

NewStatesman

Spotlight

ENGINEERING: A FUTURE BUILT BY WOMEN

Chi Onwurah / Benita Mehra / Hayaatun Sillem / Elena Rodriguez-Falcon



NewStatesman

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intersection of
technology, business
and politics.**

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Being female costs an engineer £27,542 a year



The number of women in engineering has risen by two per cent in the past two years, but while there are more women in engineering, they are paid less than men, and this situation is actually getting worse. A recent survey of 2,864 engineers by *The Engineer* found that the average pay gap between equivalent roles had increased. The average salary of a female director in an engineering company is £46,053; the average male director earns £73,595. Why are some senior engineers penalised £27,542 a year for their gender?

Partly it is a matter of under-representation. In the UK, 11 per cent of the engineering workforce is female, the lowest percentage in Europe. In the most recent statistics women make up just 6.8 per cent of engineering apprentices and 15.1 per cent of engineering undergraduates in the UK. Of the chief executives in the FTSE 100, there are more men called David than there are women. It is hardly surprising, then, that women are systemically under appreciated.

There are many reasons why this is wrong, from the ethics of an equal society to the stifling effect that discrimination has on innovation. But what underlines the futility of engineering's gender pay gap is the fact that the industry doesn't even save any money by paying female engineers less. Companies that do well at gender diversity have been shown to be 15 per cent more likely to outperform their industry averages, and companies with women on their boards have been shown to enjoy higher sales. In the UK, a 10 per cent increase in gender diversity at the senior management level brings a 3.5 per cent increase in pre-tax company earnings.

But while companies and indeed the whole country would benefit from making engineering fairer, the people for whom this is most pressing are the potential engineers, in schools and universities, who might be turned away from a career that 84 per cent of female engineers recently reported made them either happy or extremely happy. Engineering's pay gap is woeful, but the gap in who gets to do interesting, fulfilling work is, if anything, even worse.

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Parliament is playing catch-up in the world of tech

**Chi Onwurah,
Shadow Minister
for Industrial
Strategy, explains
why a diversity
of backgrounds
can help inform
more effective
policymaking**

When people ask me, I like to say I came into Parliament for exactly the same reasons I went into engineering – to make the world work better, for everyone. Until I was elected MP for Newcastle Central in May 2010, the proudest moment in my life was the day I was accepted into Imperial College London to study electrical and electronic engineering in 1984. In the intervening decades I worked as an engineer all over the world, building out networks in France, Germany, Spain, the US, the UK, Nigeria and parts of Asia. Then I moved into the public sector, as head of technology for Ofcom, trying to ensure the UK got a broadband network that worked for everyone. Engineering and politics have more in common than people tend to think: making things work for people using the resources, skills, people and technology available.

I also like to say that Parliament is the most diverse environment I have ever worked in. This surprises people as our representative body is not renowned for its record on representation. But engineering is so bad, it makes politics look good. As an engineer I was so often

the only woman in the room, the only person of colour and the only one to have gone to a comprehensive school.

The last election delivered the most diverse Parliament the UK has ever had. It's the first time it has had more than 200 women in parliament, now making up 32 per cent of all MPs. The number of LGBT MPs increased from 32 in 2015 to 45 in 2017 – an increase of 40 per cent in just two years. We have 51 black, Asian, minority ethnic (BAME) MPs. And Labour has more women MPs than all the other parties put together.

In science, technology, engineering and mathematics (STEM), on the other hand, very little has changed. Currently, only 16 per cent of electrical engineering students are female as opposed to 14 per cent when I was studying, and 9 per cent of professional engineers are women. At the same time, demand for engineers is rising and is set to rise even further. The government estimates we need to recruit 186,000 more engineers into the sector each year until 2024.

So it may seem strange that I am arguing for more engineers – male and female – in Parliament, when they are





Chi Onwurah received her degree in electrical engineering from Imperial College London



As an engineer I was often the only woman in the room

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so needed in industry. Well the reason is quite simple: technology is everywhere, apart from in Parliament.

When I announced I was going to stand, many friends and colleagues were dismayed. Why was I leaving an important, trusted, responsible profession for something as disreputable as politics? There were many answers to that question, including the desire to represent the people I grew up with in my home city, but in addition, my work in technology had brought me to the conclusion that whilst I could design the best broadband network in the world, it was peoples' skills and incomes and government infrastructure investment that would determine whether or not it was used. And that's politics.

And while I did go through a period of mourning for leaving engineering, it is increasingly proving premature, as technology has come to be at the centre of so many decisions I make as a parliamentarian. Software has eaten the world. "Everything is data," a techpreneur said to me recently. And the recent NAO report on Universal Credit cited a lack of digital skills as a key reason

for its failure. I have been moved to tears by the experiences of constituents forced to go to food banks because they could not sign on online. When I visited the United States Consumer Electronics Show earlier this year, what I saw was a car show in the middle of a health show, in the middle of a home show, in the middle of a sports show, next to an entertainment show. Tech is an enabling platform for how we do just about everything these days.

Except equality. As we have seen, those who develop technology are not representative of humanity. In my view, that makes it inevitable that the technology which is developed is not humane. And Parliament cannot be in a position to change that if there are not enough members who are as deeply familiar with technology as there are learned lawyers and policy gurus. We need a diversity of backgrounds in Parliament. As in engineering.

Diversity is not "nice to have", a fluffy add-on when everything else is sorted. It is an economic imperative if we are to compete on the global stage, especially post-Brexit. Diversity is a must-have: we saw how banking "groupthink" fostered the environment that led to the financial crisis. Diversity of backgrounds, disciplines and experiences enables innovation and resilience.

That is why diversity is absolutely central to the industrial strategy Labour is developing and our recently launched Diversity Charter Challenges. We need to be clear: the lack of women in tech is not about girls picking the wrong subjects. This is about an environment which pre-selects boys over girls.

Whether it is gendered children's toys or a working culture that devalues caring responsibilities, the UK is uniquely good at excluding women from technology. Consider that India – where female literacy rates are much below male ones – does much better than us in attracting girls into computer science.

We need more women in engineering and more engineers in Parliament, so we can deliver the technology that makes the world work better, for everyone.

As it did a century ago, the engineering sector stands on the brink of considerable change, writes Benita Mehra, president of the Women's Engineering Society

The new world of work will reshape engineering

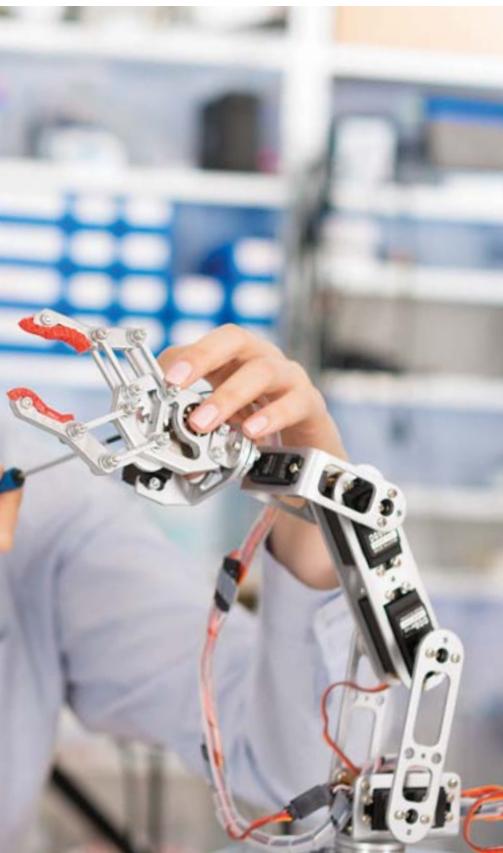


Through the Representation of the People Act of 1918, more than nine million women achieved the vote but, within a year, many of these women had lost their jobs. As large numbers of men returned from the First World War, the jobs in engineering, manufacturing and other disciplines that had been occupied by women in wartime were handed back to men. Under the 1919 Restoration of Pre-War Practices Act, skilled engineers faced returning to domestic service. Representing them was Rachel Parsons, the first president of the Women's Engineering Society, who joined with her fellow engineers that year to secure "fair play for women in the industrial world". It is for this reason that the modern WES maintains the suffragette colours of green, white, and violet – in recognition that even as we prepare to celebrate our centenary, there



is still work to be done to help the whole engineering sector enjoy the benefits of diversity.

Much has changed, of course, in 99 years. The theme for this year's Top 50 Women in Engineering (the WE50) is "Returners and Transferrers", to reflect the new world of work and the way in which it affects women, especially in engineering. Transferrers are endemic in the modern workforce; very few people choose a single career, much less a single employer or discipline, for their working life, and the attitudes of younger workers around the world suggest that this trend will only become more pronounced. This brings many benefits. People who change careers can be more open-minded, creative, enthusiastic and ambitious than those in single-track careers. They also bring new perspectives, and skills from their



previous careers that can be deployed in new ways. But without the right support, the benefits of multi-staged careers will be felt only by those with a natural predisposition to taking risks and an ability to talk up their transferable skills; those people are very often men. Women who qualified as engineers need to follow the women in other areas, such as the law or finance, in letting

Women must realise how valuable their skills are

employers know the value of the skills they bring with them.

