National Advisory Council on Women and Girls: Monthly Spotlight

WOMEN AND GIRLS IN STEM

Summary

STEM stands for Science, Technology, Engineering and Mathematics.

There are significant differences in the numbers of girls and boys taking some STEM subjects, and women are underrepresented in many STEM fields in the workplace. There is a lack of girls studying Physics and Computing at school, and in women working in engineering and construction.

There are a range of social factors which have been found to contribute to discouraging women and girls from studying and working in STEM. These include stereotypes of STEM students and workers as male, non-inclusive work environments, career insecurity, gender bias in hiring, promotion and work evaluation, and long or inflexible working hours. Older women, LGBT women, and those of ethnic minorities and/or with disabilities, face additional barriers to studying and working in STEM.

Women in STEM tend to earn less than their male colleagues, and far fewer achieve senior positions.

Key Figures

- Girls account for 66% of Higher Biology entries, 53% for Chemistry, 48% for Maths and 28% for Physics. Just 16% of Computing entries are made by girls, and 10% for Engineering Science.
- 16% of Engineering and Technology entrants in higher education are women, and 20% for Computer Science. This rises to 62% for Medicine and Dentistry and 83% for Veterinary Science.
- Women accounted for 3% of those who started a Modern Apprenticeship in Construction in the first quarter of 2018/19.
- All 60 Engineering & Energy Related apprenticeships started in the first quarter of 2018/19 were taken up by men.
- 19% of engineers in Scotland are women.
- 10% of senior managers in STEM professions are women.
- The full-time gender pay gap is 7% for science, research, engineering and technology professionals in Scotland.

Defining STEM

There is no universally agreed definition of which subjects and employment sectors STEM includes. Sometimes a more restricted definition is used, covering only the specific areas of physical and biological sciences, engineering and technology, mathematics and computer sciences.[1] The *Science, Technology, Engineering and Mathematics* (STEM) *Education and Training Strategy for Scotland* offers a broader definition of the STEM subject areas:

> **Science** enables us to develop our interest in, and understanding of, the living, material and physical world.
>
> **Engineering** is the method of applying scientific and mathematical knowledge to human activity and **Technology** is what is produced through the application of scientific knowledge to human activity. Together these cover a wide range of fields including business, computing science, chemicals, food, textiles, craft, design, engineering, graphics and applied technologies including those relating to construction, transport, the built environment, biomedical, microbiological and food technology.
>
> All of STEM is underpinned by **Mathematics**, which includes numeracy, and equips us with the skills and approaches we need to interpret and analyse information, simplify and solve problems, assess risk and make informed decisions.[2]

This broader concept of STEM can therefore include areas such as medicine, nursing, dentistry and veterinary science, construction, agriculture, forestry and fishing.

Defining STEM in the labour market is also complex, in that often people may have a non-STEM job in a STEM sector, or a STEM job in a non-STEM sector (for example, an accountant working in finance, or a doctor working in social work). In this report, the definition of STEM provided by each source is given in the endnotes, where available.

Current Position: STEM Education

Schools

Female school leavers with STEM attainment [3]

	SCQF Level 3 or better	SCQF Level 6 or better	SCQF Level 7
2013-14	97.3%	39.2%	8.3%
2016-17	95.5%	39.4%	7.8%

Overall, in 2018 girls accounted for 52% of entries to SQA National 5s in Biology, Chemistry, Maths or Physics, 48% of entries in these subjects at Higher level, and 46% for Advanced Highers.[4] However, the gender split is very different for each of these subjects, with girls over-represented in Biology but under-represented in Maths and especially Physics.

Higher subject entries, 2018 [5]

	Biology	Chemistry	Maths	Physics	Computing	Engineering Science
No. entries by female students	4,850	5,262	9,052	2,278	669	103
% entries by female students	66.4%	52.7%	48.3%	27.5%	16.3%	10.2%

As the table above shows, entries by boys outnumbered those by girls in all Higher STEM subjects in 2018 except Biology and Chemistry. However, entries by girls on average received equal or better grades than male entries in all areas. The percentage of female entries achieving an A or B grade in Engineering Science was 10 percentage points higher than the percentage of entries by boys which achieved

these grades, while the percentage of female entries achieving an A or B grade in Computing was 8 percentage points higher than for male entries.

