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# Engineering: time for change

## How women are making a difference

The Guardian

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## Inside



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**Introduction**
**Coco Khan**

## *Women are entering the sector in growing numbers*

The image of the engineer is slowly changing. No longer the preserve of men in yellow hard hats and hi-vis jackets, engineering is now a career taken up by a diverse group of people in a multitude of environments – from energy engineers working on a rig, to sound engineers at Glastonbury festival.

Women are entering the sector in growing numbers. Currently they make up 12% of all engineers, up 2% on 2015. However, this is low compared with nations such as Latvia and Cyprus, where women make up 30% of the engineering workforce, and there is still much work to be done to encourage women to enter – and remain in – the profession.

In this supplement, we look at some of the barriers women face, from education to gendered pay to working as a parent, and meet women who have beaten the odds and thrived in engineering. We look at the boom in female-focused coding clubs creating a generation of software engineers; and electrical engineer Ozak Esu discusses the importance of getting BAME women into the sector. We also focus on how apprenticeships have delivered a new route into the profession and hear from young women working on their first engineering job, whose hopeful testimonials speak to a sector changing for the better. There is still much work to be done, but the wheels have certainly been set in motion.

# Women in engineering

## 'It's an exciting time for females to join the sector'

Although the industry is still dominated by men, ongoing activism and pressure from young women is having positive effects on closing the gender gap

**Heidi Scrimgeour**

Engineering is dominated by men, but the women successfully breaking into the sector report good things. Barriers to entry for women are numerable, but career satisfaction is high; more than 80% of female engineers are either happy or extremely happy with their career choice, and 98% find their job rewarding, according to a 2013 survey by the Royal Academy of Engineering.

Yet, despite good prospects – engineering students are second only to medics in securing full-time jobs and earning good salaries – the number of women working in the sector remains woefully low.

"Women make up just 12.3% of all engineers in the UK, and only one in five of jobs are held by women in the wider engineering sector as a whole," says Elizabeth Donnelly, CEO of the Women's Engineering Society (WES), a charity and professional network that celebrates its centenary this year.

Attracting more female talent to the UK engineering sector – and retaining those people – is vital for economic growth and financial stability. Britain suffers from an acute shortage of engineers – 1.8 million new engineers and technicians are needed by 2025 – as well as a "leaky pipeline", meaning women often fail to continue to progress their engineering careers.

Award-winning chartered electrical engineer Kerrine Bryan believes addressing the sector's diversity problem is key to closing the skills gap. To help tackle the issue at the roots, she began publishing career-themed children's books, including My Mummy Is An Engineer.

"We're losing potential engineers at every stage of life, and it starts from a young age because bias and misconceptions in media and toys often implant ideas into children's minds that engineering is for men and involves getting your hands dirty and fixing things, which doesn't appeal to girls if they're brought up to believe they should be quiet, neat and tidy," she says.

Lucy Gill, a qualified engineer, Stem ambassador and founder of Digills consulting, agrees that inspiring girls from a young age about the creative aspect of engineering is key to recruiting more women to the sector.

"There's so much embedded in our culture saying engineering isn't for girls, and people still think of engineers as the men who fix your washing machine, not the people at the forefront of designing creative solutions to the world's problems," she says.

Those messages dissuade girls from studying subjects required for engineering careers. Among girls aged 11-14, almost half (46.4%) would consider a career in engineering, compared with 70.3% of boys. But this drops to 25.4% of girls aged 16-18, compared with 51.9% of boys. At A-level, girls make up just 22% of physics students.

Yet, girls outperform boys in engineering fields of study. "In all Stem A-levels, except chemistry, more girls get A*-C grades than boys, and this pattern continues at degree level," says Donnelly. "Almost 80% of female engineering students will get a first or an upper second-class degree, compared with 74.6% of male students.

"Engineering involves everyone and has an effect on all our lives, whether it's biomedical engineering when you have a surgical procedure, or electrical engineering when you're watching TV," says Jodie Howlett, a mechanical engineering student, who will join the European Space Agency when she graduates, and is one of the top 50 women under 35 in engineering in the country. "That's why the sector needs greater diversity; we need it to better represent society as a whole."

Nonetheless, sustained efforts to persuade women to pursue engineering careers are yielding fruit, albeit slowly. "When WES started in 1919, there were no female engineers, and 50 years later only half a percent of all engineers in the UK were women," adds Donnelly. "Now, we're beginning to make quite considerable inroads, so it's an exciting time to join a sector that will change radically over the next 50 years."

There's positive news from the sector when it comes to pay parity, too. The gender pay gap for engineering sector occupations is 18.7% – more than double the UK's average pay gap of 8.6% – but among graduates, the pay gap for first salaries is just 1.19%.

"It's very exciting that women starting a career in engineering can expect to earn the same as their male counterparts," says Donnelly.

In 2017, the median basic salary for engineering professionals (engineers, architects, surveyors) was £35,000 for women and £41,545 for men, and this gap widens considerably at director level, with women paid on average £20,000 less than men, according to a 2017 salary survey.

"And as more women enter the sector, I think we'll see the pay gap at director level closing. Ongoing activism and pressure from young women mean it's likely to reduce quite dramatically, I suspect, over the next 10 years."

▲ *Inspiring girls from a young age about the creative aspects of engineering is key to attracting more women to the sector* PHOTOGRAPH: GETTY

> ***'Engineering has an effect on all our lives – that's why the sector needs to represent society as a whole'***
> **Jodie Howlett**
> *Engineering student*

### Female engineers in numbers

**6.1m**
*The number of engineering jobs in the UK*

**12%**
*The percentage of female engineers in the UK*

Source: EngineeringUK

> *'If we can get girls to understand that they could make a difference, then they'd be able to see a path for themselves'*





**Comment**
**Naomi Climer**

## *'We need to stop boxing people into stereotypes'*

If there was a single key to levelling the gender imbalance in engineering and technology careers, we'd have cracked it by now. Plenty of evidence shows programming of prejudice starts with babies, and girls begin to be put off engineering between the ages of five and nine.