Returning to work, too, is an aspect of working life that is more likely to be experienced by women, often as a result of having taken maternity leave; mothers provide nearly three quarters of all parental childcare. Women also provide the majority of unpaid adult care. But for many families, having one partner taking on the role of sole breadwinner is far from ideal. As a sector that thrives on the skills and ingenuity of its employees, it is vital that engineering gives talented people the stability to work flexibly, to take time off and to return to work with renewed enthusiasm. And again, it is important that women who have qualified as engineers and have worked as engineers continue to see themselves as engineers, even when they're not working. This creates opportunities, because it encourages women to form the connections – which can be made anywhere from the school gate to the awards dinner or networking through WES events – that remain important in returning to work. It encourages women, too, to recognise their talents, and to realise how valuable they are when they return to the world of work.

In both Transferrers and Returners there is an opportunity not just for women but for the whole workforce and for all employers, but people will only make the most of these benefits if there is scaffolding to support their choices.

As consumers demand more personalised products and the manufacturing technologies of the “fourth industrial revolution” reshape the way things are made and sold, the companies that employ more diverse teams will inevitably prosper. The days of producing one product, decided upon by one person and sold identically, are over. The future belongs to companies that can use the data they have on their business, their production, their customers and the markets in which they operate to create products that are as diverse as the people that buy them. This will only be achieved by diverse teams of people. Some will continue to specialise,

and in some disciplines that will be valuable, but engineers almost never work alone.

The roots of this opportunity for change are in our education system, where a less straight-line, exam-oriented approach has much to offer. The engineers of yesterday showed a proficiency for maths or physics, and were steered along a narrow path towards those subjects. Consequently, a great many pupils decided at an early age that to follow this path would mean ending up in a specific technical discipline, and only the small number that were confident in what they wanted to do in their careers were able to commit to learning more. This approach is wholly unsuited to the new way of the world. The technologies that will shape our future, from robotics and AI to advanced manufacturing to electric vehicles, are all multifaceted disciplines, incorporating everything from design skills to mathematical theory to physical structures, and the next generation of engineers will need to understand not only how to build and maintain these systems but how to apply them in the real world, how they will be used by people and how they can be improved.

There's a lot of evidence to show that children learn best when they are told stories. When they are told not just the date of the Battle of Hastings, but the language that was spoken, the politics of the time, what people's health and life expectancy was like in the 11th century, and the physics of an arrow in flight, they gain an understanding of one event that is greater, and more memorable, than the sum of its parts. In a way, this is what we're planning to do at the WES, and what engineering as a sector needs to do – to make disciplines and industries easier to navigate and opportunities easier to grasp, so that the engineers of the future have longer, more detailed, more interesting stories. Celebrations for the WES centenary are all based on the successes of 100 companies sharing their success stories to aid us all in achieving 30 per cent of female engineers and applied scientists by 2030.

Engineering a more diverse future

**Hayaatun Sillem,
chief executive
of the Royal
Academy of
Engineering,
explains why
we owe it to the
UK's economic
future to widen
the engineering
recruitment net**

The late Karen Spärck Jones, Professor of Computers and Information at Cambridge Computer Laboratory, was a vocal advocate for diversity in the computing sector who used to say “computing is too important to be left to men.” As we move into a world of enhanced – and exciting – technological capabilities I would extend Spärck Jones’ comment to encompass the engineering profession as a whole, not just computing, and to all dimensions of diversity, not just gender.

Emerging technologies such as artificial intelligence (AI), the Internet of Things (IoT) and engineering biology have the potential to significantly disrupt the UK’s engineering and manufacturing sectors and indeed the wider economy. Ensuring that we recruit engineers and technicians from a wide range of backgrounds with the necessary skills to shape and interact with these technologies will be key to the UK fully realising the economic and social benefits of this paradigm.

However, we know from industry



partners, professional institutions and the fellowship of our academy that there is a significant skills gap in engineering. The latest EngineeringUK *State of Engineering* report indicates that there is an annual demand for at least 124,000 engineers and technicians with core engineering skills, and an additional 79,000 roles that require some engineering knowledge and skills alongside other skill sets. Worryingly, there is an annual shortfall of up to 59,000 engineering graduates and technicians to fill these roles and almost half of engineering companies say that a shortage of skilled people is already having a significant impact on their productivity and growth.

One reason for the UK’s shortage of technical talent is that many people hold outdated views of what engineering is, and what engineers do. So we have launched a new, multi-year digital campaign called *This is Engineering* to challenge those misconceptions by presenting a positive image of modern engineering



Engineering is too important to be left to men

SHUTTERSTOCK / MONKEY BUSINESS IMAGES

in all its breadth and vibrancy. Developed with EngineeringUK and industry partners, it uses digital advertising to reach teenagers and those who influence their career choices, including parents and teachers. The campaign is a major part of the Academy's contribution to the government's Year of Engineering.

Crucially, *This is Engineering* takes a marketing-led approach – drawing on the expertise of those who market brands to young people through the social media channels they use day in, day out – and is rooted in research with young people into what their current perceptions are and how they decide their futures. In the shape of real young engineers from a range of backgrounds, the campaign illustrates how engineering is behind many of the things teenagers are already interested in – sport, fashion and tech, for example – and shows how they can follow what they love into engineering, and in doing so help shape the future. The campaign has got off to a great start: since launching in January, the videos have been viewed over 13m times by a teenage audience that is roughly gender balanced and we are now in the process of casting the next wave of videos.

I feel very strongly that attracting more diverse talent into engineering, and creating a workforce that better reflects the diversity of society, will be essential if the future products and services that we are developing are to properly serve the needs of the people who use them. The latest data suggests that just 12 per cent of the UK's professional engineers and technicians are female, while only 15 per cent of those who achieve first degrees in engineering are female. In an academy study commissioned in 2016, the UK was placed a lowly 58th out of 86 countries for gender diversity among engineering graduates – in countries such as Malaysia it is not unusual to see engineering classes where women are in a majority at an undergraduate level. The situation with apprenticeships is even more stark. In 2015-16, just seven per cent of engineering-related apprenticeships were completed by women in England; in Scotland this was

as low as three per cent.

It is a source of deep frustration that we find ourselves in this position in 2018 after decades of effort, but there are some glimmers of hope. Our analysis of women who graduate from engineering degrees shows that around the same proportion go into engineering jobs as men and in a survey of 7,000 UK engineers that we published last year we found that 87 per cent of women engineers said they would recommend engineering as a great career to friends and family, demonstrating that for those women that do pursue engineering careers it can be a very positive experience.

But diversity is not just about gender, and women are not the only group underrepresented in UK engineering. Less than eight per cent of professional engineers are from Black, Asian and minority ethnic (BAME) backgrounds, despite the fact that well over 20 per cent of engineering students are. And it is a particular source of concern that ethnic minority students are twice as likely to be unemployed six months after graduation than their white counterparts, even when the type of university and degree class are taken into account. That's why the academy has just launched a major new initiative, the Graduate Engineering Engagement Programme, through which we will work with engineering employers to bring a much more diverse range of engineering graduates into UK engineering jobs.

Expanding the talent pipeline into engineering is key, but so is ensuring that we create inclusive workplaces that are open and attractive to everyone, with progression systems that are fair and based on merit. Focusing on inclusion alongside diversity also enables those in the majority groups to feel that they can fully contribute to and benefit from these changes. And that matters, because we will need everyone's help if we are to finally move towards a truly diverse and inclusive profession that can attract, inspire and retain the best talent and, in so doing, unlock its potential to deliver social and economic impact that benefits all parts of society.

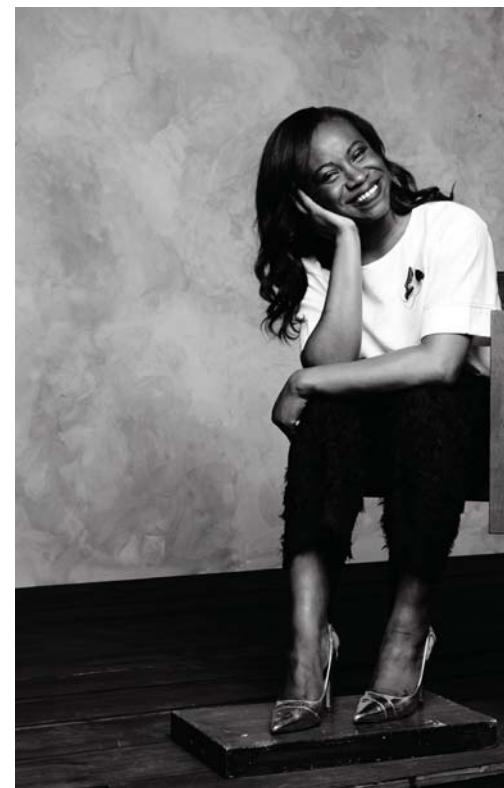
What does an engineer look like?

The engineering industry must become more appealing and accessible to a wider range of people, writes **Jo Foster**, diversity and inclusion manager at the Institution of Engineering and Technology

Engineering suffers from an image problem. There is a stereotype of an engineer, alive and well among school children. They typically describe an engineer as a white, middle-aged man. The Institution of Engineering and Technology (IET), is one of the world's largest bodies to promote engineering, particularly among young people, helping them to see that engineering provides an exciting, creative and rewarding career option.

