh universities and Careers Wales
- The Stimulating Physics Network (SPN), which works with non-specialist physics teachers to improve the uptake of physics A level and, following a pilot with 12 schools in 2014-15, has been expanded to 48 schools across Wales for 2015/16, with additional Welsh Government funding administered via Techniquest. The work in Wales at the moment is focused on non-specialist teacher mentoring, with a view to add in an 'improving gender balance strand' once the findings of the pilot in England are known.

In terms of results, in the Partner Schools:

1. The increase in the number of pupils progressing from Key Stage 4 to AS-level Physics was more than double the national rate.
2. The participation of girls in post-16 physics has doubled compared with the national average.
3. In 2012, 82 per cent of pupils achieved grades A*-C in GCSE Physics, compared with 69 per cent nationwide (Source: IoP).

The Welsh Government launched the Focus on Science campaign in October 2014 with a view to increasing awareness of the importance of science amongst teachers, children and their parents. One of the key priorities underpinning the campaign is the issue of girls' participation and progression in STEM subjects. The campaign includes a series of activities and information for the target groups and has been extended to run throughout the 2015/16 academic year. STEM stakeholders are being encouraged to participate in the on-going initiative.

School children in Wales also benefit from UK-wide initiatives, such as STEMNET and the STEM Ambassadors, Engineering UK and the Big Bang Fair and the British Science Association's CREST Awards, to name but a few.

Recommendations:

- Partnership working by universities, businesses and third sector organisations should identify and promote the most successful science outreach/engagement activity.
  ✦ (The **Welsh Government** to facilitate).
- Careers information and promotional materials from **STEM sector bodies** (businesses and otherwise) should be bias-free and include positive role models for girls.
- Models of best practice in the delivery of the **Careers and the World of Work** (CWW) framework should be identified, disseminated and **schools** encouraged to adopt them.
- All **schools** should commit to obtaining the Careers Wales Mark at the earliest opportunity.
- Imaginative initiatives – challenging gender stereotypes and encouraging girls and boys to consider non-traditional occupations should be encouraged.

✦ (The **Welsh Government** and **local authorities** to encourage the above actions).

Further education and apprenticeships

Much of the focus in the STEM agenda is on the supply of graduates, but there is increasing interest in the intermediate-level skills needs of STEM employers. A recent report for the UK Department for Business, Innovation and Skills (BIS) cites evidence that technician roles – jobs lying between the traditional craft worker and the professional engineer – have re-emerged in the aerospace industry, while in other parts of the manufacturing sector the age structure of the workforce is creating relatively high levels of replacement demand for skilled trades (BIS, 2014).

Intermediate-level skills are traditionally a core focus of apprenticeships and the further education (FE) sector more broadly. Apprenticeships are an excellent alternative to, or stepping stone towards, a university qualification and a route into STEM careers. According to the National Assembly for Wales' Enterprise and Business Committee (2015), however, only 15 per cent of employers in Wales currently offer them, mostly due to a lack of clarity about how employers can access apprenticeship schemes and what funding they can receive to do so.

The Welsh Government does promote apprenticeships to all groups as a flagship programme at the centre of its workforce skills offer and it has recently invested a total of £144m to fund 52,000 apprenticeships in West Wales and the Valleys, covering a range of areas including construction, engineering and IT. There are

encouraging signs of success: in 2012/13 just over 28,000 people in Wales started apprenticeships, compared to only 17,900 in 2011/12. Higher Apprenticeships (at level 4 and above) have also seen an unprecedented surge in popularity, with 2,275 Higher Apprenticeship starts in 2012/13 compared to just 280 in 2011/12.

Apprenticeships in Wales should already be provided with due regard for equality and diversity, in line with best practice. While participation is growing, however, gender stereotyping can still be a persistent feature of many apprenticeships. Across the apprenticeship programme as a whole, the majority of learners are female; however, in Construction, Planning and the Built Environment and in Engineering and Manufacturing Technologies, the proportion of male learners is over 90 per cent (Estyn 2014). Apprenticeship providers do work to address gender stereotyping and marketing opportunities (such as 'National Apprenticeship Week') promote the opportunities afforded through apprenticeships to all groups. Nevertheless, Estyn have found little evidence that this is having significant impact in changing patterns of participation. Clearly, more effort is needed – through marketing and mentoring – to address entrenched cultural attitudes about the roles of women and men in particular jobs and industries. We would urge that efforts continue, with extensive use made of appropriate female role models.

Engineering companies will need to recruit around 56,000 engineering technicians per year between 2012 and 2022. Apprentices help meet this demand but there is currently an annual shortfall of 30,000.

(Source: http://www.engineeringuk.com/_resources/documents/EngUK_Report_2015_Interactive.pdf)

Recommendations:

- **Apprenticeship providers** should mentor and support those who are following an apprenticeship in gender atypical sectors and occupations.

✦ (The **Welsh Government** to encourage and facilitate).

Higher education

Across all subjects taught at Higher Education Institutions in Wales, women represent the majority of undergraduate and postgraduate students, yet the reverse is true for most STEM subjects with the exception of biological sciences, as shown in Figure 5:

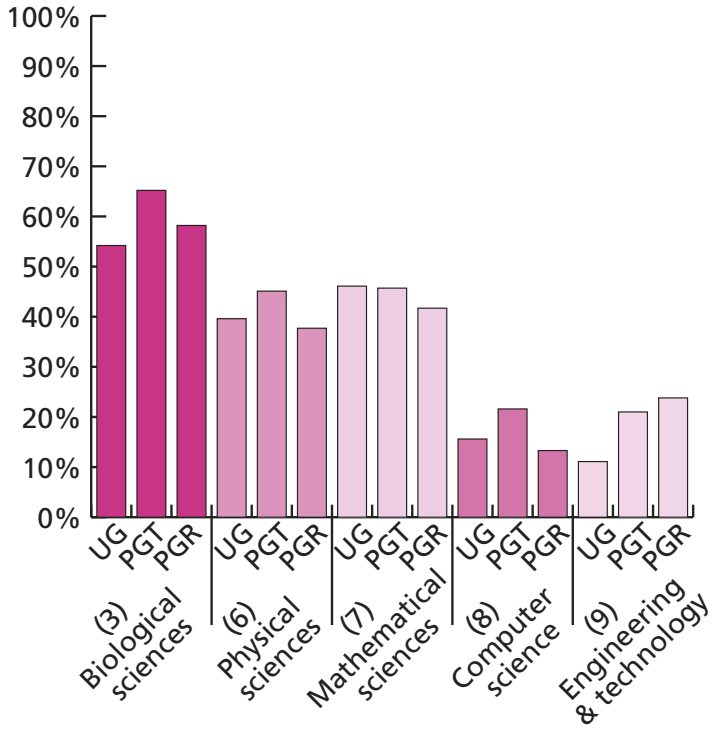


Fig. 5: Female students as a percentage of the total in STEM disciplines at Welsh HEIs in 2014, categorised by Undergraduate (UG), Postgraduate Taught (PGT) and Postgraduate Research (PGR). (Source: HESA 2014)

In 2009, the Science and Technology Facilities Council (STFC) reported that the main obstacles perceived by women to pursuing an academic career in STEM included:

- the male culture of research groups,
- lack of information about how to reconcile a career in STEM with family life,
- being discriminated against because of gender (STFC, 2009).

The Athena SWAN charter, launched in 2005, provides an incentive for universities to develop and share best practice and for STEM departments to collate information and develop comprehensive action plans addressing gender imbalance.

In Cardiff University, staff and students have come together to develop the Cardiff Women in Science network, to provide a platform for women studying or working in STEM subjects. It provides support, training, mentoring and networking opportunities. Swansea University has recently developed a similar network, called SwanSTEMWoMen. Since 2014, Swansea has hosted one of the UK Soap Box Science events where inspiring women scientists from around Wales talk to the public about science, in a novel public outreach format inspired by the soap-box orators at Speakers' Corner in London's Hyde Park.

The Netherlands offers an interesting example of a more aggressive approach to changing recruiting practices – a controversial scheme that sought to address gender balance directly. In 2011 Delft University of Technology (TU Delft), conscious of its distinct lack of female faculty, established a women-only fellowship scheme. This initiative attracted applicants from around the world (only one of the ten initial appointees is Dutch) and has been a notable success. Two of the original fellows have gone on to become full professors, while others are associate or assistant professors. The scheme was challenged on the grounds of gender discrimination and although TU Delft won the case, convincing the Netherlands Institute for Human Rights that it should be allowed to reserve a number of academic positions exclusively for women, in the UK this kind of positive discrimination continues to be illegal, in most cases.

Recommendations:

Welsh universities should:

- create a 'Women in STEM: industry and education' network, promoting cross-sector learning and best practice – working with industry;
- consider how they might, working with HEFCW, create an all-Wales mentoring scheme, following the model of the Women in Universities Mentoring Scheme, specifically to support women in STEM;
- use alumni records to identify STEM mentors for women in business.

The Welsh Government

'The impact of putting the building blocks in place to deliver excellence in STEM skills will be restricted unless this is matched by a notable shift in the perception of STEM' – Welsh Government (2015)

The National Assembly for Wales' Enterprise and Business Committee report 'Science, Technology, Engineering and Mathematics Skills' (September 2014) provides an overview of the under-representation of girls and women in STEM from school to employment and recommends:

> 'Based on proven good practice, target more interventions at an early age to encourage girls to achieve their full potential in STEM but sustain those interventions over the long term until there is a gender balance in those subjects.' (Recommendation 11)

The Minister for Education and Skills accepted this recommendation in 2014 and pledged new funding of £600,000 per annum, over two years to support the teaching and learning of science in schools.

The Minister also stated that the Welsh Government is committed to encouraging STEM graduates to consider careers in teaching There are currently employment-based routes to teacher training and financial incentives for people training to teach STEM subjects. The Minister has announced that during the 2015/16 academic year, students with a 1st class honours degree will be able to claim £20,000 to train to teach the Welsh Government's top priority subjects of maths, physics and chemistry at secondary school level. Graduates with a 2.1 honours degree will be able to claim £10,000 to train to teach the same subjects while those with a 2.2 honours degree can claim £6,000. Slightly lower rates have been set for graduates training to teach computer science at secondary school level; for these medium priority subjects, 1st class honours degree holders can claim a £15,000 incentive while those with a 2.1 can claim £6,000. Finally, in line with the Welsh Government's focus on driving up standards of literacy, numeracy and science, an additional £3,000 incentive will be available for graduates with a 1st class honours degree studying to teach primary school children and specialising in mathematics, physics and chemistry.

This will augment a number of recent initiatives, including the Welsh Government's 'Qualified for Life – Focus on Science' campaign, launched in October 2014, which aims to highlight the importance of science as a subject and a career option for young people in Wales and a new pilot scheme which enabled pupils in Wales from school years 7 to 9 to attend extended experimental sessions at the Royal Institution of Great Britain's Young Scientist Centre in London.