We need a shift in thinking so people are treated as individuals from birth rather than pigeonholed. There are many good initiatives targeting teenagers – we just need to reach younger children.

I wish in this country we had a broader education – a mix of humanities and sciences – for longer. It troubles me that by the time you are 16, you've already narrowed your learning, and by sixth form it's even narrower. I'm pretty sure we're not teaching children the right skills for the future.

Engineers and technologists need a background in arts and humanities so that when they come to design and innovate, they're thinking of wider societal impact and unexpected outcomes of what they've created.

And if we all had a better understanding of science, technology, engineering and maths, we'd be in a position to hold technologies to account and help steer the direction they are taking our lives in.

Recently, for instance, we saw a bunch of politicians trying to hold Facebook to account – a Commons committee held an inquiry into fake news that lasted more than a year and reported in February – and the questions they asked showed how little they understood of how these things work.

Research shows girls tend to be more interested in solving world problems. According to research by PwC, half of women said the most important factor when choosing a future career is "feeling like the work I do makes the world a better place" – although there are plenty of men who feel this way, too. Engineering careers are exciting – there's lots of engineering linked to climate change, for instance. If we can get girls to understand that they could make a difference, then they'd be able to see a path for themselves.

But it's the usual story: we need more visible role models – more successful young women – and we need to do a far better job of explaining the wide range of engineering possibilities.

I didn't understand what engineering was when I fell into it. My dad was an engineer and I didn't find it appealing. But it's much broader. Whether you want to become an astronaut, get into clothing design or, as I did, into television … you name the industry and there'll be an engineering career in it. I was attracted to the BBC because it sounded creative.

I went on to work for myself, and ended up building an independent radio station on Guernsey as the chief and only engineer. When I joined Sony, I got noticed for doing what, in retrospect, was making bold decisions, and this helped me progress. As president of the Institution of Engineering and Technology (IET) for a year, I hope I helped chip away at the problem of attracting women. As a visible role model, it was great to send a message to younger women.

All of our working lives will change. Millennials will change careers and take more breaks, as we live for longer. And that will really help women, who've been disadvantaged by taking time out to have children.

I struggle when people ask me what it's like to be a woman in engineering – I have other attributes, it's just one side of me. I long for the time when we treat people as individuals rather than boxing them into stereotypes.

*Naomi Climer is the co-chair at the Institute for the Future of Work. She was interviewed by Helena Pozniak*

# Audio engineering

# 'There were no role models to cling to'

At a time when less than 5% of audio engineers are female, new initiatives aim to make the industry a level playing field for women

Tara Joshi

When most people think of a sound engineer, the person that springs to mind is a man: be it in a recording studio or behind the sound desk at a live performance. Even the language used is often gendered: "the sound guy". Technical roles in music in general - producers and mixers, for example - are almost always perceived as the realm of men.

Like most stereotypes, this has a basis in fact - in both North America and the UK, for example, it's a regularly repeated statistic that less than 5% of audio engineers are women. Unfortunately, this is not a number that has changed with any great significance over the past two decades.

So what is it about music tech that makes the numbers so strikingly disparate between men and women? In part, it might well be a self-fulfilling stereotype.

Firstly, a lack of representation might make it seem an impossible pursuit. Marta Salogni is a professional sound engineer, producer and mixer, whose body of work includes recordings with the likes of The xx, Frank Ocean and Björk. Now based in London, it was back in her village in Lombardy, Italy, aged 16, when she became fascinated with the concept of sound engineering. "It made me a little bit scared because I couldn't cling on to any role model - there was no one to demonstrate that that career was possible, and I felt alone a lot of the time."

In turn, she says, this may have been what pushed her to find other people like her, and to succeed so that it became more normal to see women in these spaces. It's been a fruitful pursuit - Salogni is one of the most high-profile women in the field in Europe, and yet she finds this a strange position to be in. "Going into this profession knowing you're going to be unique means you're put under a spotlight automatically," she sighs. "Being told: 'Oh, I've never worked with a woman before' doesn't feel like a compliment - it just makes me feel like I have to do a lot of work to rebalance this whole mess."

Salogni also says the concept of what a recording studio used to be like at the height of rock'n'roll patriarchy ("a sexist man cave") can still affect the dynamic, not only in terms of how she feels in that space, but how she is perceived there - she notes that if women are expecting to feel uncomfortable in a space, then not all of them are going to be up for fighting to be there.

"People have come to the studio, they'll look around and try to understand why I'm there, what my role could be. And you can feel that on yourself, obviously - that person is doubting you," Salogni says. "Subconsciously, I hold on to that prejudice - I used to be really worried people would come into the studio and think I was not good enough, because I am a woman, or that I'm not in charge, because I'm a woman."

While representation is important, waiting on meritocracy isn't enough to redress the balance, Salogni says, alluding to the necessity for positive discrimination. More and more schemes are coming into place to try to make this a reality - Spotify launched the EQL Directory in association with organisation SoundGirls last year, providing a list of women and gender non-conforming audio professionals. It is, as SoundGirls say on their website, "a useful tool when people say 'they want to hire women but can't find any.'"

Then there are organisations such as Saffron - a Bristol-based group that's part record label and part educational facility for women, founded by Laura Lewis-Paul in 2015. Among other things, Saffron runs "Saffron For Sound", women-only courses in partnership with dBs - a local music college - teaching about music production software such as Ableton and Logic, as well as studio engineering.

> *'When I studied music tech at college, I was the only girl - things are less intimidating now'*
>
> **Lizzy Ellis**
> *Saffron*

▲ *Sound engineer Marta Salogni became fascinated by sound engineering from a young age*

Lizzy Ellis from the organisation explains: "When I did music tech at college, I was the only girl in the class - so I think we've certainly managed to create an environment that's much less intimidating for women, that's accepting people wherever they're at."