Research we conducted among a representative sample of children aged nine to 16, revealed they see an engineer as white (51 per cent), middle-aged (31 per cent), male (67 per cent), with glasses (40 per cent), with a beard (27 per cent), short (36 per cent), with brown hair (44 per cent), with brown eyes (21 per cent), of tall stature (44 per cent), and of slim build (42 per cent).

In terms of the tools of the trade "he" might have at his disposal, 44 per cent thought an engineer would wear a hard hat and 43 per cent believed he would work on a laptop. 40 per cent thought he'd wear a high-vis jacket and use a



mobile phone (40 per cent), and another 39 per cent visualised him wearing protective eye wear and carrying a toolbox (37 per cent).

Sadly, it appears that school children can't see the opportunity for future female engineers, with less than one in ten (9 per cent) children imagining the typical engineer to be a woman. And, it seems this outdated stereotyping is being passed down from their parents. When asked to describe a typical engineer, parents returned almost identical answers.

To dispel these engrained ideas of what a typical engineer "looks like", the IET each year celebrates the best female engineering talent through the Young Woman Engineer of the Year Awards. To mark the 40th anniversary of the awards in 2017, a campaign showcased engineering in a completely different light, dramatically highlighting the diverse career opportunities available in the industry through stunning and unexpected imagery.

The IET commissioned Rankin Studios, renowned for photographing

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Engineering and Technology

Dr Ozak Esu, the IET's Young Woman Engineer of the Year 2017



everyone from Kate Moss and Madonna to The Queen, to style and shoot award finalists as well as previous affiliates in a series of dramatic and thought-provoking images. Dubbed "Portrait of an Engineer", the series was shot by award-winning photographer and Rankin protégé Vicky Lawton.

These outdated and fixed ideas of what a "typical engineer" looks like are damaging to the industry, especially when the significant shortage of engineers in the UK is posing a serious threat to the economy. Currently, just one in 10 is female, the lowest in Europe. And, wide-ranging reasons have been cited for this lack of women; everything from gender stereotyping and limited female role models to misconceptions about the job itself and parental attitudes.

Engineering is perceived as masculine, unglamorous and usually depicts people wearing hard hats and overalls. The reality is very different. With this series of beautiful and remarkable portraits we want to break down the visual stereotypes and show that engineering

is a diverse and creative career which offers the opportunity to do something life – or even – world changing. It also shows that you don't need a hard hat or high-vis jacket to be a great engineer.

Engineering contributed for a quarter of UK GDP in 2015 and engineering jobs account for 19 per cent of the total UK employment. Despite this, EngineeringUK predicts 186,000 people with engineering skills will be needed annually through to 2024 in order to meet demand.

Engineers featured in Portrait of an Engineer include Roma Agrawal and Yewande Akinola. Roma is a chartered structural engineer who has worked with signature architects during her eleven-year career designing footbridges, towers and sculptures; including six years as a senior structural engineer on The Shard, the tallest tower in western Europe. Yewande Akinola's engineering experience and responsibilities include the design of sustainable water supply systems and the engineering design coordination of large projects in the built environment. She has worked on projects in the UK, Africa, the Middle East and in East Asia.

Currently, the IET's diversity efforts are largely focused on gender. Events like its annual Women in Engineering conference and multi-award-winning campaigns and the Young Woman Engineer of the Year Awards have helped to demonstrate our commitment to gender diversity.

The IET also targets parents through its Engineer a Better World campaign which, working with big, respected brands and vloggers, demonstrates to children and their parents that engineering is behind the things that inspire them in their everyday lives. The campaign also includes the annual Engineering Open House Day, where young people and their parents visit organisations to see first-hand the exciting world of engineering and technology.

The government-backed 2018: Year of Engineering campaign also provides a useful focus for the IET's diversity work, bringing together a wide range of stakeholders, highlighting engineering

as a rewarding and exciting career.

While significant attention will continue to be given by the IET to gender diversity, it is important to note that in order to make a greater impact and reach wider and more inclusive audiences, that we broaden our diversity and inclusion efforts and focus upon multiple diversity strands and approaches. It is important that the engineering profession is seen as welcoming and inclusive to all where everybody has an equal opportunity to succeed.

With the uncertainty about the status of EU workers in the UK due to Brexit, it is important that the IET utilises its position within the engineering community to help elicit change. Gaining enough "home-grown", skilled and prospective candidates from diverse backgrounds to enter the profession is one of the long-term solutions to tackling the skills shortage and pre-empting the potential negative impact that Brexit could result in. One of the ways in which to achieve this is to ensure that appropriate steps are taken to engage with minority groups. Yet, according to the IET 2017 Skills and Demand in Industry Survey; fewer than one in ten businesses takes particular action to increase underrepresented groups, namely black, Asian and minority ethnic (BAME) and lesbian, gay, bisexual and transgender (LGBT) people into their workforces.

Taking into account the scale of this demand combined with a current UK engineering workforce that is just under 90 per cent male and 94 per cent white, there is a clear need for action to increase equality, diversity and inclusion within the profession at all levels. You can help us to change things for the better by getting involved in our latest campaign. #SmashStereotypesToBits has just been launched to coincide with International Woman in Engineering Day. We've produced a short film which raises awareness of the lack of gender diversity in engineering and highlights that it's a cool career choice for women by flipping stereotypes on their head.

For more information, please visit:
www.theiet.org/ywe

Leading roles: why the world needs women engineers

Professor Philip Nelson, executive chair of the Engineering and Physical Sciences Research Council, says engineering industries can't afford to let female skills go unnoticed

In 1942, the Hollywood actor Hedy Lamarr starred in three successful films: *White Cargo*, *Tortilla Flat*, and *Crossroads*. It would be decades later, however, before her most important contribution to how films are viewed and distributed would come to light.

In the same year, the extraordinary Lamarr co-filed a patent for a device that would allow radio-guided torpedoes to avoid signal jamming. This invention would later be adopted by the United States navy in the 1960s and forms the basis of modern-day Wi-Fi and Bluetooth communications.

Lamarr's life was recently celebrated in a film called *Bombshell* that showed how her talents were left unappreciated until her later years. While her story was, in many ways, made for the movies, the sad reality is that she is not alone.

The contributions women have made to the advancement of science and engineering have long been



underestimated or overlooked, as has their potential to bring about world-changing discoveries and technologies. Today, women still face very real barriers to progression to senior positions of influence in the Science, Technology, Engineering and Mathematics (STEM) arena. This is a state of affairs that is illogical, unfair and self-defeating but hopefully it is beginning to change.

For instance, Dr Clementine Chambon is a chemical engineer who has recently been recognised with the Young Researcher Award at the Institution of Chemical Engineers (IChemE) Global Awards 2017 and received the 2018 Chemistry World Entrepreneur of the Year Award for her "outstanding contributions to the entrepreneurial application of solar and bioenergy to solving major environmental, social and gender challenges in rural India".

In 2015, she and social entrepreneur Amit Saraogi co-founded Oorja

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Clementine Chambon and the Oorja Team with a solar pump user



Development Solutions Limited, a social enterprise that aims to use agricultural waste and sunlight to provide clean, affordable and reliable electricity to off-grid communities. Dr Chambon is the chief technology officer and leads the company's technical development, and the formation of academic and technical partnerships.

This is inspiring work and builds on her doctorate at Imperial College London, which was funded by the Engineering and Physical Sciences Research Council (EPSRC). She also holds a first-class master's degree in Chemical Engineering from the University of Cambridge and is a Forbes 30 Under 30 Social Entrepreneur.

Another woman who would be largely unknown to the general public but plays a part in most people's everyday lives is Heba Bevan. While a student at the University of Cambridge she was recruited by the microchip design company ARM where she was

an integral designer of the ARM Cortex processors, which are found in virtually all mobile phones in the world. There is a little piece of Heba's imagination in most of our pockets.

After returning to the UK from America to complete her PhD she went on to found Utterberry, a company that designs and sells lightweight wireless sensors for use in monitoring large infrastructure such as tunnels. The company, and the sensors it designs have been a huge success and recent use of the devices meant that London's Cross Rail project, which has been working closely with the EPSRC-funded Cambridge Centre for Smart Infrastructure and Construction, was able to proceed without the costly closure of Farringdon/Barbican station, saving costs and weeks of project time. The Utterberry sensors have garnered Heba several prestigious awards including the 2014 Digital Innovation Award in the Chartered Institute of Building's annual Innovation and Research Awards.

These are just two current examples of female engineers making a real difference to people's lives, the economy and the broader base of scientific knowledge. They demonstrate just a few of the rich variety of fields that fall under the term engineering.

A wealth of career opportunities exist, including in sectors that people will not immediately associate with engineering, from healthcare to sport, the music industry to offshore wind energy.

EPSRC, partnering with other organisations in the field, is currently promoting 2018 as the Year of Engineering, and Women in Engineering Day is a significant landmark for a campaign that is aiming to inspire children to study and pursue a career in engineering. We are committed to attracting the best potential researchers from a diverse population into research and innovation careers in universities and business. We aim to make all of our support for students and research staff, whether grants, fellowships or

studentships, accessible and flexible for everyone, including provision of parental leave and working part-time.