Overall, the gender balance of Higher entries in Biology, Chemistry, Maths and Physics has not changed significantly since 2008.[6] Around 600 more entries were made by girls for Higher Chemistry in 2018 than a decade earlier, and around 1,200 fewer for Higher Biology.

While these gender imbalances were similar in all these subjects at **National 5** level, they became more pronounced at **Advanced Higher** level:

Advanced Higher subject entries, 2018 [7]

	Biology	**Chemistry**	**Maths**	**Physics**	**Computing**	**Engineering Science**
No. entries by female students	1,614	1,440	1,418	382	88	1
% entries by female students	69.6%	55.6%	38.5%	20.2%	13.8%	1.7%

More entries made by girls than boys were awarded A or B grades across all subjects at this level, too.[8] The difference was particularly wide in Computing: 63% of entries made by girls were awarded these top grades, compared to 46% of entries by boys.

Higher education

Overall, 27% of students in Scottish Further and Higher Education **colleges** in 2016–17 were studying STEM subjects. The percentage of these students that were female is presented below:[9]

Percentages of female students in Scottish Further and Higher Education colleges by subject, 2016-17

	Further Education colleges	Higher Educations colleges
All STEM subjects	28.8%	16.2%
Science and Maths	57.3%	50.3%
IT	39.3%	16.6%
Engineering	26.7%	7.3%
Construction	9.6%	22.3%

In Scottish **Higher Education overall** in 2016–17, just 16% of those starting Engineering and Technology courses and 20% for Computer Science were women.[10] In contrast, 62% of entrants to Medicine and Dentistry courses were female, as were 83% of Veterinary Science students and 77% of Psychology students, although these are among the subjects not always classified as STEM.

There were clear changes in the gender imbalances in student numbers between qualification levels for some subjects, as the below table shows. While the proportion of female entrants rose significantly from sub-degree to postgraduate level for Architecture, Building and Planning, Engineering and Technology, Maths, and Computer Science, the opposite was true for Medical Studies and Veterinary Science, where the majority of entrants are female.[11] Overall, gender imbalances were smaller at postgraduate level than at sub-degree level (although still significant).

Percentages of female entrants to Higher Education in Scottish HEIs and Colleges by level of study and subject, 2016-17 [12]

	Sub-degree	Undergraduate (first degree)	Postgraduate
Architecture, Building and Planning	13.6%	38.8%	54.4%
Computer Science	15.9%	18.0%	29.4%

Engineering and Technology	8.9%	18.5%	26.0%
Maths	16.2%	40.5%	40.2%
Medical Studies	84.0%	80.9%	75.9%
Veterinary Science	87.5%	84.5%	68.8%

The trends seen in Scotland are similar to the UK overall. Only 17% of Computer Science students and 18% of Engineering and Technology students are women in UK higher education, but 75% of those for Medicine and Dentistry subjects and 77% for Veterinary Science subjects.[13]

Apprenticeships

While 48% of those starting **Modern Apprenticeships** in the first quarter of 2018/19 were women, they accounted for just 24% of those starting Animal Care and 3% of Construction starts.[14] Meanwhile, all 60 of those starting Engineering & Energy Related apprenticeships in this period were male.