In addition to the issues of representation and a potential lack of respect from men in the industry, Ellis posits that jobs in sound engineering can often require "unsociable and long hours", especially for those working in the live arena who might be on touring crews for long periods of time. "It doesn't sit with the standard idea of a family setup for women - which shouldn't make a difference, but, unfortunately, it often does. That's part of a much wider conversation, obviously."

Both Salogni and Ellis are also aware that the push for inclusivity in the audiosphere needs to go beyond talking about women, too - no statistics exist specifically breaking down the number of black, Asian and minority ethnic (BAME) and/or working class women in these spaces, but Salogni notes the space is one dominated by "middle-class white people".

For now, hopefully initiatives such as Spotify and SoundGirls' EQL Directory, development platforms such as Saffron, and women dominating in the field can help push the conversation forward. The 5% statistic is one that Salogni laughs off - she's heard it so many times. "Hopefully in 10 years' time, we'll be closer to 50-50 and women won't have to do interviews about this any more."

## Everything you need to know about sound engineering

**Sound engineering is the process** by which all the elements of audio or a live performance are recorded and/or pieced together to sound as refined as possible: so that's everything from knowing the acoustics of a room, to deciding on the levels, knowing which microphones to use and where best to place them.

**Producing was once a very separate** role from engineering but, increasingly, it now crosses over. Producers work with the artist on the track in a less technical way, helping to make the artistic choices - so it's making the track the best it can be, but on a compositional level. For example, choosing the instrument that might sound best, suggesting a different song structure, and coaxing the best performance out of an artist.

**Often, sound engineers are also the mixers** - although this too can be a separate job. Mixing is the final stage - once the recording is finished, the mixer will take the files, or the tape, and create a balanced composition. So, say there were nine microphones recording one guitar, the mixer would have to take these nine different recordings and mix them together, and then - depending on what the composition calls for - mix in the other instruments, vocals, etc. They are also in charge of making the choices on volume levels and additional effects.

**If you've watched Netflix documentary** The Defiant Ones, you will be aware there was once a time when simply being available at all hours and learning by practising was how you became a sound engineer. Nowadays, things are very different - in most cases, specific training is required in the appropriate technology and software (Pro Tools, for example), be that in a higher education institution or an apprenticeship scheme. According to PayScale, the average salary for a sound engineer is £25,000 per annum, with stats suggesting the gender divide is now 95% men and 5% women.



## Experience

# 'You lift with your mind, not with your muscles'

Two female sound engineers explain why they chose a career in a male-dominated industry - and how they deal with discrimination

Interviews by Naomi Larsson

Diversity in music has come a long way on stage, but off stage it's a different picture: in the UK, just 5% of audio engineers are women. When it comes to live shows, women are having to face discriminatory stereotypes that they "can't hack tour", that working on live tours is too physically and emotionally demanding, that it's very much a man's world. But a number of women have been making waves in the industry for years. Here, two engineers, who have worked with the likes of Blondie, the Subways and Arcade Fire, share their experiences of working on live shows.

### Beth O'Leary

*Live sound technician and engineer*

Growing up in Ireland, the music scene wasn't very big and I wasn't used to big production shows, so it didn't occur to me that sound engineering could be a career path. I went to university in Sheffield to study zoology, but I got involved with club nights and music events at the students' union and ended up going into sound instead.

I'm a freelancer, so my work changes for every job. At the moment, I'm a monitor engineer for Kylie Minogue - we do in-ear monitors and throughout the show I keep an eye on the band, make sure they're happy, and if they need anything changing, I'll sort that out. As a monitor engineer, my goal is for people to forget that I'm there. If the gig goes well, the band forgets about me and can concentrate on putting on a good show.

There's a lot of technical knowledge that you need, but everything can be learned. However, you can't just be a technical wizard - you need people skills because you're looking after a band. It can be very difficult to explain sounds - we're very visual. So you need to be able to interpret when a band member is saying: "It sounds a bit crunchy." That requires skill.

There's something very satisfying about getting the sound right. When you see the crowd and how elated they can get just by hearing music, it's really rewarding. I like knowing I'm part of that. And being able to work with the same bands every day is a real pleasure - that's what I love about tour. You get to know them, you get to know their music. If you're with the right group of people, tour is really fun. It's like a travelling circus with people who become your family.

There's a lovely, welcoming crew for Minogue. But out of a technical crew of 41, there are three women. And that's good by touring standards.

I think a lot of people say it's just that women aren't interested. And a lot of people say we need to encourage women into Stem subjects, but I think that's just passing the buck on to the next generation. There's plenty of women who tried to make it in the industry and just gave up and left. I've even questioned why I'm still here at times. Most people are lovely and supportive, and while the whole industry is getting more inclusive, there is still sexism - both personal and systemic.

There's no innate reason why women don't hack it on tour. It usually involves heavy lifting, but in this day and age of risk assessments and manual handling training, that is becoming more manageable, too.

There's not that many women on tour because it's competitive and there aren't enough women coming in in the first place. Sometimes women aren't made to feel welcome, so they're either not getting the opportunity to go on tour, or if they're quitting it's because someone's made life difficult for them.

It's definitely going in the right direction, but there's a long way to go to improve diversity in the technical world - even though there's more diversity on stage now.

> *'The industry is becoming more professional - I think it's because there's more women'*
>
> **Kim Watson**
> *Sound engineer*

▼ *Beth O'Leary discovered her passion for sound engineering after taking part in uni club nights*

PHOTOGRAPH: CHRISTOPHER L PROCTOR

### Kim Watson

*Sound engineer*

From 2008 onwards, I've just been pretty much on the road. I'll do everything from front-of-house sound - which is what everyone hears - to sound monitoring, which is what the band hears.

I did studio stuff early on, but repeating the same songs over and over again got boring - whereas live sound is very instantaneous. There's much more energy to it. It's more exciting. And as a monitor engineer, you're on the side of the stage with the band, so you see a show you wouldn't normally see.

I've been on tour with Blondie, Emeli Sandé and the Subways, but my guilty pleasure is progressive rock shows - I once toured the Pink Floyd tribute band, and listening to that music every day was wonderful. One of the reasons I got into this was because I didn't want to pay for gig tickets all the time.