An independent review into the national curriculum and assessment by Professor Graham Donaldson, published in February 2015, recommends a new curriculum for pupils aged three to 16 that moves away from separate, narrow subject-based learning towards six broader 'Areas of Learning and Experience', two of which are 'mathematics and numeracy' and 'science and technology'. Such broader learning and Professor Donaldson's recommendation for an end to the current system of key stages, so that there is a 'learning continuum' for pupils, will offer a more flexible, personalised learning journey. We support Professor Donaldson's view that the curriculum should enable children to develop a good, lasting understanding of mathematical concepts; the confidence to apply numerical skills in everyday life; a familiarity with the essence of the scientific method – acquiring knowledge through observation and experimentation – and the ability to apply scientific knowledge in practical ways.

Alongside the Donaldson Review, in March 2015, the Furlong review recommended a radical plan to transform teaching training in Wales. This is a unique opportunity for the Welsh education sector to ensure that tomorrow's teachers are fully equipped to engage both girls and boys in the STEM subjects effectively.

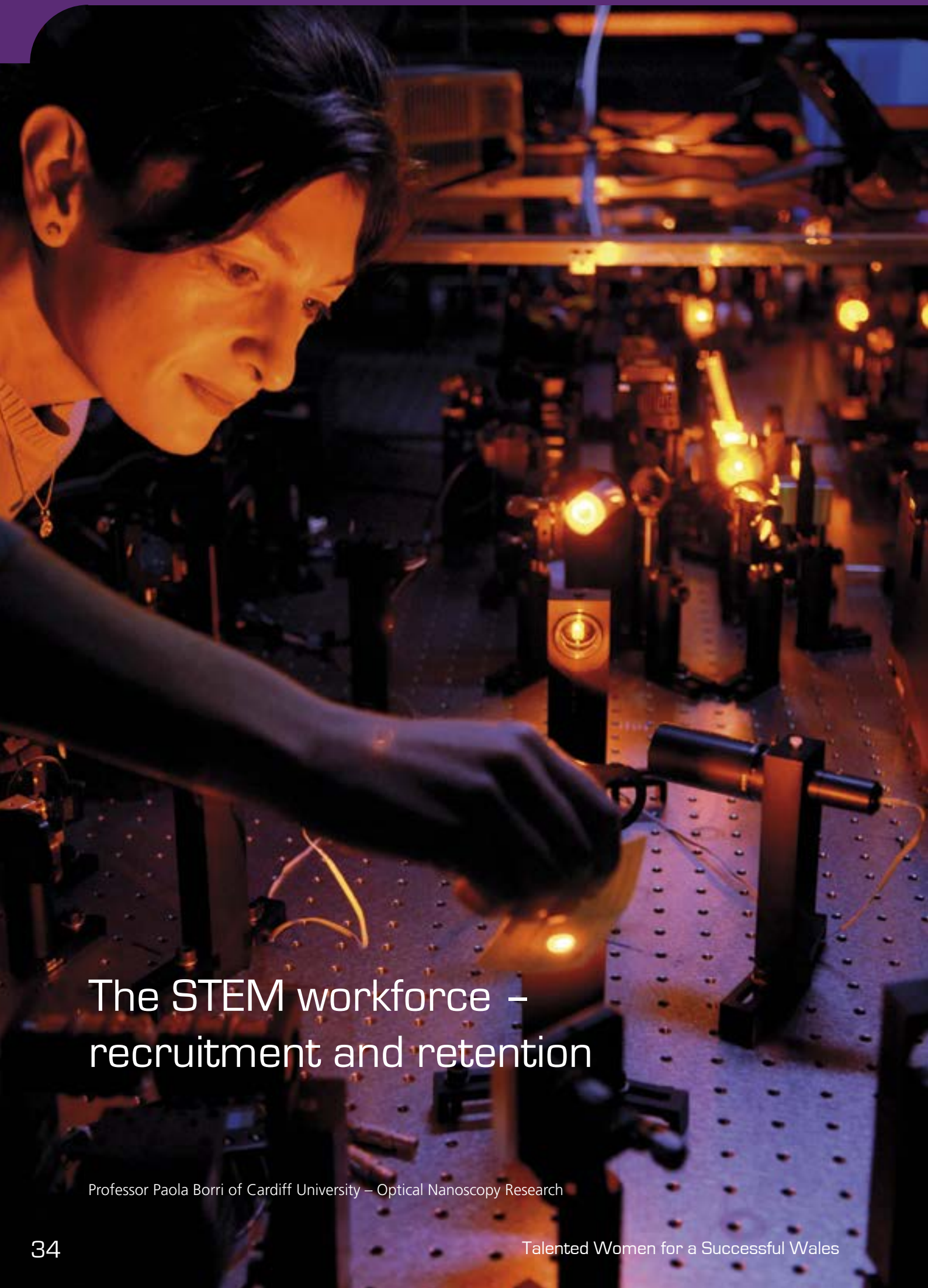
The Welsh Government's 'STEM in Education and Training: A Delivery Plan for Wales' (2016) outlines its commitment to improving the participation of girls in STEM and states that the Department for Education and Skills is prioritising girls' progression in physics and mathematics. Stakeholders we consulted agreed that although there are many excellent interventions, the lack of (and difficulty of) longitudinal tracking makes it hard to evaluate which lead to more girls participating in STEM subjects. Also, given the large number of separate interventions, there is perceived to be a risk of 'initiative fatigue'. We believe that a strategic and coordinated approach across the sector is called for, building on evaluations of 'what works'.

Recommendations:

- Relative progression of girls in STEM should be monitored beyond GCSE (where science is compulsory). Significant under-adoption by girls in any individual school, should be investigated, to identify reasons and remedies for any identified problems. Estyn should consider any special measures they might impose for this issue.

✦ (Actioned by **Local authorities**, **School heads** and **governors**, Estyn)

- **Professor Furlong's task and finish group** should consider how more effective teaching of STEM subjects, particularly to girls, could be facilitated by changes to teacher training and professional standards.



The STEM workforce – recruitment and retention

Professor Paola Borri of Cardiff University – Optical Nanoscopy Research

The 2015 CBI/Pearson Education and Skills Survey reports that employers' confidence in accessing high-skilled employees in the future has dropped steadily over the past three years, with the biggest shortfall in confidence among those businesses with employees in Wales (at -29 per cent, worse than in 2014).

A 2015 UK-wide survey, which included 79 firms which employ people in Wales, found that 72 per cent of firms in the country need more highly-skilled staff, particularly in sectors such as science and engineering, construction and manufacturing. Over 60 per cent are not confident that they will be able to find the high-level skills needed to meet demand and grow.

Although we need to be cautious in interpreting claims of skills shortages, a number of STEM professions appear on the independent Migration Advisory Committee's shortage occupation list for the UK, including biological scientists and biochemists; physical scientists; civil engineers, electrical engineers and design engineers; IT analysts, programmers and systems designers; environmental professionals; and medical practitioners (MAC, 2013). Research by the Campaign for Science and Engineering reports an annual shortfall of 40,000 skilled workers in STEM in the UK (CaSE, 2014). According to the Confederation of British Industry (CBI), 72 per cent of UK businesses aim to recruit people with STEM skills and 53 per cent of those expect problems in recruiting STEM technicians and graduates.

While there may be significant demand for workers amongst STEM employers, however, many suitably-qualified people – especially women – end up working in other sectors. The annual HESA 'Destination of leavers from higher education institutions' survey shows that in 2013, of 529 female STEM graduates in Wales, 104 went on to work in STEM industries (20 per cent), while among 1,153 male graduates, 503 were working in STEM industries (44 per cent).

The Annual Skills and Demand in Industry Survey from the Institute of Engineering and Technology (2014) reported:

- Half of companies saying they wanted to recruit engineers and 59 per cent saying they were having difficulties in finding the people they needed.
- 59 per cent of companies indicated concerns that a shortage of engineers would be a threat to their business in the UK.
- 23 per cent of organisations said that they do nothing at all to improve workforce diversity.
- 43 per cent of employers are not taking any specific action to improve diversity within their workforce.

In response to the question 'What actions has your organization taken to improve the diversity of your engineering, IT and technical workforce?' survey respondents identified the following:

- positive attitude to flexible/part-time working
- female role ambassadors in schools/colleges
- specific campaigns to encourage diverse groups
- providing mentoring
- providing structured career paths with breaks
- equal opportunities policy
- transparency of pay
- working with schools/colleges/apprenticeship schemes
- recruiting and promoting female staff

The 2015 Engineering UK report states that, if women were to participate more fully in STEM employment, it could contribute an additional £2 billion to the economy.

We need to double the number of engineering graduates or see a 50% increase in STEM graduates who will enter the profession.

(Source: http://www.engineeringuk.com/Research/Engineering_UK_Report_2015/)

In Wales, there are currently 50 anchor companies (defined as a company which is a global or international organisation and has Welsh headquarters or a significant corporate presence in Wales) and 57 regionally-important companies, mostly in the STEM sectors. The Welsh Government identified seven STEM key sectors, which employ just over half a million people. Women form only 25 per cent of this workforce and are under-represented in each key sector as shown in Figure 6.

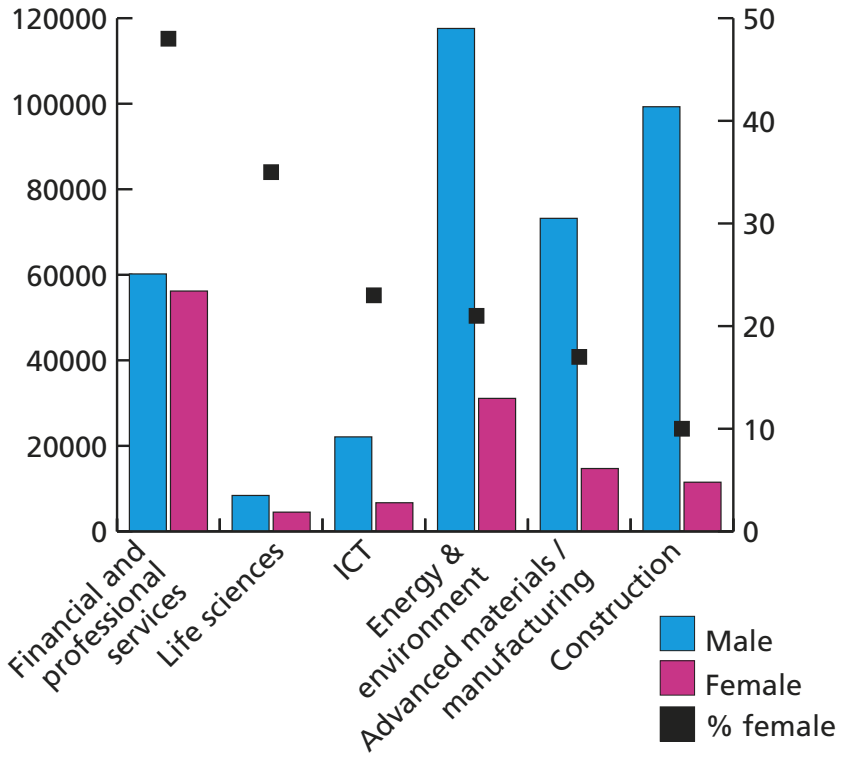


Fig. 6: Numbers of men and women, aged 16+, in STEM key sectors in Wales, 2014 (Source: Priority Sector Statistics 2015, table 3.6)

When and why do women leave STEM careers?

An enquiry by the House of Commons Science and Technology Committee in 2014 found that, once women have children, their difficulty in balancing a career with family and caring responsibilities leads to them leaving academic STEM careers.