Current Position: STEM Employment

Gender differences in occupation

Overall, the gender gap in core STEM jobs held by women in Scotland is narrowing slightly: the percentage increased from 39% in 2010 to 42% in 2016.[15] However, just as with subjects in education, the balance varies significantly between different areas of STEM. Many employment sectors remain very male-dominated; just 19% of engineers in Scotland are female, and under 3% of chartered civil engineers.[16]

Women are also particularly under-represented in the following fields:

- Construction of roads and railways (5% female workers)
- Repair of fabricated metal products, machinery and equipment (11%)
- Construction of residential and non-residential buildings (16%)
- Support activities for petroleum and natural gas extraction (18%)
- Architectural and engineering activities (19%).[17]

On the other hand, women account for 82% of those working in medical and dental practice and 80% of those engaged in hospital activities. 92% of both nursing and midwifery, and of therapy professionals, are female.[18]

UK-wide, less than 2% of UK construction trade workers are women, and around 10% of construction professionals.[19]

50% of female academics across the UK work in STEM compared to 59% of male academics.[20] Within the STEM subjects themselves, 42% of academics are female. Women are underrepresented in electrical, electronic and computer engineering (14.7% female staff) and mechanical, aero and production engineering (17.1% female staff), but overrepresented in nursing (74.9% female staff) and psychology and behavioural sciences (60.8% female staff). Female STEM academics in the UK are less likely than their male counterparts to have full-time positions (78% vs 91%) or permanent contracts (67% vs 77%).[21] Nursing was an exception here, however.

The UK as a whole has 400,000 fewer STEM graduates per year than it needs to meet demand.[22]

Gender differences in seniority

Only 10% of senior managers in science, engineering and technology professions in Scotland are women.[23] In core STEM occupations, women hold 52% of the jobs

classed as ‘professionals’, but just 39% of technician jobs, 37% of director and manager roles, and 3% of skilled trade jobs.[24]

As one example, data from 2008–9 shows that in both engineering and bioscience in Scotland, women were over-represented in administrative and secretarial roles and under-represented in management and senior official posts.[25] They accounted for 70% of engineering admin staff, and 66% in bioscience. In contrast, they accounted for just 19% of managers and senior staff in engineering, and 33% in bioscience.

Across the UK, female academics working in STEM fields (including medicine) are more likely to be in early career positions, while male academics are more likely to be in senior positions.[26] However, this is not the case for chemistry, physics, geography, nursing or veterinary science.

The gender pay gap

Initial data suggests that five years after graduation from Scottish universities, women have lower median earnings that men in all STEM fields except psychology.[27] Median earnings of female graduates were all at least £2,000/year less than their male peers in all fields except biological and physical sciences. The largest disparities were seen with veterinary science, subjects allied to medicine (excluding nursing) and agriculture, where women’s median earnings were 90%, 86% and 81% of their male peers respectively.

The full-time gender pay gap (the gendered difference in median hourly earnings for full-time workers) was 7% for science, research, engineering and technology professionals in Scotland in 2017.[28] This rose to 20% for health professionals, and to 30% for skilled trade workers. This pay gap was 18% in both manufacturing and electricity, gas, steam and air conditioning supply in 2016, and 10% in construction. However, it was -8% in mining and quarrying – that is, women’s median earnings were higher than men’s in this area.[29]

Barriers

Female students

A survey of school children in England found that even though more girls than boys say that science is their favourite subject at school, they are still less likely to aspire to a career in science.[30] Just 12% of 12-13 year-old girls wanted to become scientists, compared to 18% of boys. This research also found that girls who aspire to science and STEM-related careers are more likely to be highly academic and to describe themselves as 'not girly'. Similarly, US research shows that stereotypes about masculine and feminine gender roles mean that from a young age STEM subjects are often considered to be more suitable for boys than girls, and that the stereotype of the scientist as a man negatively impacts female students' career aspirations.[31]

Students aged 12-13 who were in a top set for science were twice as likely as average to want to work in science, due to a common conception that science is just for very brainy students.[32] It has been shown that both teachers and students are less likely to consider working-class, minority ethnic and/or female students as 'naturally' clever, so these are additional barriers in this respect. Female students are deterred from pursuing STEM subjects when the majority of other students are male according to international research.[33] A lack of confidence is also often a deterrent for girls.[34]

At university level, US research has shown that the culture of Computer Science departments (the expectations, assumptions, and values that affect how the staff and students behave) reduces female students' confidence and enthusiasm.[35] In particular, the image of a successful computer scientist as one who has a 'singular and obsessive interest in computing' alienated many female students.