I started when I was 19. I did music production at college and from there met a sound company, and I was taken on and had a mentor for a long time. Once I started working for him, I knew this was exactly what I wanted to be doing. He taught me: you lift with your mind, not with your muscles. He was right.

In the early days, the equipment was a lot heavier, but now there's a lot less of it and it's less heavy, which has given women a lot more access to this side of the industry. I can fly a whole PA system pretty much on my own now, without the help of a crew.

A lot of that has really helped because, back then, I was assumed to be a colleague's girlfriend, or just somebody he was hanging out with. People didn't think I was part of the team. I've been literally pushed out of the way for a guy to jump on the desk.

As a young woman, there was a lot of that, and I think a lot of women would quit over that.

The physical and emotional demands of tour plays both ways to both men and women. Especially in the music industry at the moment, conversations about mental health are becoming very public. I think for a long time there had been a lot of denial about this, but more recently support is coming through. Touring is a lot of work, it's very intense and very fast. Days are normally from 9am to midnight or 1am. There's a lot of downtime after tour and then a lot of work. And we have a thing called "tour comedown": you come back from tour - where everything is very regimented - and you've got to kind of readjust to real life. The support hasn't always been there.

Now the industry is becoming more professional - I think it's because of the introduction of women. I've earned respect. Mostly, engineers will come in and go: "Ah, it's you, Kim, you're looking after us today." I've become known for being a good engineer.

> *'Things are going in the right direction - but there's still a long way to go to improve diversity in tech'*
>
> **Beth O'Leary**
> *Sound engineer*

▼ *Kim Watson says there's more physical and emotional support for both men and women than ever before*

PHOTOGRAPH: CHRISTOPHER L PROCTOR

# Coding clubs
# Diversifying the tech sector

As well as providing employment, coding courses help to equip excluded communities with tech skills, while improving diversity

Jessica Bateman

After Mona Azami came to the UK from Iran in 2010, she spent five years without the right to work, then a further three struggling to find a job. "I was a graphic designer before, but I found it very hard in the UK," she says. "I didn't know British culture or British brands, and my English wasn't so good."

Initially she pursued low-skilled roles, but then a conversation with a friend alerted her to Code Your Future, a free coding school for refugees. "I went online and applied that evening," she says. Today, she is working as a website designer for Dixons Carphone.

Code Your Future is one of a new batch of free or low-cost coding clubs around the world outside of traditional education establishments, with the aim of equipping excluded communities with tech skills. The long-term goal is not just to provide employment opportunities, but to diversify the notoriously white and male-dominated tech industry.

The organisation was founded in London and initially ran coding courses for refugees, although it now caters to anyone from a disadvantaged background. It has also just launched its programme in Italy. Azami says that, as well as teaching her to code, the course gave her CV and interview advice.

One of the biggest organisations of this kind is Code Club International, which supports more than 13,000 free coding clubs for nine- to 13-year-olds worldwide, including ones in Syria, Bangladesh, Kenya and Ukraine. "We want to put a code club in every community in the world, and teach children not just to be consumers of technology but creators too," says Maria Quevedo, managing director at the Raspberry Pi Foundation, which runs the project.

▼ *Code Club International offers free coding classes for nine- to 13-year-olds around the world*
PHOTOGRAPH: RASPBERRY PI FOUNDATION

***'Education is just a tiny sliver of the problem – we need to change the entire industry culture'***
**Anisah Osman Britton**
*23 Code Street*

Volunteers have access to a full range of projects and courses for free, and don't need to know how to code themselves in order to teach. Quevedo says one of the organisation's target areas has been women, and they achieved 40% female attendance worldwide through having "gender-neutral projects" and a focus on creativity.

However, some believe that education can only go so far in fixing the industry's diversity issue. One of the biggest barriers to gender equality in the industry is the lack of retention of women, suggesting that big structural changes are also required. "Education is just a tiny sliver of the problems we have," says Anisah Osman Britton, founder of 23 Code Street, which provides coding courses for women in the UK and India. "We need to change the entire industry culture."

Cost can also be a prohibitive factor in some cases. 23 Code Street provides prayer and mother's rooms, and has around 25% Muslim women students, but Osman Britton says the £1,500 the company charges for the course may be too much for some. "We have some sponsored places and we also have a payment plan option in place. This is the best solution we've come up with so far," she says.

Others in the industry would like to see more engagement from the government on the issue. "There is a real skills gap in tech and lots of people are recruited from outside the UK," says Code Your Future co-founder Kash Karimi. "Yet, the government's strategy, if you go to any job centre, seems to be to direct people to low-skill jobs."





◀ *Nasreen AbdulJaleel's tech career has taken her around the world*
PHOTOGRAPH: SPENCER DAVIS

## A day in the life
# 'Tech careers give you so much flexibility'

Working in tech gives you the chance to work from wherever you are, says Expedia's senior director of tech Nasreen AbdulJaleel

Interview by Jessica Bateman

I've always loved physics and mathematics – I grew up watching a lot of science documentaries and found them fascinating, and my family were very supportive of my interests. I studied computer science at university, which was where I learnt how to code. I like the speed with which you can achieve something, and I find it creative in the same way I find science creative – it uses what we know about the laws of the world to solve problems. Computers are critical for solving the problems currently facing our world.

My working day starts at 9.30am after I drop my son off at daycare. I oversee two parts of the Expedia platform – one is related to our data analytics, which receives 1.8m messages a minute. The other is to do with delivering fast visual experiences to our customers. For this, we are currently building a platform that will allow customers to go through the Expedia shopping experience in a uniform way, whatever they are buying and whatever device they're using. There are people working on it all across the globe, from Australia to Seattle. The total number goes into the hundreds, but everyone works in small teams. Many use the "Spotify squad" model of working, which is all about having clear objectives and allowing people to independently solve problems.

We use Slack to communicate, which lets us work effectively across different time zones. You can have a long conversation on there going on for days, and it's actually richer than talking face-to-face because you can dive in to comments that otherwise might get skipped over.