In addition, UK Research and Innovation (UKRI) has committed to increasing the representation of women to over 40 per cent of the membership for each council, with EPSRC setting and meeting targets for over 40 per cent female members of our Strategic Advisory Network and over 30 per cent female members of our strategic advisory teams.

We have also increased participation of women in our peer review and assessment panels, increasing female panel membership from 17 per cent in 2012/13 to 30 per cent in 2016/17 and have noted a significant increase in the number of female panel chairs over the same period. We continue to work hard to achieve mixed gender panels, with less than 6 per cent of panels being single gender in 2016/17.

As part of UKRI, EPSRC will continue to work with our partners in universities and business to increase the diversity of the research and innovation community. We have made progress, but the engineering and physical sciences research community is still only 18 per cent female and we also need to step up our understanding of issues around, for example, inclusion of minority ethnic researchers, people with disabilities and people from disadvantaged backgrounds.

In October, my successor as executive chair of EPSRC, Professor Lynn Gladden, who is currently Shell professor of chemical engineering at the University of Cambridge, takes over and I am confident that she will continue to champion these aims.

It is against this background that I will leave EPSRC with an optimistic view of what the future will bring for Engineering and the part that female engineers will play in the UK of the 2020s.

For more information, please visit:
www.epsrc.ukri.org

Why are only seven per cent of inventors women?

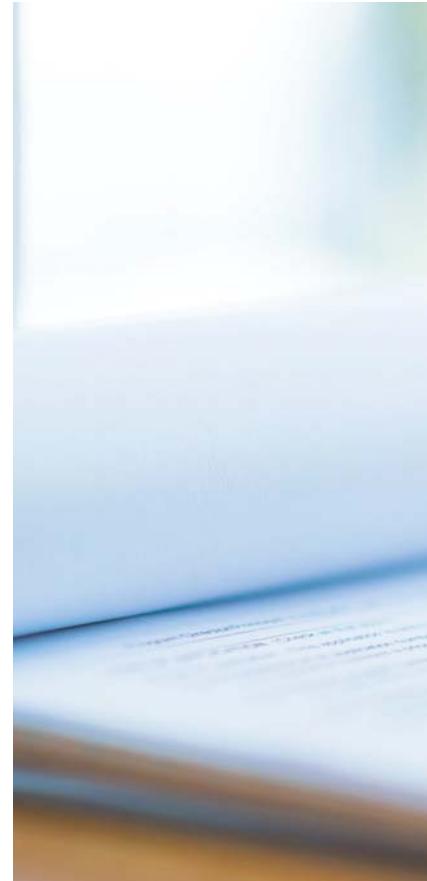
Women are dramatically underrepresented in patents. Are they no good at inventing things?
Augusta Riddy finds out

Are you a fan of fire escapes? Stem cell isolation? A friendly game of *Monopoly*? Yes, you've guessed it: these inventions were all made and patented by women. In fact, the web is awash with feel-good lists of important inventions you should "thank" women for. The Hollywood starlet Hedy Lemarr was "not just a pretty face", *Scientific American* reminds us; she was also a gifted inventor who paved the way for Wi-Fi.

Indeed, it is widely acknowledged by the internet that women are quite good at various things. Nevertheless, women only account for seven per cent of all inventors on patent applications in the UK. We shouldn't feel too bad, though; in Germany it's only five per cent.

A patent is granted when an invention of economic value is deemed unique or unprecedented; the law then prevents anyone else from reproducing that invention, without a license, for a certain amount of time. Men dominate patent applications in Britain, making up 93 per cent of applicants. Patents form the legal basis that governs all technological progress. Why are women so underrepresented?

Penny Gilbert is a partner at Powell and Gilbert, one of Europe's largest and most respected intellectual property law firms. For her, the main reason why women are not inventing as much is simple: "numbers". "There's no reason why women can't file patent applications, but you've got to be in a position where you're inventing. You don't get into that





until you've studied it."

She believes the answer lies in the established question of girls' interest in STEM subjects, and their ability to see a future for themselves within these sectors. "If you study engineering," she says, "it tends to conjure up images of high-vis and hard hats and lots of men. Maybe we need to show better role models." Gilbert points out that there tends to be a higher rate of female inventors in "gender-stereotypical" fields such as clothing, baking and domestic articles. In areas such as civil engineering and mechanical elements engineering, the numbers drops further to 3.9 per cent and 2.9 per cent respectively. As only 14 per cent of engineering graduates are women, "it's not surprising" that they are particularly

underrepresented in engineering applications, Gilbert argues, especially as not all graduates will remain in that line of work.

But while it is well known that women are outnumbered in STEM, they still make up 13 per cent of the total workforce. The extent to which women are underrepresented in patents is therefore severe even by STEM industry standards. Patents can be filed by individuals, or by teams of people on behalf of a company or another individual. Only 3.9 per cent of all patent applications are filed by female individuals, compared to 50.8 per cent by male individuals. Teams are most likely to be entirely male; 37 per cent of patents are filed by teams that contain no women, while mixed teams of

men and women account for just eight per cent. All-female teams are virtually non-existent, at 0.3 per cent of applications.

Researchers in the United States, where ten per cent of patent holders are women, have found that women who apply for patents are also less likely to be granted them. Kyle Jensen, Balazs Kovacs, Olav Sorenson and Emily Gordon of Yale School of Management recently authored a study into this disparity, entitled *Why Do Women Inventors Win Fewer Patents?* and made some unsettling discoveries. "We knew at the beginning of our study that women are underrepresented among inventors," they explain, but "we didn't know if women inventors and men inventors have the same kinds of success, or face different biases."

The research team analysed the treatment of inventors by examining the "prosecution history" of millions of patent applications, and for each application they used census data to identify applicants as male or female by looking at their names. "This let us uncover the degree to which men have different outcomes than women in the patenting process." They found that "a substantial, persistent disparity exists between the patent outcomes of men and women".

The project found that applicants by female inventors with common names had an 8.2 per cent lower chance of success, compared to a 2.8 per cent lower chance of women with "rare names", where it would be tougher for an examiner to guess the applicant's gender". The researchers analysed patent applications by inventors with "rare names", whose genders were not easily discernible, and through this were able to discover that "a substantial portion of the disparity appears to be explained by the way that patent applications by women are examined, as opposed to differences in the way that men and women write patent applications".

But the disparity does not stop at the patent application stage, it continues

Women's patents are less likely to be granted or cited



even once the patents had been granted; patents registered under common female names were cited 30 per cent less frequently than those registered under common male names. When asked what most surprised them about the outcomes of their research, the group said it was the “diverse” ways in which women seemed to be penalised. “Not only are women inventors’ patent applications less likely to be granted, when they are granted, fewer of their patent claims – the legal rights inventors get – are granted, their claims tend to be weaker, and the patents are less likely to be cited by other inventors.”

“Our study is only able to say a little bit about why that disparity exists,” they explained, but the researchers did conclude that those reviewing applications should be “blind” to the name of the applicant, and therefore avoid any gendered assumptions.

It is possible that workplace discrimination could impact female inventors at the moment when their ideas have the potential to receive acknowledgement, and economic gain.

Gilbert concedes that along with a lack of women working in STEM, other societal factors exist which continue to limit women. “There are some careers where it’s definitely going to be easier to fit in having children than others.”

The crucial question is: does it matter? As long as innovation keeps moving apace, then is this an issue? The Yale academics argue that it makes economic sense to “maximize the innovative potential for each would-be inventor”, an argument that could certainly be applied to the UK.

Gilbert believes that it is a problem, but primarily in the sense that options are being limited. “All girls should be able to choose whatever they want to do. [It’s] really important that girls and women shouldn’t feel that there are barriers to whatever career they want to pursue.”

Official figures state that seven per cent of people on patent applications in the UK are women, but, although it cannot be measured, the potential for women to invent things must be much higher.

Equal pay is just the first step towards equality

**Peter Finegold,
head of education
policy at the
Institution of
Mechanical
Engineers,
explains how
workplace cultures
can affect women's
perceptions of
engineering**

International Women in Engineering Day offers us a chance to shine a light on the experience of women in the engineering profession and continue the push for greater gender balance and diversity in the industry. Achieving these aims is essential for engineering organisations in order to become the highest performing companies they can be. Not only do businesses require the most talented employees, companies that embrace diverse experiences and points of view have been shown to improve productivity.

The current statistics around gender diversity in engineering are stark: only 9 per cent of UK engineers are women. It is a similar picture when looking at how many young women are being attracted into engineering, either through apprenticeships or university courses. Of the 490,000 apprenticeships started in England in 2016/17, 54 per cent of them were women. However, when you look at engineering apprenticeships specifically, the percentage of women drops to just 8.1 per cent.

More worrying still is that the findings of the Institution of Mechanical Engineers' report, *Stay or Go: The experience of female engineers in early career*, highlight that within a few years of gaining an engineering degree just under half of UK female engineering graduates will have left the profession.

A core message from the report was that 69 per cent of women working in engineering early in their careers reported having to adapt their personality to get by in the workplace. They cited unfair treatment in

comparison to male colleagues as the fourth most likely reason they would consider leaving the profession. Women at the same stage of their career in the finance sector ranked this reason to leave as ninth. Female medics placed differential treatment lower still, at 15th.