Many women take maternity leave during the early-to-mid-stages of their careers and women are also more likely than men to take a career break to care for children of any age or elder family members. This is often a rational financial decision within families, as the partner earning lower pay tends to take care-related leave. Unfortunately these choices leave many women with gaps in their career histories and can cause their skills and professional networks to atrophy. These factors clearly put them at a disadvantage in their prospects for promotion and career progression.

As part of a cultural change, employers should make provisions for shared parental leave and encourage and enable men as well as women to work flexibly or part-time. 'Keeping in touch' programmes should be developed within STEM organisations to ensure people on leave are kept up to date with the latest developments in their fields. Provisions should be made, akin to those ideally in place for people who are returning to work after a period of ill health – for example, a 'buddy' system or a mentoring scheme.

In 2013, recruitment consultants Harvey Nash produced a report entitled 'The Balancing Act: A Study of How To Balance the Talent Pipeline in Business' in which they found that unconscious bias is the principal barrier to women's progression. Bias against women can come about due to *employers' expectation* that women will take time off to have children or request flexible working.

In order to combat this, both unconscious bias and equality and diversity training need to be embedded into the strategic plans of organisations and need to be undertaken by everyone involved in any stage of the staff recruitment process. The Royal Society of Edinburgh's report 'Tapping all our Talents' points out that those in a position to make recruitment decisions can often view a 'full-time, uninterrupted career trajectory' as being more desirable. This puts many women at a disadvantage. We believe that it is essential recruiters and panel members learn to appreciate and credit men and women's output and potential rather than over-emphasising the importance of continuous full-time employment.

Employer's role – Higher Education Institutions

There is an estimated shortfall of just over 600 STEM academics in Wales (Halligan and Bright, 2015). The proportion of female academics in UK STEM departments is 40 per cent overall, with particularly poor representation in some subjects:

- 13.8 per cent in electrical engineering and computing,
- 16 per cent in mechanical, aerospace and production engineering,
- 16.8 per cent in physics.

Low numbers of female academics in these subjects reinforce the stereotype that they are more suitable for men.

At professorial level, in Wales women make up only six per cent of STEM professors (HESA, 2014 – not including Medicine, dentistry & health, where women are a little better represented. See Table 1)

Subject area	No. of women	No. of men	Percentage of women
Medicine, dentistry and health	125	285	30.9 per cent
Biological, mathematical and physical sciences	10	145	6.5 per cent
Engineering and technology	5	105	4.5 per cent

Table 1: Numbers of female and male STEM professors at Welsh HEIs 2013-2014. (Source: HESA Staff Record 2013-2014).

Research output is crucial to an academic's chances of winning further research funding and for promotion prospects in higher education. Many women face disadvantages in this respect. On average, female academics spend more time teaching than their male colleagues, which takes them away from research activity (Royal Society of Edinburgh, 2012). Additionally, the House of Commons Science and Technology Committee reports that women are more likely than men to take on responsibilities, such as outreach, pastoral care and departmental administration, which further reduces time they can spend on research (2014).

These activities have typically not been taken into account in HE assessments such as the Research Excellence Framework (REF), or when research funding is awarded, or in determining promotions. This emphasis on research output is even more problematic for women who take a career break; work part-time or have caring responsibilities outside of normal working hours. In order to address this, REF 2014 introduced very detailed condonment rules to mitigate these (and other) circumstances.

Following REF, the Equality Challenge Unit produced a report on the number of staff returned with clearly defined circumstances such as maternity, paternity or adoption leave and with all circumstances, including caring responsibilities, compared to the predecessor Research Academic Excellence exercise of 2008. The Unit noted:

> 'We were impressed with the number of individuals who had been submitted with complex circumstances, which indicated that HEIs had recognised that complex circumstances do not represent any kind of personal failure on the individual's part. Disclosed complex circumstances covered a range of conditions, with the majority relating to acute physical illnesses and on-going disabilities, as well as caring responsibilities.[…] Our panel was impressed by statements which showed that the institution's employer responsibilities were being taken seriously. It is important that HEIs recognise that staff cannot be expected to routinely conduct their research outside of standard working hours and the associated equality implications if this is not the case. Institutions should advocate an appropriate work-life balance and should play an active role in managing staff working hours. We recognised the particular pressures that might be associated with contracts for both teaching and research and the needs for this to be managed effectively. […] The REF has provided a safe way for individuals to disclose circumstances of a sensitive nature, but it is important that HEIs provide support beyond this. Our panel is keen to encourage a cultural shift towards a more proactive duty of care by institutions.'

Overall, the proportion of staff returned with condonement went from 2 per cent of the total in 2008, to 14.5 per cent in 2014, with 2,601 staff submitted with clearly defined circumstances alone (e.g. maternity, paternity or adoption leave). This is a very encouraging increase, perhaps the beginning of a much needed culture change. The panel that reviewed these results also scrutinised universities' Equality Impact Assessments (EIAs). The panel made the following recommendations:

- HEIs should proactively address inequalities in staff selection, rather than simply accept them as a general 'sector issue'.
- The funding bodies' analysis of selection rates by staff characteristics should be undertaken and published at institutional level, as well as sector level (including gender and any other characteristics for which there are sufficient data at this level).

The data provided in EIAs appeared to display different levels of gender equality in staff selection across the sector. This suggests that an analysis of staff selection for the whole sector (as planned by the funding bodies) would conceal differences at an institutional level.

In March 2014 work by the Research Councils UK (published in The Times, Higher Educational Supplement and using data on all grants awarded since 2010-11) showed that women applying for research council grant funding had a markedly lower success rate than male academics. The greatest difference in success rates came for scientists aged 50-59, applying for large grants, where women were barely over half as likely as men to succeed in their applications. We recommend that further work is undertaken by the research councils on this issue, that other funding bodies be encouraged to look at the gender percentages for research grants and that Welsh universities collect data on this problem.

One of the most difficult periods in a female academic career is returning after a career break. The Daphne Jackson Trust aims to support the UK's research community in its efforts to encourage diversity by offering part-time paid fellowships hosted by universities and research institutes throughout the UK. The Trust works in partnership with universities, research councils, learned societies, charities and industry, to support STEM professionals wishing to return to a research career after a break of two or more years taken for family, caring or health reasons. Whilst the Trust provides the infrastructure and dedicated staff to recruit and retrain Fellows and administer the awards, external sponsors and hosts provide financial support. Many universities choose to both host and sponsor a Daphne Jackson Fellow.

In 2010, the European Commission highlighted in its report Stocktaking: 10 years of women in science policy by the European

Commission that women were less likely to work as research leads and are disadvantaged when applying for funding, due to prohibitive application criteria of continuous employment. In addition, the 2014 House of Commons Science and Technology Committee report found that women were less likely to apply for funding, applied for smaller amounts of money for projects of shorter duration and waited longer to reapply after rejection. All those factors contribute to women progressing more slowly up the career ladder.

The Athena SWAN charter was launched to tackle inequality and the under-representation of women in STEM research and academia. Now driven by the Equality Challenge Unit – a charity, funded through the UK higher education funding bodies, that works to further equality and diversity for HE staff and students – Athena SWAN has started to raise the profile of these and associated issues and gives an opportunity for the HE sector to develop and share best practice in this area.

Universities, individual departments and research institutes can obtain Athena SWAN accreditation and apply for an institutional or departmental bronze, silver or gold award to demonstrate their commitment to gender equality. As of 2015, there were 132 Athena SWAN members across the UK, six of which are Welsh universities and 463 award holders. Although institutionally Welsh universities are mostly showing a commitment to Athena SWAN, table 2 shows that only two institutions in Wales currently hold some departmental awards.

An evaluation of the effectiveness and impact of Athena SWAN conducted by Loughborough University in 2013 reported that 90 per cent of institutional champions and 81 per cent of departmental champions reported a positive impact on gender issues and over half of champions reported a positive impact on women's career progression. Women believe the charter has improved their visibility, confidence and leadership skills and membership has resulted in important actions such as new mentoring systems targeted at women, changes to maternity leave cover and women's networks and leadership training events.

For universities and departments relatively new to the Athena SWAN process or looking to move up to the next award level, the actions that had shown most notable impact were:

- Increased departmental engagement in the process of putting in place equality structures and data-collection systems;
- Increased engagement of university senior management in the Athena SWAN process;

University	Member since	Athena SWAN Awards	Main contact
Aberystwyth University	2011	**Institutional:** bronze	Female
Bangor University	2010	**Institutional:** bronze	Female
Cardiff Metropolitan University	2012	None at end 2015	Female
Cardiff University	2006	**Institutional:** bronze **Departmental:** Biosciences: bronze Chemistry: bronze Dentistry: bronze Engineering: bronze Medicine: bronze Pharmacy & pharmaceutical sciences: silver Psychology: bronze Healthcare Sciences: silver Optometry & vision science: bronze	Female
Glyndŵr University*	-	-	-
Swansea University	2007	**Institutional:** bronze **Departmental:** College of Human and health sciences: bronze College of Medicine: bronze College of Science: bronze	Female
University of South Wales	2012	**Institutional:** bronze	Female
University of Wales, Trinity St. David*	-	-	-

Table 2: Members of Athena SWAN. (Source: Equality Challenge Unit, 2015)

*These two universities offer STEM courses but are not Athena Swan members.

- Improved processes for promotion and reward/review panels, the development of mentoring systems targeted at women, the appointment of designated Athena SWAN officers and changes to the maternity leave cover process;
- The development of women's networking and leadership training events.

According to the report, the most important actions taken since receiving an Athena SWAN departmental award were:

- Enhanced communication within the department concerning equality and diversity matters, in particular the sharing of survey findings and proposed solutions;
- Enhanced support and encouragement for women academics to apply for promotion;
- Ensuring the voice of postdoctoral researchers was heard and acted upon.

The 'Women Adding Value to the Economy' (WAVE) programme provided recommendations for employers with large STEM workforces principally in health and education on the key issues of recruitment, retention and progression for women in STEM careers. WAVE supported the employers with change management advice to embed the actions (WAVE, 2014):

Recruitment – to address the number of women who study STEM subjects but do not go into STEM careers:

1) Research decision factors/influences/barriers;
2) Create an internal careers advisory service that proactively offers coaching and mentoring to women studying STEM subjects;
3) Increase STEM students' exposure to business/commercialisation activities/ job shadowing in academia and in industry;
4) University or university/industry funded Fellowships for research only contracts (Welcome, Nuffield etc. only offer buy out of teaching time);
5) Review wording and images used in STEM recruitment.

Retention – to understand why women leave or do not progress at the same rate as men, and where there is dissonance with organisational values, career-track 'norms', work intensity, lack of flexibility or and barriers for women 'returners'.