Right now, I'm overseeing 10 people in San Francisco, Seattle, London and India, who are ensuring the components for check-in and check-out dates work in all languages and date systems. Some work from offices and some from home. Tech careers give you so much flexibility – I once had a developer on my team who lived in a trailer and was travelling around the US. We wouldn't ever know exactly where he was, but it didn't matter. These are truly amazing jobs from a quality-of-life perspective.

***'Gender balance increases creativity. People feel more relaxed and are able to speak more freely'***
**Nasreen AbdulJaleel**
*Expedia*

Every day we all post what we're doing today, what we're going to do tomorrow, and any blockers. This helps us stay connected, and is also very flexible. When a team accomplishes something, they record a mini video so everyone knows what's happened and can have a global celebration. I oversee small teams of developers, ensuring what they're doing has a roadmap and that their priorities are in line with the business's priorities.

We make sure we work normal days, so I'll finish around six and always take a lunch break. There's no one clocking me in or out as long as I deliver, and I can work from home whenever I need to. That environment of trust also creates a greater sense of accountability.

My career has taken me around the world. I relocated from Seattle to London, and I recently opened an office for Expedia in Jordan with a 50:50 gender split team. Expedia employees also get the opportunity to volunteer overseas, and we get great deals from the site. The company is focused on achieving equal gender balance, which is something I see as part of my life's work – I've left jobs before because they weren't interested in this problem.

I see it increases the creativity because there are more voices. People also feel more relaxed and are able to speak more freely about their lives, such as revealing they have caring responsibilities at home.

Comment
**Clare Sutcliffe**

# *'We need to teach children creativity, intelligence and empathy'*

In the future world of work, many jobs will be automated. With that in mind, it makes sense for humans to focus on work that can only be done by us, requiring emotions and skills not replicable by machines, such as kindness, empathy and creativity. Despite this, our current education system focuses heavily on reading, writing and maths. They are certainly important, but focusing only on these is to the detriment of building rounded people. In my opinion, so-called "soft skills" are, in fact, essential skills for the future world of work. We need to prepare our future generations for working closely with machines by building their confidence in working with them and their agency over them.

To do this, children need exposure to opportunities to experiment with computers and encouragement to build their ideas with code. When I co-founded Code Club in 2012, which provides opportunities for children to develop coding skills through free after-school clubs, the aim wasn't to turn every child into a programmer. It was to give them the confidence and the skills to work with technology.

It shows children what they can do, and inspires them to build ideas and be creative, giving them skills to help in their attitude and agency over technology. Teams of people building products and services with technology should be representative of their users. Therefore, we should be making the opportunity to attend programmes such as Code Club available to everyone, regardless of gender, ethnicity and background. This was really important to me when setting up Code Club, so every effort was made to make it gender-neutral. Now, 40% of Code Clubbers are girls, which is a step in the right direction – but we can still do more.

*'Now, 40% of Code Clubbers are girls, which is a step in the right direction – but I believe we can still do more'*

Changing the way we see education is complex and cannot be laid at any one door. It's like turning an oil tanker around – it takes a very long time and a lot of conscious effort. Teachers have a hard job as it is, caused in part by the government, whose focus on SATs and academic assessment means creative subjects are often left to "fill the gaps", while a lack of funding forces cuts to creative subjects such as art and music. However, if we fail to make changes now, we will face significant problems in finding employment for large groups of people in the future.

The good news is that industry and the non-profit sector are working extremely hard to engage young people in what we call digital making. The Raspberry Pi Foundation, for example, recently brought together a consortium of partners to create the National Centre for Computing Education, funded by the Department for Education, to invest in the provision of computing education in England through courses, bursaries for teachers, regional support networks and free resources. They are also working with the National Citizen Service to build a digital programme, helping young people design solutions to social problems.

The key to preparing young people to become functioning members of society is to construct an education system that creates well-rounded, emotionally mature people who use creativity, intelligence and empathy to look after others. They are the ones who will build machines to do our dirty work, as they should, leaving us to the do the work only humans can do: care and create.

*Clare Sutcliffe is a social entrepreneur, consultant and professional speaker. She was interviewed by Ellen Manning*

# Femtech

## The rise of women-centred innovation

In a bid to make technology work for everyone, new female-run tech categories are starting a digital revolution

**Sabrina Faramarzi**

We know that technology has historically been a field dominated by men. But things are starting to change. Whether they're helping you learn about your body, or arming you with the tools to navigate the internet better, a whole swath of female coders, makers and engineers are making sure the technology we interact with works for everyone - not just men.

The space seeing the most action is one called "femtech". Short for "female technology", it's a category of technology that encompasses products, apps and other digital services from companies focused on women's health. This includes everything from fertility and periods, to sex and pregnancy. The term femtech was coined by Ida Tin, founder of menstruation app Clue, which enables people to track things such as their weight, moods, sleep, energy, cravings and bleeding. It is now a market expected to be worth $50bn (£39bn) by 2025.

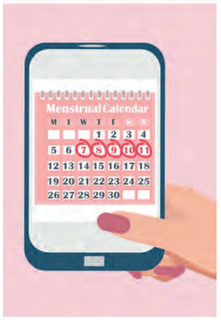
One woman who has changed the space dramatically is Tania Boler, founder of Elvie, a company that sells two products: their first, launched in 2014, is a pelvic floor trainer that allows women to do kegel exercises (repeatedly contracting and relaxing the muscles that form part of the pelvic floor) and is connected via Bluetooth to their phones so they can track their progress. Last September, they launched their second product, a hands-free, cordless, wearable breast pump that they debuted with a rather humorous advert.

On Mother's Day in 2017, Elvie put inflatable breasts around Shoreditch in London as part of their #FreeTheFeed campaign to fight the stigma around breastfeeding and pumping in public.