Women in employment

Career insecurity, requirements to move abroad for jobs, long or unusual working hours, subtle gender bias in hiring, promotion and work evaluation and non-inclusive work environments have all been identified as barriers making it harder for women to work in STEM.[36]

Research has suggested that a **lack of opportunities for women to work-part time** is a cause of many women leaving science and engineering jobs, especially during their late 20s and 30s.[37] 80% of STEM-related jobs in Scotland are full-time, compared to 75% overall.[38] While 42% of female employees work part-time across the UK, just 26% of women in architectural and engineering activities are part-time,

22% of women in manufacturing or electricity, gas, steam and air conditioning supply jobs, and only 15% of those working in scientific research and development.[39] This figure rises to 39% for civil engineers, 42% for construction employees, and 49% for those working in agriculture, forestry and fishing.

US research has also demonstrated that in male-dominated fields (such as STEM), women had to show clear evidence of their excellence in order to be judged to be equally as competent as their male colleagues.[40] However, showing their excellence also then meant that women were considered less likable. This places women in a 'double bind' as both competence and likability are considered important for success.

Perceptions of construction as dirty and having a **macho culture** are seen as barriers to more women working in the sector, as are the long hours demanded and the lack of encouragement given to girls and women to consider this career.[41] Research has found that some male resistance to women being construction workers is rooted in belief that women may not be strong enough to do the physical work required, or that their presence may lead to problems with sexual harassment and discrimination in these predominantly male workplaces.[42] However, jobs that require attention to detail and less physical strength, such as tiling, painting, joinery and electrics, were seen as more 'appropriate' for women. The masculine culture of building sites has also been found to be challenging and intimidating for many female architects, as are the long hours often demanded in architecture and the competitiveness over contracts.[43] Some female engineers have felt the need to explain and justify their decision to enter this male-dominated profession.[44]

Academia

Female STEM academics in the UK perceive having heavy teaching or administrative workloads, having children or caring responsibilities, or taking a career break, as more detrimental to academic careers than male academics.[45] There is a culture and expectation of working long hours within academia, which is particularly challenging for those with disabilities or caring responsibilities.

Research in the United States has shown that letters of recommendation for medical faculty positions systematically **presented female and male applicants differently**.[46] Women were more likely to be portrayed as compassionate and as students and teachers, while men were more often presented as high achievers, professionals and researchers. Female STEM academics in the UK spend more time on teaching and public engagement, and **less time on research** than their male colleagues.[47] This is significant since research is generally given greater academic prestige.

Significantly fewer female than male UK STEM academics report having had training in all areas except teaching.[48] More women than men reported having experienced **barriers to training**, including cost, time, caring responsibilities or an obstructive line manager. 12% more women than men reported that lack of time has prevented them receiving necessary or desired training in the last 12 months (58% vs 46%).

Both male and female STEM academics think on average that it is **easier for men to obtain senior posts** than for women.[49] Female academics believe this more strongly, though: while 50% of female STEM academics believe it is easier or much easier for men to obtain senior posts, just 20% of men think the same. Male academics are more likely to perceive equality of opportunity, or only a small male advantage. More male academics working in medical or physical sciences and in engineering in the UK are formally promoted to their posts (rather than, for example, applying to an advertised post or receiving an ad-hoc promotion) than their female colleagues. This gendered difference was not found in nursing or bioscience academia.

Overall, female academics are much less likely than their male colleagues to have been encouraged or invited to apply for a promotion (49% vs 60%).[50] Men are also much more likely to have the opportunity to serve on important departmental committees, feel that their research is valued by their department, to have access to senior staff in the department or to have a supportive line manager.