1) Create clear career paths for teaching and research, teaching and scholarship, and research-only contracts;

2) Undertake research with staff to understand the impact of the organisational culture and values, and whether this creates particular dissonance for women;

3) Research the membership of formal and informal networks, and their influence on participation and citizenship within the university;

4) Data analysis of career progression for women who return to STEM careers after maternity/childcare leave;

5) Introduce a Returners Policy: for returners to work from any extended period of leave (maternity, paternity, parental, adoption, carer, career break) to ensure that people can catch up with skills, learn about changes in the organisation, request flexible working, and discuss their personal development plans;

6) Career Advancement Fellowships for women returners;

7) Implement Agile working arrangements, work towards these becoming the organisational norm;

8) Limit Fixed Term contracts to three, after which an application for a tenured position can be submitted for consideration;

9) Pay childcare costs and provide a carer so that women can attend conferences in the UK, Europe and international;

10) Unconscious bias training to address perception that women who have had career breaks to care for children are no longer career orientated.

Progression – women 'ceilinged' within academic or medical careers for the reasons above:

1) Analyse the rate of progression of women working on a part-time basis in higher graded jobs;

2 Create a Ready for promotion scheme – a promotion panel is arranged once criteria are met, and mentoring/coaching for promotion offered;

3) Require gender balance on all school, college, university committees, recruitment, promotion and award panels;

4) Undertake research to discover the importance of line management endorsement for promotion/promotion panels;

5) Make staff progression part of line managers' personal development reviews;

6) Include non-traditional evidence in promotion decisions;

7) Provide Job-Shadowing and Job-Swapping opportunities throughout career pathways, not just for new entrants.

Recommendations:

Welsh universities should:

- take account of candidates' breaks for maternity / parental leave when short-listing for academic and research posts or when considering for promotion;
- encourage research departments to provide STEM researchers returning after a career break protected time in their workload and targeted mentoring to enable them to lead on research funding applications;
- demonstrate their commitment to equality in STEM by achieving an Athena SWAN institutional award or ensuring they have publicly-stated equivalent standards in place.
  ✦ (with **HEFCW** encouraging).
- sponsor dedicated academic fellowships for researchers returning from a career break.
  ✦ (with **HEFCW** also).
- cause the 'Women in STEM; industry and education' network, when established, to host a STEM employers' conference, for STEM employers to share best practice and promote opportunities for women returners.
- integrate WAVE measures within Athena Swan actions plans in Higher Education, and in medical careers when Athena Swan is rolled out with health providers.
- **Research councils** should undertake further work, building on their work showing female applicants for grant funding as being less successful than equivalent male applicants; other **funding bodies** should be encouraged to look at their gender percentages for research grants and that **Welsh universities** collect data on this problem in their institution.

Employers' role – Business and industry

It is essential that returning to a career is as seamless as possible to encourage women to stay in STEM-related professions. If women do not return, their knowledge and work experience will be wasted and their potential contribution to future STEM innovation will be lost. If more women return and remain in STEM careers, the STEM workforce will become more diverse and representative of the population and the pool of female role models for future generations of scientists and engineers will become increasingly rich.

For employers, there is also a price for losing skilled employees who need to be replaced, incurring recruitment and training costs. Retention is a more cost effective approach, especially for small and medium-sized enterprises (SMEs).

The gender pay-gap and gender segregation

Although, on average, people in STEM occupations earn 20 per cent more than in other sectors (CaSE, 2014), women in management roles are paid less than their male counterparts. The Chartered Management Institute (CMI) reported a staggering gender pay gap among all managers in Wales of £3,771 in 2014, with male managers earning an average of £30,387 compared with £26,616 for female managers. Salary figures for 2014 show that a 'mid-life pay crisis' is also hitting female managers, with women aged 40-plus earning 34 per cent less than men. To earn the same as a male manager over a career, a woman would have to work the equivalent of over 14 years more. Findings from the 2015 survey of 72,000 UK managers reveal that women working in equivalent full-time roles now earn 22 per cent less than men. This is equivalent to their being unpaid for one hour and 40 minutes of each working day, if they received the male rates – a total of 57 working days every year,

Analysis of the data from the 2015 National Management Salary Survey highlights pay imbalances across the UK's professional workforce. For men and women of all ages and in all professional roles the gender pay gap now stands at £8,524, with men earning an average of £39,136 and women earning £30,612. In 2014, the pay gap stood at £9,069, or 23 per cent (CMI 2015).

The pay gap rises to £14,943 for senior or director-level staff, with men earning an average of £138,699 compared with the average for women of £123,756. Women managers are also missing out across all levels when it comes to bonuses, with the average man's bonus of £4,898 almost twice that of the average woman's bonus of £2,531 (CMI 2014).

A survey, conducted in 2014 by Prospect; Women in Manufacturing; TRS and the Women's Engineering Society, sought to understand the barriers to women entering or returning to STEM careers. Of the 5,000 respondents, 30 per cent were not currently working in STEM. Despite the generally attractive salaries on offer in STEM occupations (see CaSE, 2014), respondents cited a poor level of pay, in comparison with other sectors, as the biggest single reason given for not returning. The survey found that STEM qualifications opened the door to better remuneration in other sectors where women found greater flexibility, speed of career progression and better general working environments.

Recommendations:

- **Anchor companies** and **employer bodies** to encourage employers to adopt models of best practice in retaining women after career breaks.
- The '**Business Wales**' service should provide further advice, guidance and support to employers on equality and diversity issues.
- **Businesses** should support campaigns to eliminate the gender pay gap, such as that element in the 'Women Adding Value to the Economy' (WAVE) project.

✦ (**Welsh Government** to encourage and facilitate).

Training and development

Findings from the House of Commons Science and Technology Committee (2014) suggest that before applying for a promotion, women tend to wait until they have all the essential and desirable criteria, whereas men are more likely to take their chances. Interventions aimed at encouraging women to apply for promotions could be very beneficial.

The problem is most acute for women returning after a career break, as their knowledge can be out of date by the time they return, particularly since STEM-related fields are often very fast moving. In addition to support and training for returners to update their knowledge, 'keeping in touch' days during periods of leave could also be extremely beneficial. Ideally, initiatives to encourage returners to resume STEM roles after a career break should be embedded into University strategic equality plans but we appreciate that they have been finalised recently and will only be reviewed in 2020.

Recommendations:

Welsh universities and **Major STEM businesses** should:

- provide coaching, mentoring and training for employees in workload management, career development and managing work/life balance;
- develop 'keeping in touch' strategies to help researchers maintain and update their scientific knowledge and skills while on maternity or parental leave.

✦ (**Welsh Government** to encourage and facilitate).

Work culture

In 2012, the CMI presented evidence to the Business, Innovation and Skills Committee on Women in the Workplace. In its submission, CMI stated:

> 'while progress has been made, issues persist regarding both pay and career progression for women. More needs to be done to change corporate cultures and […] more transparency would help encourage the worst offenders to take action. Research shows that companies who embrace gender diversity and have one or more women on their board perform better compared to those who do not. However, for lasting progress to be made, efforts should not focus solely at the board level, but also on creating a strong talent pipeline of women at all levels in the workplace.'

A number of recommendations to employers made here are not gender specific, but address the broader work culture. When an organisation introduces policies to accommodate women returners, such as part-time or flexible working and mentoring programmes, it is important that such policies are available for all groups of staff and are promoted as positive change. Indeed there are organisational and learning benefits in encouraging more men to take up these opportunities; mentoring provides two-way learning opportunities for both mentors and participants (de Vries, J, 2011).

In some organisations, the attitude still prevails that anyone working part-time or flexibly is not as committed or productive as those who work long hours on a full-time basis. This perception will only be tackled if it is recognised that flexible working arrangements constitute a positive overall culture change for everyone.

The CMI report states:

> 'flexible working can have huge benefits for employers and employees alike, which is why CMI's members have consistently supported the extension of the right to request by around two to one. In addition, around one in five female managers (22 per cent) cite family commitments as a barrier to progression, while they are also more likely than men to mention 'work-life balance' when asked what would attract them to a new job. CMI's annual 'Future Forecast' report surveys our members on their preferred policy options for the year ahead. Sixty-two per cent of respondents supported extending the right to flexible working, however this rises to 75 per cent when looking at female respondents, although it only ranked tenth for male managers (59 per cent in favour). Despite this difference, the figures clearly show this is a popular measure among managers. […] Flexible working is highly valued by staff and can make a real difference to their lives. As a result it generates a lot of goodwill and enthusiasm for the company. That alone is of huge benefit to employers.'

The report concludes that managers have a pivotal role to play in making flexible working a success, by focusing on managing the results that employees achieve and not simply the hours they spend at a desk.

The long-hours culture of many STEM jobs makes it is particularly challenging to combine careers with family commitments. One obvious solution is for employers to offer quality part-time job opportunities. In many STEM employers, however, jobs have not been designed to accommodate part-time working, leaving employees in the position of missing out on important meetings and – in academia – with less time to conduct research. The Royal Society of Edinburgh (RSE) recommends that STEM employers should 'address the issue of job design' for women and men (RSE, 2012). A similar rethink of job design in Wales, improving flexible working options for both women and men, would be greatly beneficial. Moving away from the language of part-time/full-time work to describing hours worked and role would contribute to this culture change.

> 'Until more flexible and/or part-time working becomes the norm for men as well as women, it is likely to be negatively stereotyped.' – (Norma Jarboe 2013)

We would like to see the positive promotion of role models, not only of women in STEM who successfully balance career and family life but also of men working flexibly or part-time, either in a STEM occupation themselves or so as to allow their female partners to invest more time in a STEM career. This would help challenge the popular assumption that women should take on the majority of caring responsibilities.

When designing and implementing policies to help women returners, it is vital to consider how these policies could impact positively on everyone. Flexible and part-time working options for men would not only make for a positive culture change and allow women to share childcare responsibilities with their partners, they would also relieve many men from the burden of the long-hours culture and allow them to participate more fully in family life.

Many businesses appreciate the benefits of flexible working, for instance:

- improved competitiveness;
- an opportunity to extend operating hours, which could lead to increased profits;
- better staff morale due to greater job satisfaction;
- reduced level of sickness and therefore reduced costs of associated absences;
- increased efficiency and saving on overheads through some staff working from home;
- ability to attract and retain a more diverse workforce and reduce recruitment costs;

- lower rates of staff turnover as staff who might otherwise have left can be offered hours they can manage.

Peter Boucher describes what flexible working looks like in the era of mobile technology and promotes its benefits to employers:

'Flexible working' is more than just working from home. It's about working from wherever you need to be, whether that's from a café with a client, a customer's HQ or during your commute. By making best use of technology such as audio and video-conferencing, instant messenger and mobile internet, this can be achieved while strengthening collaboration and enhancing a sense of community between colleagues – even if employees aren't physically in the same place.' (In 'How Flexible Working Can Benefit you and your Employee' (Source: http://gu.com/p/3f4mb/sbl)

Flexible working would also help those women and men with STEM skills and qualifications who cannot find suitable vacancies within a convenient commuting distance of their homes. This is a particular problem in rural areas, such as mid-Wales. In a recent survey of women in STEM in Wales, 53.3 per cent of respondents stated this was a significant issue (Chwarae Teg, 2012).

A separate point concerning recruitment material in Welsh can be made. It is note-worthy that in the Welsh language many job titles have been traditionally assigned genders, according to historic views. Best practice has ensured that such job titles are rendered in a gender-neutral way.

Recommendations:

- **men and women working in STEM** professions should exercise their right to request flexible working and shared parental leave
  - ✦ (**Welsh Government**, **anchor companies** and **employer bodies** to encourage and facilitate).