"I've always seen myself as a campaigner for women's rights and I always wanted to do that through research and science," says Boler, who has a PhD in sexual health. She began her career by working with governments on HIV prevention, sex education and access to modern contraception, but it was only when she became a mother herself eight years ago that she learned about pelvic floor health. "I found out that it was this massively hidden epidemic for women," says Boler. "Most women don't think about their pelvic floor until they start having a problem, and the problems they have are yucky ones that nobody wants to talk about," she says. "Starting Elvie was about moving it towards something more positive, and that your pelvic floor should be just as important as going to the gym."

"It's just accepted that, as a woman, when you have a baby, you can no longer run or jump on a trampoline without peeing yourself, or that you're not going to enjoy your sex life, and it's all put under this 'women's things' umbrella, and actually that's what we need to break open because a lot of those things don't have to be that way at all."

Although femtech is growing, there are other spaces that female technologists are moving into to make sure that technology works for everyone. One of those spaces is voice technology. Charlotte Webb is an ethical tech consultant who founded Feminist Internet, a non-profit organisation that aims to fight technological and internet inequalities. Webb, who began her career as an academic and an artist, wanted to change the way that the tech sector not only discriminates against women in the workplace, but also in the products we use every day, too. In one of their latest projects, members of Feminist Internet designed an artificial intelligence chatbot. Initially launched at the EY Innovation event in Boston, the chatbot takes you through the ways that artificial intelligence is being built with biases in mind.




***'I've always seen myself as a women's right campaigner, through research and science'***

**Tania Boler**
*Elvie*

Because only 22% of the people building AI right now are female, making sure that the technology we interact with is not sexist, racist or homophobic is incredibly important. "Diversifying tech is massively about women, but it's a lot more than that," says Webb. "There aren't even any statistics on the number of trans people or gender minorities in the big tech firms. There are on women, but the fact that it's not even considered as a metric is awful."

Webb and her team are using technology to show its own problems, and partnering with people such as Josie Young, a feminist AI researcher who designed a guide to building a feminist chatbot. "Although the internet has so much potential for human connection and positive social change, there are still a lot of problems that we need to address, such as online abuse, the inequality in the tech sector and the systemic biases that are reproduced in AI systems," says Webb.

Much of the fight about getting more women in technology - more women of colour, of race, of sexual orientations and abilities - is about making sure that during this period of technological innovation, there are women making, engineering and coding technology to make it work for them, too.

▼ *The femtech boom is finally changing the face of the women's healthcare industry*

PHOTOGRAPHS: GETTY

### Five ways the tech industry is improving diversity

**Offering coding camps.** Only 17% of the tech sector is made up of women, and addressing this imbalance has been a priority for the industry. To do this, companies are looking to dismantle discriminatory workplace practices and help to skill women with the technical training they need. Funding has been pumped into bootcamps to get people equipped with basic coding and programming. School of Code (for adults) and Codecademy (free) are just a few of the courses available.

**Employing diversity officers.** A recent study shows that companies in the top quartile for racial and ethnic diversity were 35% more likely to have above-median financial returns, while another study found that inclusive teams make better decisions 87% of the time - and twice as fast. Many companies are finally understanding the value of diverse teams and are hiring diversity officers to make sure this is put into practice. Data from online jobs board Indeed found an 18% increase in postings for diversity officers from 2017 to 2018.

**Specialised grants and funding for women.** According to a recent report, the amount of funding going to startups with a female founder has not increased since 2016. However, there are now a number of specialised organisations - such as EnrichHER, or grants such as the Digital Skills Innovation Fund - helping more women and minorities to get their tech projects, companies and products off the ground.

**Flexible schedules and remote working.** Technology has changed the work landscape from stuffy offices and rigid schedules to more fluid and flexible ways of working. A recent report shows that 73% of employees said flexible work arrangements increased their satisfaction at work, and the tech sector is at the forefront, opening up ways of working for people who need their jobs to work around children, caring responsibilities, chronic illness or even long commutes for those who can't afford to live in inner-city areas.

**More jobs for people with disabilities.** Currently, the number of people with disabilities who have jobs stands at 36%, compared with 78% of people without disabilities who are employed. This needs to change, and as the tech sector is currently trying to create products to ease everyday problems for a variety of disabilities, they are hiring people with those disabilities who know first-hand how those experiences affect people. For example, tech giant Google is actively making products for disabled people, and 7.5% of their workforce identify as having a disability.

# Women in energy

# 'We need more female role models'

With women accounting for only 14% of the energy sector, experts believe the industry will be under threat if diversity doesn't improve

Georgina Fuller

The energy sector has been in the spotlight recently, with young, pioneering women such as Greta Thunberg campaigning to get climate change on the agenda – and receiving a plethora of misogynistic abuse for doing so.

So what is it like to work in the energy industry, where only 5% of executive board seats in UK-based companies are held by women, and 61% have no women at all on their board?

Sarah Merrick, founder and CEO of Ripple Energy, says that the energy sector is going through a seismic period of change. "By 2050, more than 80% of the UK's electricity could come from wind and solar," she says. This is good news for women and the environment, as the more progressive "clean" energy companies are, in Merrick's experience, considerably more egalitarian than the fossil and nuclear energy sector. "Having worked in renewables for more than 20 years, I would say there's a stark difference in gender equity between clean energy and fossil fuel companies," Merrick says.

The more conservative fossil and nuclear energy sectors have an "old boys' club" culture, which has led to businesses being overwhelmingly dominated by men, according to Merrick. "This area of the energy industry is lagging behind on the gender divide. However, the renewable sector is still relatively new, which means that culture has not had the time to fully develop, and women's voices are not as overlooked."

Kerrine Bryan, an electrical engineer at WSP, says our everyday life depends on the energy industry. "Everything from preparing and maintaining food, to keeping warm, travel, maintaining reliable healthcare systems, as well as national safety and security – these are just a few things energy provides," she says. "Yet, as the global demand for energy increases and the push for cleaner energy and new technology expands, the sector is struggling to keep pace because of the skills shortages in engineering."

Encouraging more women into the sector (the Global Energy Talent Index report 2019 found that women account for only 14% of workers) is one way of closing the skills gap, but gender barriers need to be overcome too, says Bryan. "Put simply, I believe the sector will be unable to keep up with the demands of the world if the diversity skills deficit continues."