Returning after career breaks

Just 27% of women working in STEM across the UK have taken a maternity break, even though 80% of all women in the UK have children at some point.[51] 34% of female STEM academics felt unprepared for returning to work after parental leave, compared to 8% of male academics.[52]

60% of women working in STEM in the UK think there are barriers preventing their return after maternity leave or a career break.[53] After financial barriers, including childcare costs (cited by 52%), the most important barriers were that there were not enough options for different working patterns (flexible or part-time working, job-sharing or condensed hours: 27%) and a lack of help and support (25%). 43% said that they would want training or advice to enable them to return. The fast-changing nature of science has also been found to make it hard to return to STEM after a career break.[54]

Impact of Other Protected Characteristics

While both male and female UK STEM academics think that being homosexual or bisexual, non-white, transgender or disabled somewhat negatively impacts academic STEM careers, women perceived slightly more of a negative impact than men across all these areas.[55]

Age

Female engineers in the UK are younger than men, on average.[56] There has been a consistent gap of around 1 year in the mean age since 2004.

While female STEM academics of all ages are more likely than male academics to believe that male colleagues receive preferential allocation of tasks and resources related to professional development, older women report this to a greater degree than younger female colleagues.[57] Both men and women working in STEM academia under the age of 30 believe that women have an advantage in the allocation of additional academic roles, but for those over the age of 30 a stark gender difference emerges: male academics continue to believe that women have the advantage, while female colleagues think the opposite. Half as many female academics over the age of 61 were invited or nominated to their current post as their male colleagues of the same age. 11% of female academics over 60 want to leave STEM (compared to just 6% of male colleagues of the same age), while 6% of those 31–60 years old want to leave academia, but continue working in STEM (4% of men).

Ethnic minorities

The factors which make it less likely for 12-13 year-old students to want a career in STEM (their family's knowledge and interest in science, being female, and not being highly academic) are amplified for Black students.[58] Asian students are more likely than those of other ethnicities to want to pursue a science career.

Female BME STEM academics in the UK are less likely than their white and/or male colleagues to be in senior positions.[59] Just 1% are head of their school, division or department, compared to 3% of white women and 7% of both BME and white men. On the other hand, 19% are senior lecturers, more than white women (14%), BME men (18%) or white men (11%). BME women were the only group to report negative impressions of their department's fairness and transparency in allocation of work and resources. When returning from parental leave, BME women were less likely than

their white female colleagues to be offered KIT days (66% vs 71%) or flexible hours (64% vs 75%). Female BME academics are more likely than their white colleagues to report having found their gender identity, marital status, accent or line manager a barrier to receiving training. They are also less likely to report departmental encouragement for their career development.

Female BME STEM academics report greater gender inequalities in terms of allocation of departmental tasks and resources than their white female colleagues. On the other hand, BME women are more likely to have been formally promoted to their current post than their white female colleagues. The quality of working life and the commitment to equality in a department are more important to BME than white female academics when deciding whether to accept a new position. Overall, female BME academics think that their ethnicity has negatively impacted their careers.

Female STEM academics who come from a country outside Europe on average think that this identity has negatively impacted their careers, whereas male academics from outside Europe do not report the same.

22% of BME engineers have experienced bullying or harassment at work in the past 12 months, compared to 13% of white engineers; female engineers also experienced this more than male colleagues (26% vs 12%).[60] BME engineers feel less able to be open at work about their personal lives than white engineers (72% vs 85%), and female engineers equally feel less able than male engineers (80% vs 85%). BME engineers are also less likely to speak out about inappropriate behaviour than white engineers (72% vs 83%), and female engineers are less likely to than male engineers (72% vs 84%).

Disability

Evidence suggests that just 5% of engineers in the UK are disabled, compared to 17% of the whole population.[61] 50% more STEM university students declared a disability in 2015 than in 2009, although fewer than for other subject areas.