One junior manager highlighted how senior staff were more likely to circumvent her and approach her team directly – something that never happened to male managers at the same grade. Female engineers also reported the common experience of people assuming they worked in administrative or non-technical roles, until told otherwise.

The Institution of Mechanical Engineers research highlights how, for the most part, it is not the individuals within organisations who are to blame, but the sanctioning of attitudes and behaviours through the accepted norms. To counter this requires companies to reflect on more than pay parity and to explore the wider culture. Employers must make the working environment and culture more conducive for women, so that there is less of a need to support female engineers to adapt and cope with an unaccommodating environment.

The report makes a number of recommendations including the promotion and adoption of an industry-wide quality mark including pay parity so every company is crystal clear about what constitutes best practice. It also suggests that employers should consult all employees annually, and in confidence, on their views about the fairness of staff recognition, reward, professional support and work social activity – and, where necessary, implement changes to bring about improvement. Also, employers must promote a message that no employee should feel a need to “toughen up” to be successful in their career. The most effective way of ensuring that women remain in engineering and technology is to create working environments where they feel free to be themselves.

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The aviation industry is under pressure to deliver more cost-effective and environmentally friendly and technologies. Rohan Banerjee talks to the engineers making this happen

Engineering a new Jet Age

The aviation industry understands that progress has come at a price. But what progress there has been. Since Tony Jannus conducted the world's first scheduled commercial airline flight on New Year's Day in 1914 – a 23-minute jaunt between St Petersburg and Tampa in Florida – air travel has facilitated industry, business and tourism across the modern world.

In 1914, Jannus flew his Benoist XIV wood-and-muslin biplane with the former mayor of St Petersburg, Abraham C Pheil, paying \$400 for the privilege of being the world's first commercial airline passenger. Pheil sat on a wooden bench in the open cockpit. Just over a century later, budget airlines operate short-haul journeys between neighbouring countries for a fraction of the price.

The International Air Transport

Association (IATA) forecasts that annual air passenger figures will continue to rise steeply, with 7.2bn journeys predicted to be made in 2035 – a near doubling of the 3.8bn in 2016-17. Most of this growth, IATA notes, will come from "emerging markets". The Middle East, for example, will grow strongly (4.8 per cent annually) and will see 24.4m more passenger journeys each year on routes to, from and within the region in the next 17 years. Europe will have the slowest regional growth rate (2.5 per cent), but this will still provide an additional 570m journeys annually. All of this growth is happening within the context of increasingly high fuel prices and rising carbon emissions.

How can the aviation industry continue to fulfil its vital role in society without damaging the planet? And so the great electric air race has begun.

Industry heavyweights are now working on a solution to make air travel more sustainable and more cost-effective, without compromising on capacity or capabilities.

The Californian company Wright Electric claims that within a decade, passengers could be taking battery-powered flights as a result of its engineering partnership with Easyjet, aimed at delivering less environmental impact than conventional aircraft. "For the first time in my career, I can envisage a future without jet fuel," Easyjet's outgoing chief executive Carolyn McCall told *The Guardian* last year.

Wright Electric says the new aircraft, which is designed to carry around 150 passengers, will be "ultra-short-haul", with a range of about 550km. But Easyjet says this would be enough to cover a





Passenger numbers could reach 7.2bn by 2035

ROLLS-ROYCE

fifth of its current network, including London-Amsterdam and Paris-Geneva. Achieving the goal to fly these routes within a decade, though, depends on improvements in the power-to-weight ratio of batteries, as well as new propulsion systems – dependent on technology that doesn't yet exist.

Another company based in the United States, Zunum Aero, which is supported by Boeing, is building a 12-seater hybrid electric plane that it says could massively reduce operating costs for private jets, with the proposed craft to be ready by 2022. In Norway, Avinor, the public operator of the country's airports, has the ambition to make all its short-haul flights entirely electric by 2040. More immediately, though, it plans to launch a tender offer to test a commercial route flown with a small electric plane with

19 seats, starting in 2025. But before reaching that point, Avinor said it would need to rely on intermediary technologies, such as biofuels and hybrid-electric solutions.

Smaller aircraft are more likely to take off sooner, as big planes are more complex technically and legally. François Chopard, the CEO of Starburst Accelerator, a leading investor in aerospace, explained during an interview with Quartz that larger scale electrification projects are being held back by regulatory and safety implications that the industry is still ironing out. "Fully electric larger planes are not yet ready," he told Quartz, "because currently there is little to no regulation of electric aircraft." Even when the technology for large electric planes is developed, the regulatory environment may take years to make

Electric planes could require shorter runways



them available to passengers.

Accordingly, big aerospace firms such as Rolls-Royce, Airbus and Siemens are more conservative with their predictions for commercial application. They forecast that hybrid commuter jets will take to the skies on routes of up to 1,000km between 2030 and 2035, although the three companies have already started working on the technology that will be involved, with a view to launching the E-Fan X hybrid-electric demonstrator by 2020. The E-Fan X is based on a BAe146 aircraft in which an electric unit, powered by an on-board generator, replaces one, and eventually two, of the plane's four gas turbine engines.

Riona Armesmith, Rolls-Royce's chief

project engineer for hybrid electric propulsion, says these engines are not solely about moving away from one kind of fuel. "Hybrid-electric and electric propulsion systems are being investigated as the next potential major step in improving propulsive efficiency as we reach the limits achievable with gas turbine technologies. Today's limited aircraft design space could feasibly be opened up by these new technologies due to the ability to split the physical location of, or remove entirely, a hot exhaust from a propulsor by introducing an electrical network."

Frank Anton, head of eAircraft at Siemens, agrees that "we are not betting on batteries, we are betting on hybrids.



Batteries add additional power during take-off and climb.” Armesmith notes that “advances in battery technology, which have been primarily driven by the automotive industry, are beginning to make hybrid-electric and electric propulsion a feasible prospect.”

The BBC’s international business reporter, Theo Legget, offers further context. “Jet fuel makes up a significant proportion of a typical airline’s running costs. Over the past few years it has varied from 17 to 36 per cent depending on the price of oil.”

As part of its Flightpath 2050 plan, the European Commission expects the aviation industry to reduce its carbon dioxide emissions by 60 per cent,

nitrogen oxide pollution down 90 per cent, and noise pollution by 75 per cent.

Part of this could be achieved not only by electric motors, but by the radical changes in plane design that they could allow. Rolls-Royce’s chief technology officer, Paul Stein, notes that motors “can be tilted more easily”, which could dramatically alter the way they fly, and the kind of airports they need. Quieter and cleaner travel might also mean that airports could be situated much nearer to city centres, and the infrastructure that provides transport to them could be simpler. Armesmith explains that electrification “could allow us to take off and land quietly, from shorter runways, therefore opening up underutilised

small airfields and potentially negating the need for enormous civil engineering projects such as road and rail developments. Economies that have dispersed islands or mountainous regions, without existing road or rail infrastructure, could benefit hugely.”

She predicts that electrification will “deliver a radical shift” in passenger experiences as a result. “We can envisage that passengers could make point-to-point journeys by aircraft alone. This could mean that a passenger flies internationally from a large hub, but then completes their journey home in a much smaller aircraft by simply crossing the airfield, similar to the process of changing platforms in a train station.”

Stein says that electrification of the aviation industry is too complex for any one company to saddle the pressures of the project on its own, and that has necessitated the collaboration between key industry players like Rolls-Royce, Airbus and Siemens. He says of the E-Fan X: “We’re taking a BAe146, an old four-engine regional aircraft, and removing the starboard inner engine, the right-hand inner engine, and replacing it with a 2MW battery from Siemens, while running a fan from Rolls-Royce. Inside the BAe146, there is a Rolls-Royce AE2100 engine that we developed for the Lockheed Hercules [a military aircraft], except now instead of driving a propeller it’s driving a generator. Airbus, meanwhile, is developing the two-tonne battery packs inside the craft or frame.”

“It’s very exciting,” Stein says, “and unless anyone comes to the party sooner, it’ll be a world-first hybrid generator. We’ll learn lessons about de-risking the technology for a natural aircraft design. The 146 has three conventional gas turbines which mean it is a low-risk solution to demonstrate this new and exciting hybrid technology.”

Ultimately, the reality of globalisation is setting the agenda for the future of flight. If people can’t and won’t stop flying, then making planes more energy-efficient and cost-effective must be the sector’s priority. Electrification, the main players are sure, is the answer.

Why stereotyping is a sorry sight

Race, gender and social background should have no bearing on career choices, according to **Rebecca Thompson**, president of the Chartered Institute of Building



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My own introduction to the world of construction and engineering happened by accident. As part of some school-organised work experience during my teenage years, I was placed as a receptionist at a building surveyor's office. While girls were assigned the more administrative tasks in the office, boys were given the more interesting, in my view at least, technical roles. I found myself intrigued by those roles, certainly more so than by the reception desk. It was through the support of my colleagues and mentors that I eventually chose to pursue a career in construction, but I look back and wonder: if I'd known more at a younger age, would I have been able to take that path more quickly?

The willingness to stereotype genders in the job market is an enduring concern for the modern workforce of the United Kingdom. While science, technology, engineering and mathematics (STEM)

fields remain largely the preserve of white, male candidates, this sorry state of affairs means that the UK is struggling to address its skills shortage. Put simply: evolving industries are requiring more roles to be filled than there are skilled candidates to fill them.