This change needs to start at the grassroots, according to Bryan. "It begins with schools linking subjects that are being taught with real jobs in society. This could be enhanced by getting more BAME role models and Stem ambassadors into schools to talk about their work, which would help debunk any misconceptions children might have that they can't do such a job because they don't fit the mould, especially BAME pupils and young girls."

Louise Kingham, CEO of the Energy Institute and board member for POWERful Women (PfW) – a professional initiative that pledges to ensure 40% of middle management and 30% of executive board positions in energy will be filled with women by 2030 – says the rate of progress has been "glacial".

"We need more visible female role models and we need louder, clearer leadership and targets," Kingham says. "We also need a range of internal policies and programmes – for example, on flexible working and changes to recruitment practice – to remove unconscious bias and become consciously inclusive."

Emma Bridge, chief executive of Community Energy England (CEE), a membership body representing more than 200 local community energy generation schemes, points out that it's not just boardrooms where women are unrepresented. "In government, we have a woman, Claire Perry MP, holding the position of minister of state for energy, yet, far too often when I attend events, am invited to speak on panels, or at a high-level policy meeting, unfortunately I'm the only woman," she says.

This means a range of opinions and ideas are not being heard; it also means a lack of role models. "More women, particularly young women, need to be made aware of the amazing opportunities available in the fields of engineering and energy generation."

> *'More women need to be made aware of the opportunities available in the field of engineering'*
>
> **Emma Bridge**
> *CEE*

▼ *Award-winning electrical engineer Ozak Esu's interest in electricity started as a child*

PHOTOGRAPH: AMIT LENNON

## Experience

# 'My experience as a black woman in the industry has been positive'

Electrical engineer Ozak Esu speaks of the importance of getting BAME women into Stem careers

Interview by Mark Smith

Understanding the reason behind Dr Ozak Esu's fascination with electricity is simple – as a child, she often didn't have any.

Now an award-winning electrical engineer, she grew up in Nigeria, where the ability to do something as simple as switch on the lights was dependent on her parents' income.

"We went from lighting candles with matchsticks, to kerosene lanterns, then rechargeable lamps. Eventually, my parents earned enough for us to own our private diesel generator."

As a child, she recalls being conscious about protecting the environment and of the challenges neighbouring African states faced following the fallout of exploration for crude oil, with issues such as air and water pollution playing on her mind from an early age.

"I witnessed the pollution caused by households and businesses who owned a private generator," she says.

"There was also the fluctuating costs and scarcity of fuel, marked by long queues at petrol stations. I always had this belief that this wasn't the case in other countries and that I could do something to fix it."

Arriving in the UK in 2008 at the age of 17 to study electronic and electrical engineering at Loughborough University, she later graduated with a first-class degree and won a £54,000 PhD studentship at the university, which she describes as "her proudest achievement".

With the energy sector reluctant to sponsor UK working visas at the time, she got a foot on the career ladder with the construction industry, eventually being able to bring her PhD expertise to bear on the subject of "smart cities". She is now the technical lead at the BRE Centre for Smart Homes and Buildings (CSHB).

> *'I have been fortunate in my early career to work with cultured, well-informed engineers'*
>
> **Ozak Esu**
> *CSHB*

Having won a string of awards for her work – including the Young Woman Engineer of the Year – she continues to champion the cause of getting BAME women into Stem careers. In addition to serving on the Athena Swan feasibility committee at Loughborough University, she has been a panellist for the Association for BME Engineers.

But she says that her age, rather than her gender or race, has been more of an issue for the 28-year-old.

"I can only speak about my personal experiences as a woman and black person working within the industry, and it has been positive. I have been fortunate in my early career to work with and be mentored and supported by cultured, well-informed engineers and managers."

She adds: "Ageism has been a more prevalent occurrence – the assumption that I am less competent because I am young. I simply shrug off these incidents by reflecting on my achievements and personal journey, from where I began to where I am now in my career."

Her advice for any women from a BAME background is simple: "Go for it!"

"Stem subjects provide so many career disciplines to choose from, so I recommend attending careers fairs, seeking work experience opportunities and engaging with people within the industry to get a feel for what's involved."

Left: Melissa Chigubu is an apprentice at the Manufacturing Technology Centre

# Top 50 Women in engineering

Women are excelling across a wide range of sectors in engineering, as demonstrated by this top 50 of current and former apprentices

In the UK in 2017, some 11% of engineers were women – but given this figure stood at just 6% in 2011, education and training in science, technology, engineering and maths (Stem) seems to be making headway. The latest figures from the Women into Science and Engineering (Wise) campaign show that the number of women working in core Stem careers (including engineering) rose by more than 60,000 between 2016 and 2017.

After the government launched its new "trailblazer" scheme in 2013 to initiate industry-set standards in apprenticeships, these pathways have played a key role in better representation for women in engineering. Nevertheless, while women currently make up approximately 12% of engineers in the UK, just over 7% of engineering apprentices are female.

This year's Top 50 Women in Engineering highlights 22 current and 28 former apprentices at the forefront of UK engineering, from HS2 to Typhoon jets and the 5G rollout. It was put together by the Women's Engineering Society (WES), a charity that celebrates its centenary this year. Elizabeth Donnelly, its CEO, explains: "We want a world where women are as likely as men to choose an engineering career, and it can be seen from this list that women are excelling across an impressive range of sectors."

### Katrina-Rose Allen
**APPRENTICE ENGINEER, GOVIA THAMESLINK RAILWAY (GTR) LTD**
Current apprentice

Now in the third year of her apprenticeship, Allen has already become a role model for apprenticeship hopefuls. After she appeared in one of GTR's videos, her story was featured in Metro and the Evening Standard, and on BBC Surrey radio. Colleagues noted that applications from women for next year's scheme are up by more than 200%.