Disabled female STEM academics in the UK earn less on average than non-disabled colleagues, despite having worked in their post and department for longer.[62] They also tend to spend more time on teaching and less on research. Disabled female academics are more likely to perceive male advantage in terms of allocation of departmental tasks and resources than non-disabled women. They are also less likely than their male or non-disabled colleagues to have received a formal promotion to their current post. Although disabled STEM academics do not, on average, think that their disability has negatively impacted their careers, disabled women working in this field are more likely to think that both their sex and age have negatively impacted their own careers then their male and/or non-disabled colleagues,

suggesting that cumulative negative effects particularly impact this group. Disabled female academics are much more likely than non-disabled female colleagues to say that their age has prevented them receiving training they wanted or needed (8% vs 3%). Disabled women are less likely to feel supported and encouraged in their careers by their department, including being less likely to have been invited or encouraged to apply for a promotion.

LGBT+

The evidence summarised below is drawn from different sources, which address slightly different groups – some present research on lesbian, gay and bisexual people, while others also cover transgender people or use the term 'LGBT+' which includes other groups, such as asexual or pansexual people. The terms used here reflect those used in the original research.

The number of LGBT+ architects who are open about their sexuality at work across the UK is falling, currently standing at just 62% outside of London.[63] 30% feel that being LGBT hinders their careers, and 20% say that being LGBT in the construction industry has damaged their mental health. 39% report hearing homophobic or transphobic slurs used at work. Even higher numbers of LGBT engineers (60%) and contractors (69%) report hearing these slurs at work.

Expectations of discrimination may be a significant deterrent to entering construction for LGBT people, with over 50% expecting to experience discrimination in construction or engineering MA courses.[64]

Female LGB STEM academics believe even more strongly than their heterosexual female colleagues that it is easier for men to obtain senior posts in their department.[65] While LGB women are less likely than their straight female colleagues to cite caring responsibilities as a barrier to receiving training that they wanted or needed, they are significantly more likely to report the following as barriers: costs (27% vs 21%), disability (4% vs 1%), marital status (3% vs 0.4%) and an obstructive line manager (14% vs 6%).

What Can Be Done?

Policies aimed at increasing women's participation in STEM have included those which:

- Aim to get more women and girls into STEM
- Support women and girls already studying or working in STEM
- Aim to change STEM cultures and practices to make them more inclusive.[66]

A 2010 study showed that there was limited evidence on the success rate of various policies that have been implemented, both in Scotland and across Europe.[67]

STEM education

Research has shown that teaching girls that intelligence can be developed and cultivated (rather than that you cannot change how intelligent you are) can help protect girls from the negative effects of the stereotype that girls are bad at maths.[68] It has been shown that most young people's attitudes to science are quite fixed by age 14, and that if they aspire to a science career at this age they are more than 3 times as likely to get a physical science or engineering degree.[69] Therefore, it is important to encourage aspirations to a science career with girls from a young age. Having female role models in STEM has been found to help with this both for young girls and those later in their education.[70]

It has been found that 3D spatial-visualisation skills, important in engineering, can be quickly improved with training, and that this training improves the likelihood of female engineering students staying in the field.[71] Creating a welcoming and inclusive atmosphere which fostered relationship building and organising opportunities for students to learn about different career options has been found to benefit female Physics students at university.[72]

Women returners

Female STEM academics in the UK find flexible hours particularly helpful in enabling them to return to work after parental leave.[73] Keeping-In-Touch days, being able to build up from part-time to full-time hours and having a lower teaching load to start with were also found especially beneficial. Women who were offered KIT days, information about workplace childcare facilities, leave cover and handover, and the option of returning gradually tended to find the impact of their caring responsibilities on their career is less negative than for women who are not offered these things. Disabled academics consider having childcare facilities available at work to be even

more important in facilitating return from parental leave than non-disabled colleagues.

A small pilot project aiming to help women in Scotland return to work in STEM after a career break showed positive initial results.[74] Participants reported that the project boosted their confidence, helped them frame their career breaks in terms of its positive assets and gave them practical skills and strategies to help their return to STEM employment. It found that it was important to have good communication between employers and returners about flexibility of hours, and to offer returners CV feedback and guidance. There was also a need seen to support and promote benefits with employers, as while feedback from employers afterwards was positive, it is not currently a common recruitment route in Scottish STEM organisations.

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