Major STEM businesses should:

- provide unconscious bias training: firstly for staff involved in recruitment and promotion, then all line managers, in due course.
  - ✦ (The **Welsh Government** to encourage and facilitate).

The Welsh Government

In 2014, the National Assembly for Wales' Enterprise and Business Committee report 'Science, Technology, Engineering and Mathematics Skills' recommended that the Welsh Government:

'…work with STEM employers to develop support structures… providing more flexible and family-friendly working environments.'

A report from Cardiff University (2011) entitled Insight into ill-treatment in the workplace: patterns, causes and solutions identifies employees' lack of awareness of their rights, benefits and employers' obligations as a key factor in fostering inequality. In Wales, only 18 per cent of workers felt 'very well informed' about their rights, compared to 26 per cent in England and 30 per cent in Scotland.

The survey underpinning this report showed that workers have good awareness of their rights in relation to discrimination and paid maternity leave, but relatively poor knowledge of their rights regarding flexible working and unpaid leave. A greater awareness of rights in Wales, alongside public encouragement for both women and men to take parental leave, would help promote a more equal allocation of caring responsibilities and career opportunities between the genders.

The authors place the responsibility for raising awareness of rights in the workplace firmly with employers and line managers. We also see a role for the Welsh Government in encouraging businesses and providing or facilitating any additional information, advice and guidance on good practice which can be provided. The Business Wales website already has considerable material on flexible working rights and duties and related policies.

The availability of accessible, high-quality childcare is a critical issue for working parents, whichever sector they work in. Eight out of ten families in Wales with children under 15 use childcare and the majority pay for it. Childcare in the UK is particularly expensive. Families here pay more for childcare than in any other country in Europe, except for Switzerland. The Family and Childcare Trust's 2015 survey of childcare costs revealed that parents spend, on average, more than £7,500 a year on childcare for two children, more than the annual cost of a typical mortgage.

The high cost of childcare is linked to the need to maintain safe supervision levels and also to our national reliance on the private and not-for-profit sectors to provide most such services. The Family and Childcare Trust concluded that only 5 per cent of Welsh local authorities provide enough out-of-school childcare for 12 to 14-year-olds, a significantly lower proportion than in England or Scotland.

The Welsh Government provides support to help local authorities with out-of-school childcare, via the Out of School Childcare Grant. In 2015-16 the grant provided £2.3m to local authorities to help them provide good quality and affordable out-of-hours childcare. The Flying Start programme provides 12.5 hours a week of high quality childcare to eligible 2 to 3 year olds, targeting the most disadvantaged communities. We applaud the expansion of the programme, which has doubled the number of children benefitting from 18,000 to 36,000 but we believe that more needs to be done.

Besides Flying Start, people on low incomes can receive some help to pay for childcare through the tax credits system. Families who are not eligible for tax credits, however, have fewer options. Some employers offer childcare vouchers under a HMRC-backed 'salary sacrifice' programme and a new tax-free childcare scheme is scheduled to begin in 2017. This is a welcome measure but it will not address the continued problem of an inadequate and inflexible supply of childcare.

We agree with the conclusion of the Welsh Government-commissioned Graham Review, which argued that, over the long term, Wales should aspire to a universal offer of high-quality early childhood care and education for all of its pre-school children. This would be good for working parents and good for children. International evidence indicates that those countries which invest most heavily in early years care and education, such as Denmark and Sweden, have lower rates of child poverty and higher rates of social mobility, as well as a better record on gender inequality (Ben-Galim, 2011).

Recommendations:

- Businesses should be provided with specific advice on how to attract, retain and support women in the STEM workforce.
  ✦ (The **Welsh Government**, **anchor companies** and employer bodies to advise, encourage and facilitate the action above).

Effective interventions

Table 3: Examples of effective interventions addressing common barriers to women's advancement in STEM careers.

Intervention	Impact	Context & content		
Details	Core effect	Knowledge	Maturity	Complexity
Actions by organisations				
The Promotion Project University of Tromsø Simulates the academic professorial promotion process https://genderedinnovations.stanford.edu/institutions/UnivofTromPromotionProj.pdf	Women are confident that they are ready for promotion and should apply when the opportunity to advance becomes available	Based on evidence that women are reluctant to self-nominate for promotion even when ready.	Developed and successfully tested in 2010 – 2011 at the University of Tromsø, Norway	Simple and easily reproducible approach, designed to increase self-confidence by enabling better understanding of the promotion criteria and processes
Discover Markets Fraunhofer Gesellschaft Uses participatory approach to enhance the variety and scope of innovation ideas http://www.cerri.fraunhofer.de/en/projekte/discover-markets.html	Women (and other 'user' groups) who are outside the formal innovation system (e.g. not based in research labs) are engaged in the idea creation process.	The ideas produced by the 'non-experts' are validated for their implementation potential by Fraunhofer engineers. As an example, of the 100 ideas produced in the context of rehabilitation, 70 were judged as ready for implementation and some the engineers said were better than their own ideas.	The Discover Market method has been devised by Martina Schraudner and her team in 2010 and has been further improved through different applications. It has led to the creation of the Centre for Responsible Research and Innovation at Fraunhofer Geselschaft, Berlin	The method has been well tested and the process can be replicated elsewhere and for a range of technical topics. It is a useful and a novel approach for crossing the 'valley of death' in the innovation ecosystems, i.e. bringing technical knowledge and market opportunities closer together.

Intervention	Impact	Context & content		
Details	Core effect	Knowledge	Maturity	Complexity
InnoCentive Uses crowdsourcing to identify solutions to scientific or technical and other problems research labs, or companies find hard to solve. www.innocentive.com	Women scientists and engineers outside the formal system (i.e. not based in universities or research labs) can participate in innovation problem solving. This ensures that all available talent can be harnessed to improve outcomes.	Analysing a unique dataset of 166 science challenges involving over 12,000 scientists revealed that female solvers – known to be in the 'outer circle' of the scientific establishment – performed significantly better than men in developing successful solutions. http://dash.harvard.edu/handle/1/3351241	www.innocentive.com has been operating for several years. (Nature.com is one of the partners.) The method successfully uses 'markets' to solve internal, firm-based R&D problems, also taps to the female talent 'lost' to formal research and innovation through the 'leaky pipeline' phenomenon.	Problems are broadcast by organisations on the Innocentive website. Upon learning of the existence of the problem, solvers self-select to attempt to create a solution and are rewarded for their efforts if they are successful.
Daphne Jackson Trust Fellowships Daphne Jackson Trust Retraining research fellowships designed to enable return to STEM employment after a career break. www.daphenjacksontrust.com	Women (and men) are provided with the opportunity to update their research competences and improve future employability in STEM after a career break.	The scheme was set up in 1987. It involves a 2-year part time research-based retraining fellowship, hosted usually at a university or a research lab (including in industry). The scheme was set up by Daphne Jackson, the first woman Physics professor in the UK.	The scheme achieves 97 per cent success rate of fellowship completion and return to STEM related employment.	A team of ex fellows acts as advisers to the applicants. The applicant is responsible for finding the host organisation and the supervisor and to structure a proposal that shows how the research retraining will improve employability. Similar schemes have been since adopted by in the UK by Wellcome and by STFC.

Intervention	Impact	Context & content		
Details	Core effect	Knowledge	Maturity	Complexity
Equalitec Portia Two career support schemes to help women re-establish careers in ICT. http://www.portiaweb.org/index.php/equalitec	1. Women returned to software development through in-house (re) training 2. Women returned to ICT through in-house training and experience of project management.	1. Designed and tested by ThoughtWorks in collaboration with Portia as part of an EU funded project during 2006-2007. A dozen women out of 60 applicants were selected for training in house on Java programming and agile software development methods. 2. Recruitment process tested with Fujitsu Services in 2005-2007, in collaboration with Portia and Daphne Jackson Trust. Fujitsu Services needed project managers for their work on the NHS Health Informatics programme and as part of this had to demonstrate commitment to gender equality.	1. According to Thoughtworks this was a successful and a cheaper way to recruit talent than their traditional route of using the service of external recruiting agencies. Interestingly, the non-standard CVs of these women would have been rejected in a normal recruitment process for failing to match the company's expectations. 2. The selection process used here was an adaptation of the Daphne Jackson approach. The selected women spent one year at Fujitsu Services being trained on project management industry best practice.	1. An advert was placed in Metro newspaper; 60 women applied, 12 were selected for a 3-month, in-house training programme. The same competency assessment methods were used as under normal conditions. Four women were employed by ThoughtWorks and eight were placed elsewhere by Portia. 2. The women were retrained on the PRINCE methodology as part of the project then put forward to Fujitsu Services as candidates for the scheme. Fujitsu Services used their internal process to make the selection decisions.

Intervention	Impact	Context & content		
Details	Core effect	Knowledge	Maturity	Complexity
Academia Net Robert Bosch Foundation European database of excellent women in STEM www.academia-net.org	Women are nominated for inclusion in the database by leading European science institutions according to specific excellence criteria. Their CVs are listed on the Academia Net to enable easier access to the pool of excellent women scientists working (mainly) in Europe.	The aim of Academia Net is to help organisations wishing to recruit or appoint female scientists to have access to suitable candidates. It operates through partners who select and nominate suitable candidates. Among them are Royal Society, Wellcome, Max Planck, Fraunhofer, VDI, EMBO and many other leading research organisations in Europe.	The database was created in 2000 by the Robert Bosch Foundation and has accumulated around 2000 entries during the first 5 years. It continues to grow as new partners join the scheme.	The three main criteria are: outstanding professional qualification; independent leadership activities; and academic credentials. The database provides a good source of career role models for women at the start of their science careers, showing how diverse STEM career pathways can be.
Creating Futures in Science Portia Scenario Workshop for organisations to provide career development support for women at early career stage (PhD, Post doc). http://www.portiaweb.org/index.php/2012-07-11-23-46-44/creating-futures-in-science	Women at early career stage become better informed about the landscape in which their career can develop; the variety of possible career pathways that are possible; and learn to improve their self career model.	The method is based on the extensive body of research findings about career issues in science. It provides a variety of participatory activities in the form of a Scenario Workshop. Participants learn from role models, from each other, as well as from senior institutional research leaders, HR leaders and senior women from other organisations about career-life demands and how to resolve them.	The Scenario Workshop was developed and tested in three institutions in three countries: Fraunhofer, ETH Zurich and Tel Aviv University as part of a project funded by the Elsevier Foundation. It could be offered on a regular basis as a career development support service for newly recruited PhDs and Post docs.	The scenario workshop was designed for use by institutions. It produced a toolkit, which provides all needed details. The design can be adapted to local circumstances and needs.