Indeed, research undertaken by the Federation of Master Builders (FMB) found earlier this year that a shortage of construction workers faced by small and medium-sized businesses has hit its worst level on record, threatening the government's plans to build hundreds of thousands of affordable homes annually as it tries to tackle the wider housing crisis. Brian Berry, the FMB's chief executive, said of the organisation's findings: "Skills shortages are sky-rocketing, and it begs the question: who will build the new homes and infrastructure projects the government is crying out for?"

As the UK's decision to leave the European Union exacerbates this

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predicament – Brexit's effects on access to skilled migrant workers is a real powder keg for policymakers – there is an obvious need to improve and expand our skills base at home. The domestic construction and engineering scene has not modernised or diversified sufficiently for supply to meet demand. An over-reliance on just one section of society to provide the construction and engineering workforce, then, is not only undesirable, but is also unsustainable. Society as a whole benefits from

Construction has struggled with an image problem

construction and engineering. It would make sense, therefore, for the construction and engineering workforce to reflect a diversity of insight and experience. That means attracting and retaining more women, more ethnic minorities and people from various social backgrounds to industries that they may have previously felt were not suitable for people like them.

So where have these industries been going wrong? Principally, there has been a failing on the part of companies and course providers in "selling" their opportunities. Where technologies and trends within industries have developed and progressed tenfold, the same unfortunately cannot be said for the marketing strategies attached to them. The language and imagery used in engineering prospectuses for universities, for example, are too often tailored towards male candidates, where really more neutral descriptions or diverse pictures should be used. A quick Google search of "construction manager" even now would likely return a mosaic of hard hats and muddy boots. In reality, construction and engineering encompass far more than just manual labour; there are opportunities within both to pursue IT, project management, procurement, planning and communications to name but a few sub-sections of these fields.

The important thing to convey when selling the construction and engineering industry is largely their impact on people's everyday lives. In reaching out to the next generation of builders and engineers, we should be able to show them that what they could potentially achieve, and how it will have a tangible impact on the world around them. Construction and engineering have a vital role to play, for instance, in nurturing a sustainable environment and battling climate change – issues that affect us all. Construction and engineering provide

infrastructure – roads and railways for our transport networks – and the buildings which contain our most precious public services, including healthcare and education. There can be no hospitals, there can be no schools, without builders and engineers.

The Chartered Institute of Building, an industry body armed with nearly 200 years' worth of experience and expertise, views the drive for greater diversity and inclusion in the construction and engineering industries as paramount to their capacity to survive and thrive. Preconceptions have historically led to misconceptions, about who is and isn't good at what, and the skills lull that we observe in the UK today is owed in no small part to the laziness of stereotyping. This is why the CIOB is urging policymakers, academia and industry professionals alike to review their approach to recruitment and retention of staff and students.

Construction and engineering need a wide variety of ideas – informed by different points of view – and as well as appealing to more women and ethnic minorities, they also represent unique portents for social mobility. Compared to other industries, both construction and engineering have clearer routes to transition manual, entry-level jobs, to trades and senior management.

Buildings are, ultimately, assets to our society. They are catalysts for productivity and key to our safety. As Winston Churchill put it while addressing the English Architectural Association in 1924: "There is no doubt whatever about the influence of architecture and structure upon human character and action. We shape our buildings and afterwards they shape us. They regulate the course of our lives." And in 2018, that sentiment should pertain.

For more information, please visit:
www.ciob.org

Introducing an engineering course without A-Level maths

Hereford's NMiTE is the first new university in the UK in 30 years. Its inaugural provost, Elena Rodriguez-Falcon, outlines a new liberal approach to learning

The United Kingdom has a huge shortfall of talented engineers and part of this problem is that too few female teenagers see it as the sort of career they want to undertake. As a female engineer who has had the privilege of helping thousands of undergraduates become engineers I can say it is in fact a fantastic career for women, especially for those who want to improve the world.

To enable more women and indeed other groups of people who would make great engineers but are currently excluded, I joined the New Model in Technology and Engineering (NMiTE), the future university currently being built at Hereford, as its provost. NMiTE is probably the biggest experiment in the UK's higher education sphere in the past 30 years, bringing radical but proven innovations from universities around the world into one exciting experience.

We are setting out to break the mould of engineering education, and will be proudly offering the world's most radical engineering education when our first pioneering undergraduates arrive in September 2019. For instance, our



MEng in integrated engineering will be taught not in four but three years, 46 weeks a year, during which time our engineers in training will be learning by solving real challenges from partner employers 100 per cent of their time. So, with hands-on learning, we will have no lectures. Absolutely none! There are no set textbooks either.

Our learners will not sit traditional exams. They will instead demonstrate their competencies and skills by addressing challenges from engineering and manufacturing companies. Furthermore, they will be tasked with understanding society's challenges and translating them into not just technically viable, but holistic solutions. As such, our engineers will have a liberal approach to engineering, using a variety of techniques including those utilised by business, philosophy, sociology and the arts.

We are also slaying perhaps the most sacred of cows in UK engineering; we will not require our learners to have maths and physics A-level. Engineering does require a high standard of maths so instead those without it will be provided



with tailored support to bring them up to speed.

Our approach has been featured widely in education, engineering and also national newspapers and a recent prominent article about NMiTE in *The Times* highlighted many of the underlying problems: a deeply conservative profession stuck in the past coupled with a public perception that professional engineers with degrees and masters don blue overalls, hard hats and

man production lines.

Let's deal with the misconception about what engineers do first of all. The view that engineers spend their time in overalls fixing things is about as accurate as believing lawyers spend all their time in powdered wigs interrogating the accused. This widespread misconception was highlighted when the online article in *The Times* was initially illustrated with a photo of women in blue overalls in a factory filing parts in a vice. I and others highlighted this inaccuracy and it was replaced... this time with a photo of three women in hard hats down a tunnel.

It sounds such a small complaint, but readers of the *New Statesman* will know the damage that is done when negative stereotypes are perpetuated. In this case teenagers and their parents see engineering as male, manual and dirty. The reality is that engineers, like other professionals, whether accountants, lawyers, or journalists, spend most of their time at desks or in meetings solving big challenges and earning high salaries!

The bigger issue was highlighted by the huge number of comments attracted by the article, over 100 comments last time I looked, largely from people purporting to be engineers. I do hope pupils and parents don't see them as I can't think of a better way of putting people off engineering than reading these misogynistic and old-fashioned views. What had set off the ire of this phalanx of crusty engineers and led to such an outpouring of disdain? It was the very idea that maths and physics A-level won't be compulsory to get a place at NMiTE!

For us, the dogmatic insistence on A-level maths and physics is at the heart of the problem with attracting enough people into engineering. But can it be done without dumbing down the profession? Quite frankly the outpouring showed it is dumbed down already. Instead we are here to help lift it up to be fit for the impending fourth industrial revolution as every aspect of life becomes interconnected and digitised.

It is worth noting that Brunel, Eiffel, George and Robert Stevenson, and other great engineering figures from history did not have an A-level in maths. I dare

say they were excellent mathematicians, as will be our graduates.

However, too few female teenagers are inspired to take maths and physics at A-level, partly because they don't see it leading to the sorts of careers they want. There have been lots of attempts to change this, but to no avail. NMiTE can't change the UK's deeply entrenched misunderstanding of engineering on our own nor can we suddenly make thousands more teenagers suddenly want to do maths A-level. But we can catch them once they seriously start thinking about careers in the sixth form and take away the requirements of A-level maths for entry into an engineering degree programme.

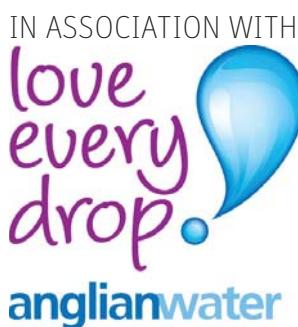
But it is not just about "jobs for the girls". There are also lots of others who we are looking to attract who will make excellent engineers, such as ex-forces personnel, who have the aptitude, grit and passion, but perhaps not the maths. After all, they may well have been responsible for large teams maintaining some of the most sophisticated and advanced equipment on land, sea or water. We think such people can make great engineers despite not having studied trigonometry and calculus in their teens.

Our approach of wanting smart people who have lots of aptitude and attitude to become engineers, rather than only drawing from the limited pool of sixth-formers doing A-level maths, is radical in the context of England. But NMiTE is not out of step when you look internationally, including Scotland, where the syllabus is not so specialised. It is also worth noting that in these countries engineers have a much higher status than in the UK. In fact, it is the dogmatic insistence on people requiring A-level maths in England that is out of step with much of the world.

NMiTE will open its doors in September 2019 to our first cohort of students, and from autumn 2018 we'll be opening our doors to a group of participants drawn from recently graduated engineers and people who have just finished their A levels. The "design cohort", will co-design and co-develop the NMiTE proposition and help us truly embed the "student voice" across our organisation.