Intervention	Impact	Context & content		
Details	Core effect	Knowledge	Maturity	Complexity
Research Oriented Standards on Gender Equality German Research Foundation (DFG) Recommendations and practices for universities to use to remove barriers to women's advancement in academic careers. http://www.dfg.de/en/research_funding/principles_dfg_funding/equal_opportunities/research_oriented/	A streamlined and regularly monitored process for checking progress. The DFG produced a 'Toolbox' with resources for Germany's scientific community, which contains a collection of equal opportunity measures, practical examples and many helpful tips.	The 'Research-Oriented Standards on Gender Equality' were set up in 2008 on advice of a commission of experts to significantly increase the proportion of women at all academic career levels on the basis of the 'cascade' model, which sets out targets for each career level based on the proportion of women at the next lower level.	In 2013 it was decided to enhance technically and revise the content of the Toolbox and for the DFG coordinated programmes to include precise details of the female researchers involved and their levels of qualification. Each university is required to submit annual figures on gender equality to the DFG.	Well-defined and clear process of monitoring and demonstrating progress across the universities receiving funding from DFG.
Returner Fellowships Science and Technology Facilities Council (STFC) Fellowship enabling women (and men) to re-establish their academic careers http://www.stfc.ac.uk/funding/fellowships/returner-fellowships/	Women (and men) seeking to resume a research career, following a period of absence from active research of, normally, at least two years, due to, for example, long term illness, family or caring responsibilities or working in non-academic employment.	Returner Fellowships are additional fellowships, on top of the normal Ernest Rutherford Fellowship awards, that can be awarded to outstanding candidates returning from a career break or from working outside academic research.	This is a relatively new scheme but is guided by similar excellence criteria as the Ernest Rutherford Fellowship awards.	Applications must fall within the remit of the STFC core Science Programme (astronomy, solar and planetary science, particle physics, particle astrophysics, cosmology, nuclear physics) and afford scope for original work.

Intervention	Impact	Context & content		
Details	Core effect	Knowledge	Maturity	Complexity
Actions by leaders				
Professor Dame Sally Davis, Chief Medical Officer for England and Chief Scientific Adviser, previously also past head of National Institute for Health Research (NIHR) Letter to NHS Trusts and Medical Schools http://www.medschools.ac.uk/SiteCollectionDocuments/Letter_from_Dame_Sally_Davies_-_Women_in_Science.pdf	The letter was sent in 2010 to express concerns that both the academic and NHS partners were failing supporting women in clinical academia and ensuring they develop and are appointed to senior leadership positions. The letter recommended that institutions should achieve at least the Silver Award of the Athena SWAN Charter for Women in Science if they wish to be shortlisted for funding.	The letter was a response to the external evaluation of NIHR which showed that those receiving funding were ignoring gender equality issues.	The letter was widely circulated and stimulated action within and outside medical schools, as well as making impact abroad, e.g. Australia has initiated a similar action to promote the take up of the Athena Swan approach.	The Athena Swan programme method has been extensively tested over a number of years. Following Dame Sally's intervention, applications to Athena Swan tripled.

Intervention	Impact	Context & content		
Details	Core effect	Knowledge	Maturity	Complexity
Professor Katja Becker Chair of Biochemistry and Molecular Biology, Interdisciplinary Research Center, Justus Liebig University Giessen Practical support enabling career-life balance for young women scientists during pregnancy and maternity. Katja.Becker@ernaehrung.uni-giessen.de	Young women researchers starting a family are able to remain strongly connected to their research careers through support measures that enable them manage family life and career responsibilities.	The scheme allows the women the required flexibility in managing time. To help with the lab responsibilities, up to two MSc students are assigned to take on more routine research tasks. The woman involved has the responsibility (and the opportunity to learn how) to manage these assistants.	This scheme has been active for a number of years. The additional funding needed to employ the MSc students is provided by the University.	The scheme is effective and not expensive but its implementation does depend on departmental and institutional support.

(Table 3 compiled by Elizabeth Pollitzer, available at: http://www.portiaweb.org/index.php/publications)

Wales

The Sêr Cymru National Research Network for Low Carbon, Energy and the Environment launched Returning Fellowships in June 2015 for researchers returning to work after maternity, paternity, adoption leave, other caring responsibilities or an illness. The funding of £20,000 per returner can pay for replacements for administrative or teaching duties, travel and subsistence to establish new collaborations for research and travel to conferences.

The Women Adding Value to the Economy (WAVE) Programme was funded by the European Social Fund through the Welsh Government (WG), and key partners: the University of South Wales, The Women's Workshop @ BAWSO and Cardiff University. The aim of WAVE was to understand and 'interrupt' the ways in which gender pay inequalities are consistently reproduced through occupational segregation in employment and self-employment, through the ways in which 'women's work' is valued and contracted and through the operation of pay systems The WAVE research team, within the School of Sciences at Cardiff University, worked with collaborating employers to understand how the employment structure can result in women being over-represented in low paid jobs and not progressing at the same rate as men in professional careers, such as those in STEM.

Following data analysis, the WAVE team provided recommendations for action, and then supported employers through providing change management expertise to embed change in organisational systems and cultures. The evidence and tools and techniques that were developed have been referred to in over 30 internal Welsh Government evidence papers, policy documents and also National Assembly for Wales plenary debates. So it is well known within the Welsh Government, which is proud to have sponsored the tools and techniques, developed through ESF funds.

This is especially important as private sector companies with more than 250 employees will have to report their gender pay gaps, when new regulations are implemented in Spring 2016. The WAVE employment and pay analysis method provides a way for employers to understand how pay gaps are reproduced and to act on gender segregation – recruitment, retention and promotion. In the higher education field it has been used to integrate Athena SWAN objectives to actions and extend objectives beyond Athena's framework.

United Kingdom

WISE has developed a two-day Returners' Programme aimed at women on maternity leave or within six months of returning to work. It equips women with practical advice and tools on how to balance career and family, to overcome negative emotions such as guilt and to identify personal motivators and objectives. To date, 100 per cent of participants have reported increased confidence and feeling more positive about their future with their organisation.

The Wellcome Trust offers career re-entry fellowships to research scientists with at least two years' postdoctoral experience following a break of two years or more. The fellowship is aimed at researchers who have taken a break for family commitments. To date, seventeen women and three men have been awarded the fellowship. Funding covers research expenses and expenses for public engagements and may be provided for further training.

The Women's Engineering Society held a conference in London in June 2015, entitled Engineering Women: Are they Returning to Work?, which covered such issues as corporate best practice around career breaks, how to support career breaks and engineering returners.

Technology company Allstate Northern Ireland has introduced a range of family-friendly policies including flexible, condensed and remote working; child tax credits; emergency days; duvet days; bring your child to work days; sports and social events and a free car seat for employees' first child. The company has a higher rate of women returners than similar companies and a relatively high proportion of women managers.

Republic of Ireland

The Science Foundation Ireland has an Advance Fellowship Award programme for women scientists to encourage them to remain in or return to research careers. Grants of €150k are available to women scientists returning to work, to help with the cost of childcare or to enable them to work part-time. Initially, 100 grants will be awarded and this number may increase if the scheme proves to be a success.

USA

The National Science Foundation (NSF) has a range of policies and initiatives to support a career-life path for women and men. STEM researchers who take maternity or adoption leave or take a period of absence to look after dependents are able to suspend their research funding for up to a year. This enables them to return a year later and continue their research projects. NSF funding can also be used to employ replacements for researchers who are on leave. The NSF's ten-year CLB (career-life balance) Initiative was launched in 2011 by Michele Obama to increase the number of women securing tenure. One of the current leading NSF initiatives is the ADVANCE programme (Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers).

The National Institute of Health (NIH) offers a Biomedical Research Careers programme, which supplements existing NIH grants to support full- or part-time research by men or women returning from a career break. The grants can pay for mentoring, skills enhancement training and enables awardees to participate fully in ongoing research projects.

Leadership and role models – the key to success

Professor Julie Williams with Professor Diana Huffaker, a world-leading compound semiconductor expert, appointed to Cardiff University from UCLA, California

Why do we need more women in STEM leadership?

For gender equality initiatives to succeed, they need to be championed from the top and embedded into an organisation's strategic plans (Rees, 1999). Currently, the majority of leaders in STEM industries and academia are men. These leaders should demonstrate their commitment to support gender equality.

There is a strong business case for diverse board memberships. A report by Catalyst (2007) demonstrates the very strong correlation between corporate financial performance and gender diversity. Smart companies appreciate that gender balance leads to more independence of thought; more innovation; better governance and maximises company performance.

Increasing the number of women in leadership positions would provide a realistic reflection of the workforce and consumers and ensure that decisions are made with both men and women in mind.

Women in senior positions within STEM can be role models, who create greater visibility of the careers available; inspire girls to study STEM subjects and encourage women to remain or return to STEM careers.

School leadership

> Women make up around 75 per cent of registered teachers, but less than 60 per cent of head teachers.

This figure is skewed further in that most female head teachers are in primary schools. In secondary schools the proportion of female head teachers drops to less than 30 per cent.

According to the Association of School and College Leaders in Wales, the situation has been improving in recent years because middle management level changes have had positive impact higher up. The Association of Teachers and Lecturers Wales identifies family-friendly policies, increased awareness of gender issues and the weakening of 'old-boy networks' as the main reasons for this change.

Academic leadership

> Women are poorly represented in STEM academic leadership positions in Wales, which reflects the poor gender balance in those disciplines.

There were 10,140 academic staff at Welsh HEIs in 2013/14, of which 45 per cent were women (HESA, 2013/14). This is in line with the UK average. Within STEM subjects, however, only 25 per cent of academic staff in Wales were women, compared with 27 per cent across the UK as a whole. The situation is particularly acute in Engineering & Technology. Amongst professorial STEM staff in Wales, the proportion of women drops to only 6 per cent (HESA 2013/14).

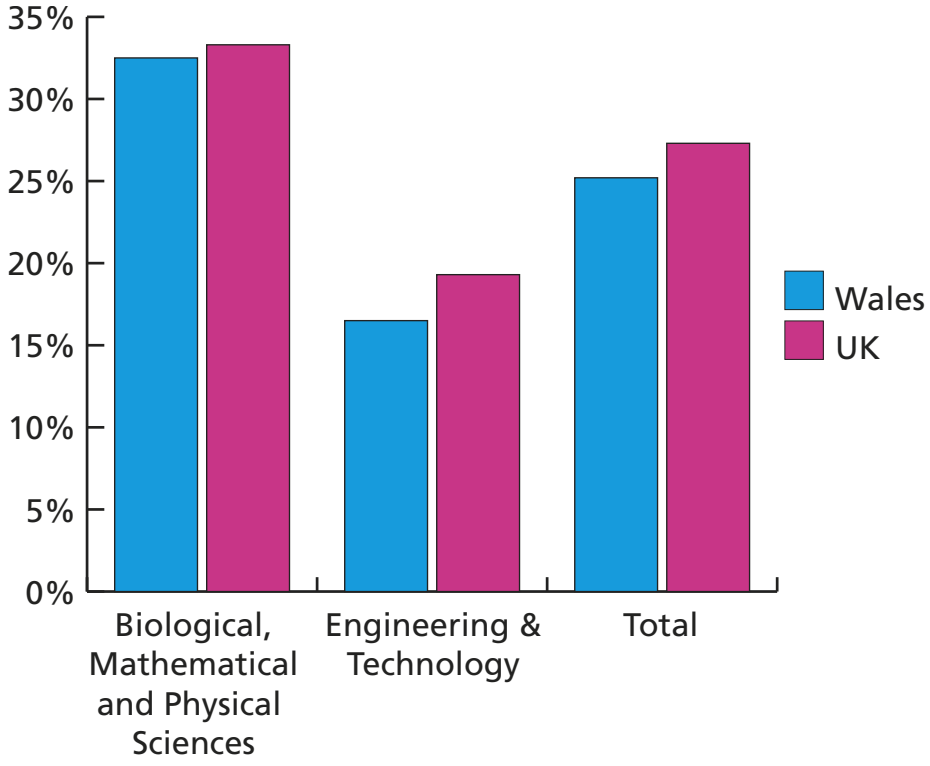


Fig. 7: Proportion of female STEM academics in HEIs in Wales and the UK, 2013-2014. (Source: HESA 2013/14)

The Learned Society of Wales is Wales' first national scholarly academy, founded in 2010. The society has taken steps to increase the proportion of women nominated and elected as Fellows – a public recognition of academic excellence. In 2013 the society established a working group on gender balance. The group found that far fewer women were nominated than men, which meant there was less chance of women being elected as Fellows. Figure 8 shows that in 2014, 12 per cent of all Fellows were women and amongst Fellows working in STEM fields, eight per cent were women.

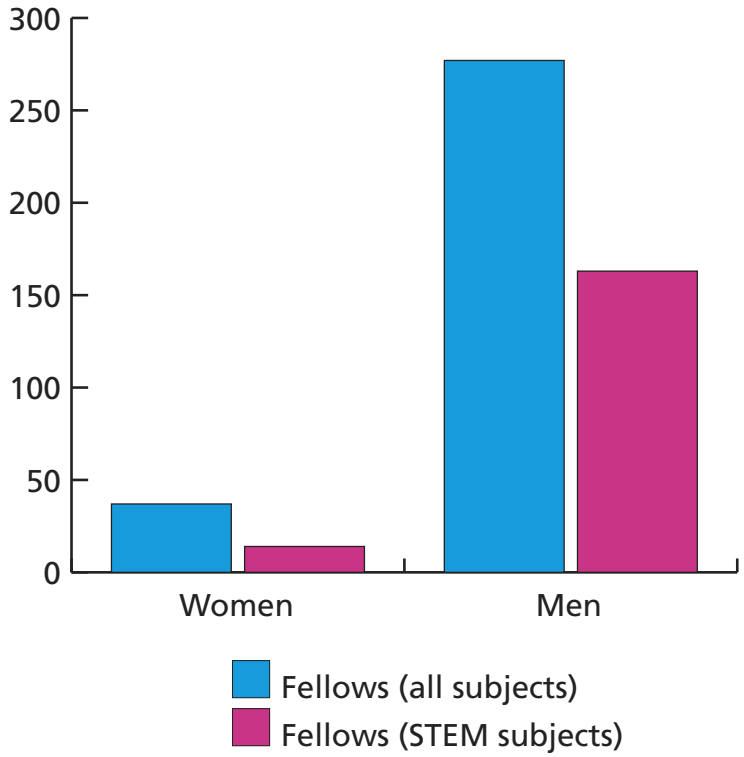


Fig. 8: Number of men and women fellows of the Learned Society of Wales, overall and in STEM subjects (2014).

As a result of recommendations by the working group to broaden the pool of nominated candidates, 40 per cent of nominations in the 2014-2015 year were women and it is encouraging that the proportion of female Fellows elected (35 per cent) is the highest in the history of the society.

In the Royal Society, which is the UK's academy of sciences and the second oldest learned society in the world, currently only six per cent of the Fellows are women. Over the last 12 years, about ten per cent of new Fellows have been female and the society believes that numbers of women in the Fellowship are improving steadily. It is taking positive steps, which include encouraging the nomination of more women for candidacy, ensuring that women are actively sought for recommendation to committees and inviting women as speakers, in order to increase their exposure at scientific meetings.

The proportion of female Fellows is similarly low in other UK learned societies. For example, women account for only five per cent of the Royal Academy of Engineering's Fellows and a similar proportion in other STEM-related learned societies and institutions.

All learned societies in the UK, however, are acting to increase the number of women Fellows. Proactive membership committees, with the aim of increasing diversity among their fellowships, have been or are being developed within the Royal Academy of Engineering and the Academy of Medical Sciences. The Royal Society of Edinburgh has taken further steps, including providing unconscious bias training

for committee members, ensuring women feature in publications, encouraging institutions to name buildings, rooms and awards after female (as well as male) scientists and exempting female nominations from the rule of nominating only two Fellows per year.

Improved diversity and a widening of the talent pool of STEM researchers could also contribute to the wider goal of growing the size of the Welsh research base. The population of Wales is just under five per cent of the UK total, yet Welsh universities gain significantly less than five per cent of overall funding from the UK Research Councils. Halligan and Bright (2015) suggest that this is due to a shortage of just over 600 STEM academic staff and especially so in disciplines which apply to the highest-spending research councils (EPSRC & MRC). Increasing their number will result in more funding applications being made and more competitively-awarded funding being won by Welsh institutions.

The updated Women Count: Leaders in Higher Education report by Norma Jarboe OBE, to be launched mid-2016, will provide UK key indicators of the representation of women as Chairs, Vice Chancellors and governing body members within higher education (http://www.women-count.org/).

Further and higher education governance

There are 251 governors in Further Education (FE) colleges in Wales, of whom 81 (32 per cent) are women. The proportion of female governors is 50 per cent or more in only two colleges: Coleg Ceredigion (64 per cent) and Coleg Gwent (56 per cent). The lowest proportion is at Coleg Sir Gar (17 per cent). The proportion of female chairs of FE committees is similarly low (26 per cent) and there are six FE colleges with no female chairs at all. However, 47 per cent of all FE executives are women and there are seven colleges with a proportion of women executives over 50 per cent (Chwarae Teg, 2014a).

Fifty-three per cent of Higher Education (HE) students and 45 per cent of academic staff in Wales are women, yet only 32 per cent of members of university governing bodies and only 12 per cent of chairs are women. Only two of the eight universities have a female vice-chancellor and the ratio of women to men on executive boards or equivalent is very variable, as shown in Figure 9 below.

Fig. 9: Vice-Chancellors and Senior Executive teams, Wales (August 2015) Larger figure indicates the Vice-Chancellor

The current proportion of women in FE and HE governance is both fluid and vulnerable, so steps need to be taken to ensure that female representation increases. In March 2011 the Welsh Government received 'A Review of HE governance in Wales', which recommended that:

> 'Institutions should review their appointments processes and ensure that they recognise the importance of balanced selection panels to achieve balanced boards.'

Unlike an equivalent review for Scotland, there was no recommendation made that referred specifically to women. It is essential to have more women in leadership positions in our

universities, if they are to be representative of the staff and students. It is not simply a question of parity but one of visibility to challenge stereotypes, of providing the next generation with inspiring role models and ensuring the sector can benefit from the richness of perception, experience and skills that comes from a more diverse workforce.

The report 'A Woman's Place in Academia: Moving Forward' (Chwarae Teg 2014) suggests steps which institutions can take to improve the situation. These include setting inspirational goals and targets and putting strategies in place to achieve them; addressing organisational culture; getting men involved; sharing best practice and lobbying for change.

In addition, it is crucial to ensure that recruitment and selection criteria for election to governing bodies are open and transparent, not relying on personal networks. There should be fixed terms of office, to ensure rotation rather than 'possession' of seats.

Leadership in industry

Across the UK, women hold ten per cent of management roles within STEM industries (Chwarae Teg, 2014). They comprise 11 per cent of STEM business owners and 13 per cent of board members of FTSE 100 companies in STEM sectors (WISE 2012). The proportion of women managers across all sectors in the UK is 35 per cent, slightly higher than the European Union average of 34 per cent (ONS 2013).

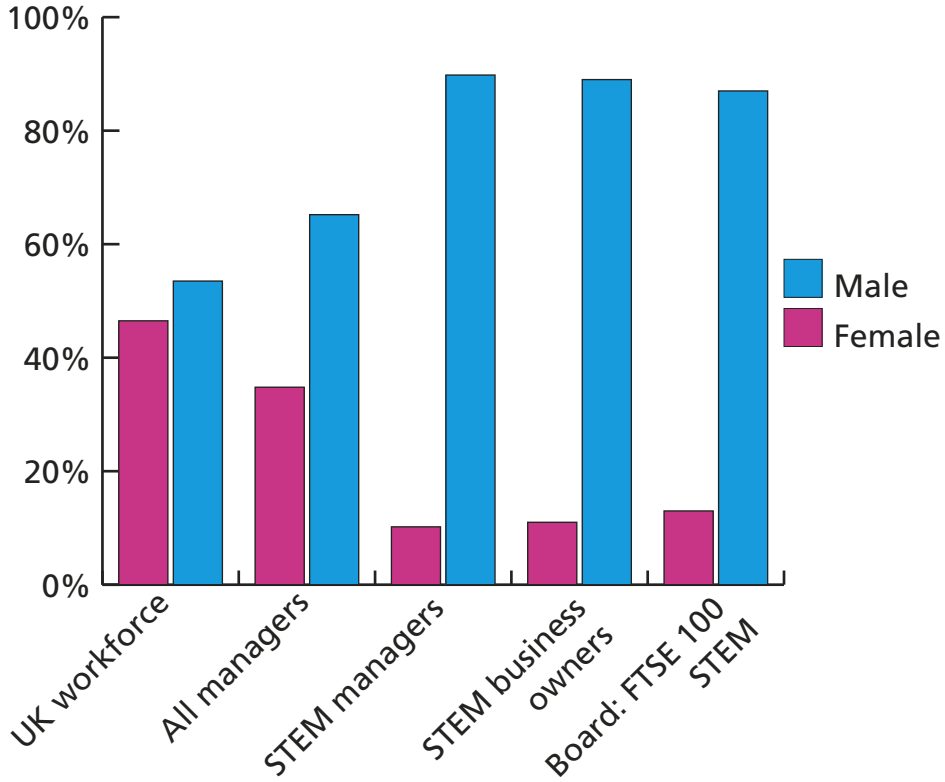


Fig. 10: Proportion of male and female managers, business owners and board members compared with the UK workforce.

The proportion of women in STEM-related Welsh Government sector panels is very low. Only two panels have more than one woman representative and the Advanced Materials and Manufacturing Panel (now disbanded) had no female representation.