Meet the female water manager who keeps the taps running

Hannah Stanley-Jones is a water resources development manager at Anglian Water



When Hannah Stanley-Jones was deciding what career to pursue, she knew it had to be related to her passion for environmental sciences, with a sustainable element. Fast-forward a few years, and she is now a water resources development manager at Anglian Water, using her technical engineering capabilities to oversee the company's groundwater assets. "Water resource is a really critical issue, and it will continue to be a critical issue for our economy, for our environment."

Anglian Water has been fostering Hannah's career since before she even joined the company. Whilst studying at Leeds University for a BSc in physical geography, and then an MSc in environmental geochemistry, she spent her summer breaks working as a laboratory technician at Anglian Water. She then went on to join the company's graduate scheme as a water

resources graduate management trainee, moving around all the different teams, including the ground water engineering department who maintain the company's physical assets, changing pumps and monitoring boreholes amongst other activities.

Having completed the graduate scheme, Hannah became a water resources specialist for three years, focusing on ground water. This was an extremely technical role, as part of which she led ground water quality investigations, and worked closely with the engineering team to deliver a borehole maintenance programme, and manage operational responses to pollution incidence. "In that time I was developing my management skills, completing a diploma in leadership that I have been able to put into practice by managing a technical team in my current role."

Hannah has been a water resources development manager for the past two years, managing a business unit responsible for ensuring full operability of groundwater assets. These assets supply 50 per cent of raw water required to meet the demand

"Recognise achievements regardless of gender"

of 4m customers.

As part of this role, she has been involved in the delivery of the Water Resources East Project which "outlines how we will maintain the balance between water supply and demand in our region, managing the risks associated with climate change, severe droughts, the needs of the environment and population growth." This multi-company, multi-sector



project has allowed Hannah to meet and discuss with professionals in other organisations, and represent Anglian Water externally at critical conferences and meetings.

As a woman, does she feel like the exception in such a technical and senior role? "I would say no. In more traditional hydrology and hydrogeology-type roles, at quite a technical level there is good female representation." In her team, she explains, there has sometimes been stronger female representation than male.

Nevertheless, Hannah does point to the more general problem across STEM sectors of a lack of female representation at the senior leadership, boardroom level. She believes this is due to a combination of a lack of girls and young women studying STEM-related subjects, and complications that arise with family and childcare responsibilities. Additionally, something

that is particularly typical of the water industry is a slow pace of turnover. "People do spend their entire careers in the industry, so it's very difficult to recruit at a senior level because you just don't have the turnover," she explains. "What you have to do is make sure that the recruitment you are doing for people earlier in their careers is representative." At that level, there isn't the same problem, and Anglian Water has got "really good representation and diversity."

Hannah is, therefore, confident that this gender diversity will trickle up the organisation as industry entrants progress through the ranks. However, the company is making a concerted effort at "both ends of the spectrum" to ensure that the very best candidates are being given opportunities, regardless of gender or any other factor.

To inspire youth to get involved with

water, and STEM in general, Anglian Water has a dedicated education team that go into both primary and secondary schools, running fun and engaging activities with children. The company sponsors the Peterborough STEM festival, and makes sure that it always has strong female representation at the festival so that girls and young women attending know that it's not just a career for men, breaking down that stereotype. The company also runs specific events for Women in Engineering Day; inviting girls onto an Anglian Water site so they can understand and see how water treatment and water recycling works.

Hannah only has to give the example of her own career to show how much opportunity for progression the company has provided. "I've been fortunate enough to be able to get a lot of technical experience, and the role that I'm in now was specifically created to give me the opportunity to develop my career."

At the other end, Anglian Water is "actively promoting flexible working at a senior level" to alleviate the pressures of family life, for both men and women as men continue to increasingly take time to be their families. The company has a diversity board, which offers advice and direction on how best to create an inclusive employment environment. "Anglian Water is committed to being an equal opportunities employer," says Hannah. "People are promoted and recognised for their achievements regardless of their gender."

Getting young people excited about critical industries like water management isn't hard, she explains, as they are "very tuned into environmental issues and sustainability". Her initial interest in sustainability and "making a difference" has led her into a successful, exciting and rewarding line of work. Anglian Water is committed to supporting individuals with a huge amount of potential, like Hannah, into senior technical roles, so that they can achieve the highest level of workplace satisfaction, and deliver the best possible service to Anglian Water customers.

“The art of thinking independently together”

Sue Percy, chief executive of the Chartered Institution of Highways and Transportation, explains why a diverse approach to recruitment is key for the engineering industry

Malcolm Forbes, the esteemed American entrepreneur and publisher of *Forbes* magazine, conceptualised diversity as the “art of thinking independently together”. Quite, as Forbes put it, difference does not necessitate division, but rather offers businesses and industries the opportunity to access insight from a variety of perspectives and experiences. Given that engineering is an industry that services the whole breadth of society – everyone uses products made by engineers – it makes sense that its human resources should be reflective of that fact too.

Yet for myriad reasons, the engineering sector is currently, and has been for some time, fishing from a small pond when it comes to its workforce. The overwhelming majority of candidates for engineering roles tend to be white and male, but it's not just white men who use roads, railways, or any of the other crucial



infrastructure provided by engineers on a day-to-day basis.

Combatting a national crisis

The United Kingdom's skills shortage in science, technology, engineering and mathematics (STEM) fields is brought into sharper focus by the country's decision to leave the European Union. Brexit brings about a renewed urgency to saddle industry pressures, while reducing the reliance on migrant workers and the drive for more diversity must, therefore, take centre stage. If the issue is a pure numbers game, and the UK needs more roles filled than there are candidates, the answer is to find more candidates ready and willing to apply.

There is a very logical starting point in meeting this challenge. Consider that women, who make up half of the UK's population, represent only a tiny section of the country's engineering workforce. Research undertaken

IN ASSOCIATION WITH





by WISE – the campaign for gender balance in STEM – found that in 2017, the UK had the lowest percentage of female engineering professionals in Europe at less than 10 per cent. This was less than the 30 per cent figure in Latvia, Bulgaria and Cyprus.

And the UK's lack of female engineers should come as no surprise if one considers that just 15 per cent of current engineering undergraduates at the country's universities are women. This is compared to 30 per cent of engineering students being female in India. While the Higher Education Policy Institute (HEPI) has recently confirmed that women are more than a third more likely to attend university than men, within the context of engineering it seems that this trend is not being capitalised on.

Addressing engineering's image problem

So as the UK struggles to produce the numbers of engineers required to meet

industry demands, let us ask: what is putting off women from pursuing engineering? The subject and the industry at large, it would appear, have not absconded from some of the outdated language and imagery of the past.

Given the exponential growth of technological and engineering capabilities over the past 20 years especially, it is disappointing that this has not been translated to better marketing. It's not all hard hats and muddy boots; it's not even all cranes and tarmac. Engineering today is an industry that encompasses a whole host of sub-industries. There are opportunities in IT, in communications, in design and in project management.

Engineering, particularly within the context of transport, has a massive social role to play. As transport helps to offer choices – whether or not we can, and how we travel, determines much of our work and life – it is important that any promotional material reflects just how significant engineers are in shaping the world around us.

Articulating engineering's impact should aim to inspire, but too often, for women and for people from ethnic minority backgrounds, it has run the risk of alienation. While that alienation might not have been intentional, it's high time that we realised that it has taken place. The relative homogeneity of our engineering workforce suggests as much.

What we're talking about here are micro-aggressions – a real enemy to progress – which have put people off entering an industry they've been led to believe isn't welcoming to people like them. Even something as basic as a job description or university prospectus, for example, can be hugely influential in a person's decision whether or not to apply for a role or course. It is important to make sure that the language is balanced and that any imagery used doesn't just peddle a stereotype.

The CIHT is fully committed to the

mission of improving diversity in the UK's engineering workforce. It is our hope that diversity can represent less of a novelty for organisations in the future, and rather form a core tenet of theirs from the onset. As the UK, and indeed the world, becomes more progressive in its social attitudes, towards gender and race equality, it is only fitting that engineering as one of its most vital industries, follows suit. And the normalisation of more women and ethnic minorities in engineering – because that is frankly a clear solution to sub-target application levels – will only be achieved if the industry is more proactive in its approach.

Diversity as business strategy

Concordantly, the CIHT has launched a diversity and inclusion charter, inviting members to sign up and coordinate a strategy to make sure that diversity and inclusion are at the heart of their business plans. It makes business sense to be diverse, as Forbes noted, because it helps to coalesce multiple mind-sets and deliver products which are sensitive to different consumer needs. This opens up new targeted market opportunities, while acknowledging that no one group in society has a monopoly on good ideas.

Ancillary to the charter, the CIHT has also established a diversity and inclusion toolkit, advising members on best practice when it comes to recruitment and retention of staff. Diversity is not a box-ticking exercise to be tainted by short-term tokenism; it is a genuinely beneficial decision to take in growing a business. The CIHT wants to see forward-thinking appointments, then, from entry-level through to the boardroom, to help engineering increase its capacity while improving its capabilities.

For too long engineering has been a slave to the status quo, and in meeting the multiple challenges it faces moving forward, it must challenge itself.

For more information, please visit:
www.ciht.org.uk/diversity

ENGINEERING

The latest contracts, jobs and training

THE LARGEST PUBLIC SECTOR CONTRACTS NOW OPEN FOR BIDS

These contracts are now open for tenders.