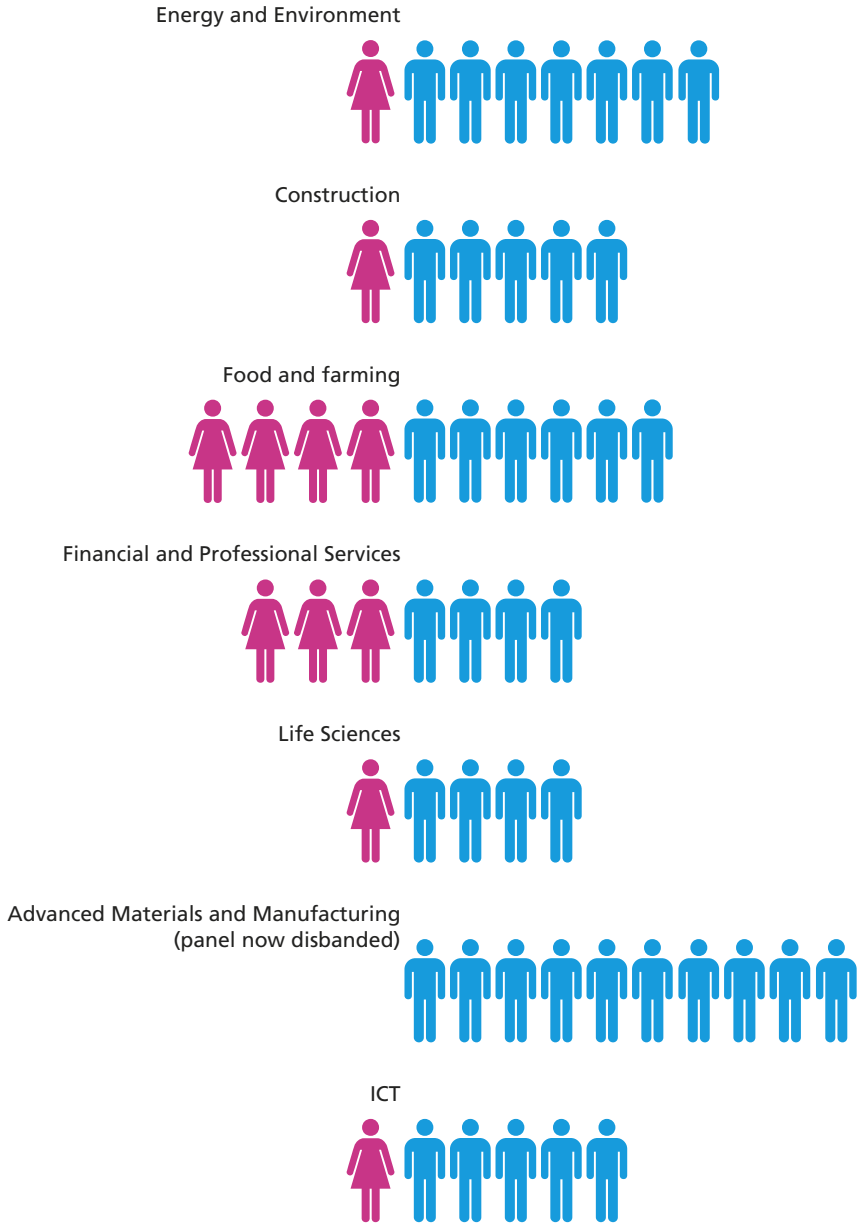


Fig. 11: Number of female sector panel members (2015)

Effective interventions

The 50:50 by 2020 campaign pioneered by Ann Beynon (BT Wales) and Professor Laura McAllister (Chair of Sports Wales) and promoted by Chwarae Teg, aims to achieve gender balance in leadership in all sectors by the year 2020 and is supported by men and women representing a broad cross-section of organisations in Wales including the Permanent Secretary of the Welsh Government. The campaign takes positive steps towards gender equality such as publicising supporters' pledges and success stories – for example, BT Wales worked with Chwarae Teg to reword its recruitment materials to increase the number of women taking engineering apprenticeships.

As part of the Welsh Government's goal to increase the number of women appointed to public bodies in Wales, Sport Wales's leadership team pioneered some different and innovative methods to improve the appointment process to its board. By creating a more flexible and equality-conscious process, it was felt this would generate a more diverse field of applicants, as well as more equal outcomes.

Sport Wales volunteered to use its innovative approach to appointing members of the board as a case study, for use by the Welsh Government to help influence other public bodies. The case study report established several factors that encouraged currently under-represented groups – especially women in this case – to apply for board positions. These included more imaginative dissemination of the opportunities through social media and other channels; changing the wording of advertisements, job descriptions and other information in the application pack to make them less exclusive; and most importantly, high-level leadership, commitment and drive – from the chair especially – to see through the implementation of the process to improve gender balance.

Sony UK Technology Centre has a development programme for staff in professional roles to be 'talent managed'. All female employees who request this receive personal development to facilitate future career progression.

Women Adding Value to the Economy (WAVE) was created to address gender employment and pay disparities in the Welsh labour market and workplaces. As part of their programme, 30 women with graduate-level experience and management responsibility were supported to undertake strategic leadership skills in ICT by the Women's Workshop. Twenty women completed the programme, 16 obtained a post-graduate diploma, six obtained new responsibilities, six improved their pay and five progressed to new job roles.

'Working Patterns In Wales: Gender Occupations and Pay' (Parken, Pocher and Davies 2014) describes the patterns of gender segregation among all occupational groups in Wales. Most striking is the finding that fully three-quarters of all women working in professional occupations in Wales do so in education and health; this implies that many businesses are making limited use of women's knowledge and skills. The report gives searchable access to information on the proportion of men and women in many individual STEM occupations.

The Science, Technology, Engineering and Mathematics Network (STEMNET) report that participants in the STEM Ambassador programme, of whom 44 per cent are women, gained new skills and confidence that can facilitate future promotion.

The Leadership Foundation for Higher Education (LFHE) launched a

women-only leadership development programme in October 2013 called Aurora, in which 1,473 women have so far participated. One of the aims of the programme is to encourage women to prepare for leadership positions earlier in their careers by meeting role models and networking with women at similar stages in their careers.

Role models should include a wide range of women in STEM, including those who successfully balance their careers with family and those at various stages on the career ladder. An increased media presence of such women would also help dispel myths that STEM is a man's domain.

WISE, in conjunction with the Royal Academy of Engineering, has launched the 'Ten Steps for sustaining the pipeline of female talent in science, technology, engineering and manufacturing'. This has been signed by the leaders of 20 STEM businesses with a significant workforce in the UK. The 'Ten Steps' calls on chairs and chief executives to:

1. understand the starting point and put plans in place to improve performance and monitor progress;
2. educate leaders and give them accountability for change;
3. change mindsets by challenging bias and sexism whenever and wherever it occurs;
4. be creative in job design;
5. make flexible working a reality for all employees;
6. increase the transparency of opportunities for progression;
7. sponsor talented women, giving them the same exposure as men and support to develop their career;
8. demonstrate to women that we want to retain them through career breaks and beyond;
9. treat the retention of women as we would any other issue affecting our core business;
10. share learning and good practice with our industry partners.

Recommendations:

Major STEM businesses should:

- sign up to the 50:50 by 2020 campaign;
- sign up to the WISE 'Ten Steps for sustaining the pipeline of female talent in science, technology, engineering and manufacturing';
- provide unconscious bias training for their staff.

Abbie Hutty of Airbus Defence and Space with the ExoMars Rover – Europe's first Rover mission to Mars.

Conclusions

The under-representation of women in the STEM workforce is a critical issue for Wales. Addressing the factors which affect women's decisions to enter, remain or return to STEM education and careers will have a profound effect on the talent available to business and the research community in Wales and by extension the well-being and prosperity of our society.

Children start to formulate ideas about gender from a very early age and those ideas can become relatively fixed by the ages of 10-14. The National Assembly for Wales Enterprise and Business Committee called for 'a more strategic and joined-up approach to interventions in the different STEM subjects' and pointed out that 'getting young people interested in STEM, girls especially … need[s] to start as early as possible.'

Given that most primary school teachers do not have a STEM background and many secondary school teachers are not trained in the subjects they teach, more support is necessary to equip teachers with the skills, knowledge and confidence necessary to enthuse both girls and boys about science. Better links between industry and schools would be beneficial, as would allowing children access to a broad range of female role models in STEM careers, at all levels. Careers education and information provided within the school or college environment needs to be improved and provided without gender bias to allow children to explore the wealth of STEM opportunities open to them. All children need to be exposed to what is fascinating and rewarding about STEM in the world around them.

One of the key points when women leave STEM careers is once they have children. The long-hours culture of many STEM jobs is difficult to reconcile with family life, so improved childcare and flexible working options for both men and women are necessary. It should be possible to balance a flourishing STEM career with family life. There are currently, however, few role models of women who are successfully combining a career in STEM with caring responsibilities. The use of mentors, improved arrangements to attract and support women returning from maternity leave back into STEM and a more equal sharing of responsibilities in the home would all help to retain the best female talent in industry and academia.

Unconscious bias is evident across education and the workplace, from young girls being led to believe that the STEM subjects are more suitable for boys, through to women applying for senior leadership roles being subconsciously and unfairly judged during the recruitment process. Improved equality and diversity training for everyone, from teachers through to university vice-chancellors and corporate chief executives, should help to challenge this pervasive problem.

There are a many good initiatives to attract and retain women in STEM education and careers in Wales. The challenge is to learn

from and expand on ‘what works’, ideally through an integrated strategy. If we can get this right, we will make Wales a global beacon of excellence for women in STEM, making better use of all of our nation’s talent, increasing our nation’s economic prospects, as well as creating a fairer future for both women and men.

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Appendix 1

The working group's approach & methodology

We have been determined that our report should be based on a rich understanding of the evidence base. We conducted a comprehensive literature review, consulted stakeholders and held a focus group to discuss emerging themes and issues.

Our stakeholder consultation asked for views on:

- why girls and women remain under-represented in many STEM educational courses and occupations?
- what can be done to encourage and support girls and women to pursue opportunities in these areas and?
- how different organisations in Wales can help address the problem?

We received substantive responses from a number of organisations that submitted substantive responses including:

- Careers Wales
- EESW
- Sony UK Technology Centre
- STEMNET
- Universities Wales
- Welsh Government Department for the Economy, Science and Transport – ICT sector team
- Welsh Government Department for Education and Skills

Our focus group was attended by representatives from:

- Welsh Government
- Education and research (Cardiff University, Colegau Cymru, The Institute of Physics, Learned Society of Wales)
- STEM outreach (EESW, Science Made Simple, STEMNET and Techniquest)
- Industry (Norgine Ltd, Tata Steel and GE)

Appendix 2

Members of the Women in STEM working group and contributors of expertise

Dr Louise Bright – Associate Director for Wales, Leadership Foundation for Higher Education

Chriss O'Connell – Welsh Government Cross-Cutting Themes Team, responsible for Equal Opportunities and Gender Mainstreaming

Dr David Cunnah – Cardiff University School of Physics and Astronomy – National Officer for Wales, Institute of Physics – expert input on IoP's extensive work on encouraging more girls to study Physics

Dr Sara Delamont – Cardiff University School of Social Sciences – expert in the history of women's education and the sociology of women in the professions and science

Sue Dye – Equality and Human Rights Commission in Wales

Professor Yvonne Galligan – Director, University's Gender Initiative & Director, Centre for the Advancement of Women in Politics at Queen's University, Belfast – holder of a Gold Athena Swan Award

Professor Siân Hope – Executive Director of Innovation and Professor of Computer Science at Bangor University

Joy Kent – Chief Executive, Chwarae Teg

Professor Laura McAllister – Management School, University of Liverpool and Chair of Sport Wales

Sue Midha – Acting Head of Human Resources at Cardiff University

Dr Sarah Morse – Senior Executive Officer with the Learned Society of Wales

Dr Alison Parken – Senior Research Fellow and Director, WAVE, Cardiff University

Dr Elizabeth Pollitzer – Portia Ltd London (European expert)

Professor Dame Teresa Rees – Professor Emerita in the School of Social Sciences at Cardiff University

Wendy Sadler – 'Science Made Simple' – STEM engagement and outreach practitioner and expert

Dr Anita Shaw – Acting Chief Executive, Techniquest

Linda Tiller – Higher Education Funding Council for Wales