1. Warwickshire County Council

WCC – Provision of Construction Works

Bid deadline: 20th July

Tender value: £125m

Warwickshire County Council seeks a construction partner for an initial two-year contract, with an option to extend a further two years, to build and maintain civil engineering projects in the local area, including transport infrastructure.

Contact: procurement@warwickshire.gov.uk

2. LHC Building Components and Services

Construction Consultancy Service – South West England

Bid deadline: 31st July

Tender value: £70m

LHC is inviting bidders to provide consultancy services, including health and safety assessments, quantity surveying and building standards, on a range of engineering projects in South West England.

Contact: tony.woods@lhc.gov.uk

3. Welsh Procurement Alliance

Construction Consultancy Services (Wales)

Bid deadline: 1st August

Tender value: £60m

Description Bids are open for the provision of construction

consultancy services, including architectural design and health and safety assessments for non-residential building projects in Wales over the next four years.

Contact: info@lhc.gov.uk

4. Port of Dover

Civil Framework 2019-23

Bid deadline: 27th July

Tender value: £20m

Description: The Port of Dover is looking for a single partner to accept a contract of four years to build and maintain infrastructure on and around its main site. The infrastructure will include power lines and surrounding rail and road links.

Contact: procurement@doverport.co.uk

5. Department for Environment, Food and Rural Affairs

National Provision of Statutory Engineering Inspection Services

Bid deadline: 16th July

Tender value: £4.8m

Description: Defra is seeking a partner for eight years to oversee and maintain its multiple offices' compliance with the legal requirements of the Health and Safety Work Act, including any on-site mechanical and electrical installations.

Contact: dorothy.holding@environment-agency.gov.uk

Total value: £279.8m

THE LARGEST PUBLIC SECTOR CONTRACTS OPEN FOR BIDS SOON

“Pre-Information Notices” give advance warning of contracts that will soon be open for tenders.

1. The Coal Authority

The Coal Authority will invite bidders

for a four-year contract to redevelop disused mining and metal areas around England. The areas will be refurbished and repurposed through civil engineering projects to introduce, for example, new water treatment facilities and electric power lines.

PIN Value: £32m

2. Cyngor Gwynedd

The local council of Gwynedd will seek partners to deliver a range of engineering (civil, mechanical and software) and construction projects, including the provision of police equipment and telecommunications infrastructure.

PIN Value: £10m

3. Sellafield Limited

Sellafield Limited, the company tasked with the safe and secure operation and clean-up of the Sellafield nuclear site, will look for a partner to provide comprehensive engineering and technical advice to future users of the site, through a web-based portal.

PIN Value: £2m

Total value: £44m

ENGINEERING JOBS NOW OPEN FOR APPLICATIONS

Development Engineer, UK Atomic Energy Authority

Salary: £44,959-£50,272 p.a.

Location:

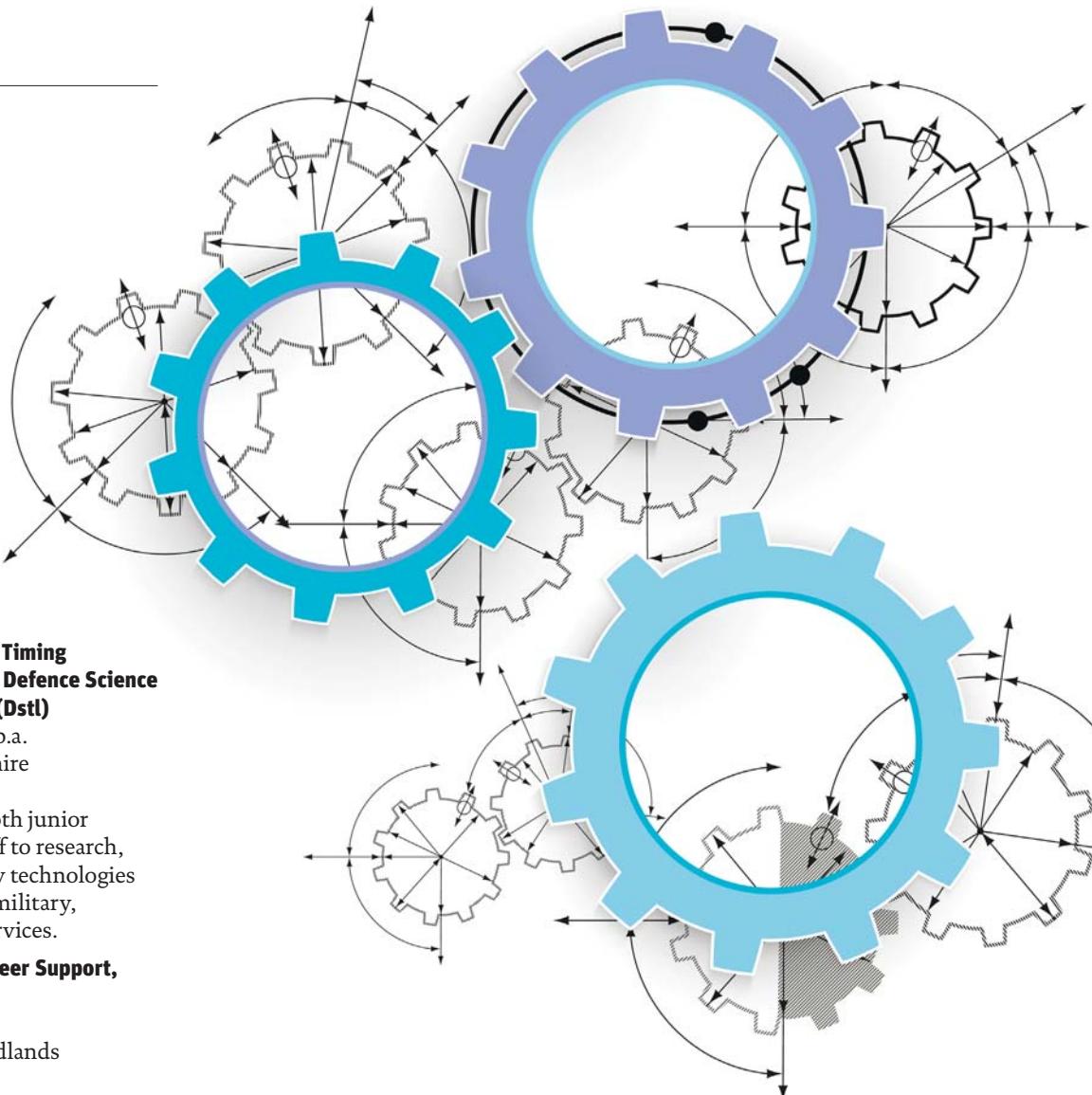
Culham, Oxfordshire

Closing date: 11th July

The UK Atomic Energy Authority is seeking an experienced engineer with extensive knowledge of manufacturing and testing solutions development, especially for components exposed to harsh weather conditions.

Tender and framework data supplied by

tussell



Positioning, Navigation and Timing

Scientist/Systems Engineer, Defence Science and Technology Laboratory (Dstl)

Salary: £24,000–£52,000 p.a.

Location: Salisbury, Wiltshire

Closing date: 15th July

Dstl is looking to recruit both junior and senior members of staff to research, develop and prototype new technologies for the benefit of the UK's military, security and emergency services.

2FTS Deputy Chief Air Engineer Support, Ministry of Defence

Salary: £31,136 p.a.

Location: Newark, East Midlands

Closing date: 15th July

The post-holder, with an academic background preferably in aerospace engineering, will be responsible for sustaining and developing the operational requirements at the RAF Syerston and Volunteer Gliding Squadron sites throughout the UK.

TRAINING OPPORTUNITIES

BSc Engineering, Dyson Institute of Engineering and Technology

This full-time four-year course, designed by inventor James Dyson in partnership with the University of Warwick, offers participants the chance to gain a degree qualification while working for Dyson Ltd three days a week. Based at a specialist facility in Malmesbury, Wiltshire, students will earn a salary of £16,000 p.a. while splitting their time between the classroom and working across different departments of Dyson Ltd.

MSc Engineering Management, Brunel University

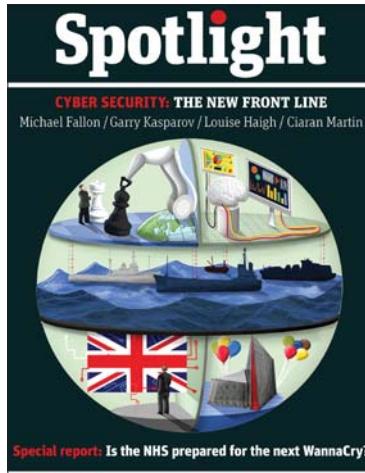
This one-year full-time post-graduate course helps students to master current and emerging industry trends. Balancing

academic theory with practical placement opportunities, the course covers advanced manufacturing, robotics, supply chain relationships, engineering finance, human resources and navigating new industry regulations.

Rolls-Royce PhD Studentship in fluid-induced vibrations in gas turbines, Imperial College London

This doctoral course is sponsored by Rolls-Royce and will be supervised through the partnership between its "University Technology Centres" and mechanics division. The four-year project will focus on investigating fluid-induced vibrations in gas turbines and computational aero-elasticity, with the aim of informing future RR products.

Spotlight



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