### Natalie Asimeng-Gyan
**ENGINEERING APPRENTICE, GSK**
Current apprentice

After joining GSK's automation team last year [May 2018], Asimeng-Gyan didn't take long to impress colleagues. On a critical cross-site project, she learned to configure control systems, follow wiring diagrams and work successfully with external suppliers and contractors. The project went on to win an industry award. Now in her second year, Asimeng-Gyan has gone on to represent GSK on projects in Europe and at careers events to promote its apprenticeship scheme.

### Natalie Atherton
**ZONE OPERATIONS MANAGER, SODEXO**
Former apprentice

Atherton impressed from the start: after completing an apprenticeship at AstraZeneca, she won sponsorship for a degree, graduating in 2015. Now a chartered building services engineer, she manages a £15m warehouse – one of AstraZeneca's key assets – for Sodexo. In charge of 12 staff and responsible for managing facilities across the site, including automation, Atherton is passionate about mentoring women who've transitioned into the industry from facilities management.

**'We want a world where women are as likely as men to choose an engineering career'**



### Abbie Beaver
**APPRENTICE FABRICATOR/WELDER, ADI GROUP** Current apprentice

Beaver joined a pre-apprenticeship programme at 14 and then the ADI Group two years later as its first-ever female apprentice. Her tenacity sets her apart, and last year she became one of six female engineers for WES's campaign to promote engineering to primary school-age girls.

### Jacinta Caden
**BUSINESS DEVELOPMENT (EUROPE), CRITICAL PROJECT SERVICES**
Former apprentice

Of all the fields in engineering, refrigeration remains one of the poorest for equal representation. Caden is the fourth woman ever appointed to the board of the 119-year-old Institute of Refrigeration (IOR), and now sits on the IOR's steering group for women in the sector. Her experience also provided key insight for developing its new trailblazer standards for apprenticeships in the sector.

### Sophie Caffrey
**TECHNICAL APPRENTICE, LEONARDO**
Current apprentice

Though only in her fourth year, Caffrey has already designed printed circuit boards that have been used in trials across the world. Last year, she was selected by Naomi Campbell to star in a Nike advert alongside nine other young women, whose work disrupted cultural stereotypes. She is studying for a degree in electronic engineering.

### Emily Carr
**APPRENTICE ELECTRICAL/ INSTRUMENTATION TECHNICIAN, GSK**
Current apprentice

Carr was recently shortlisted for a "young talent in the chemical industry" award for her work as a Stem ambassador in schools and was recently selected to develop her leadership skills on a Fieri course. Now in the third year of an HNC programme, she hopes to become an industry technician on completion.

### Rachael Carr
**SENIOR SYSTEMS ENGINEER, BAE SYSTEMS** Former apprentice

After Carr joined BAE in 2006, she moved swiftly through the company into a senior engineering role, where she leads on key responsibilities including platform airworthiness certification. A former BAE apprentice of the year, Carr is now a mentor and performance coach to the next generation of women at BAE.

### Nicole Chamberlain
**AUTOMATION AND MES ENGINEER, NESTLÉ** Former apprentice

When Chamberlain started out, she was one of just three women in a 100-person cohort, and the only female engineer in her workplace. But it was her dedication rather than her gender that stood out – most obviously in her final year, when she was nominated for a future manufacturing award. Chamberlain now sits on the board of governors for Nestlé's

# Top 50 Women in engineering

apprenticeship scheme and mentors young women at her site. She is studying for a degree in electrical and electronic engineering.

**Melissa Chigubu**
**APPRENTICE, MANUFACTURING TECHNOLOGY CENTRE (MTC)**
Current apprentice

Chigubu learned her first engineering skills thanks to her uncles in Zimbabwe, and on moving to the UK in 2012 she joined the MTC's apprenticeship scheme. She has since been named apprentice of the month three times, and was the first woman to complete the foundation course.

**Heather Clarke**
**TRUSTEE, INSTITUTION OF MECHANICAL ENGINEERS (IMECHE)** Former apprentice

Clarke's career was shaped by not one but two apprenticeships – one technical, and one voluntary. At British Railways, building the Medway rail bridge and Heathrow Express line gave her hands-on experience, and in 2006 she become a chartered engineer. In 2007, she joined the IMechE as a president's apprentice, and 10 years later was elected as a trustee.

**Lisa-Jayne Cook**
**SENIOR SALES AND APPLICATIONS ENGINEER, AQUA TEMPERATURE CONTROL SOLUTIONS** Former apprentice

As an apprentice, Cook was one of the star pupils on her BTec, and was named a finalist in RAC's student of the year awards in 2004. Her passion for learning persisted: in her nomination, colleagues at Aqua praised Cook's commitment to training junior engineers.

**Dr Katherine Critchley**
**CONFIGURATION MANAGEMENT BPM, SAFRAN SEATS** Former apprentice

As an apprentice in the 1980s, Critchley gained valuable experience in computer-aided design. But after graduating from a master's in the subject, she found it so hard to break back into engineering that she ended up working in a chocolate shop. Critchley then completed a PhD and developed a career in the aerospace sector, but her experience made her a vocal advocate for other "returners" in Stem.

**Alexandra Ellis-Jones**
**JUNIOR ENGINEER, GSK** Former apprentice

Ellis-Jones has made significant cost savings through digital innovation at work. She's also made great efforts to promote apprenticeships among senior business leaders at a Science Museum "late" – an adults-only, after-hours theme night – and in a film for the IET.

**Jasmine Ewers**
**UNDERGRADUATE ENGINEER, WSP**
Current apprentice

As a young female apprentice on HS2, Ewers has now represented her peers in interviews on the BBC and ITV, as well as featuring in a short film for BBC Bitesize Careers about engineering apprenticeships. She's also written articles, attended careers fairs, and won the ICE Quest Technician Plus scholarship for her writing.

**Danielle Flynn**
**DEGREE APPRENTICE, JAGUAR LAND ROVER** Current apprentice

The only female apprentice in her year at Halewood, Flynn excelled in her work on equipment standards for car-making machinery and was named Liverpool apprentice of the year in 2018. She is her apprenticeship's first female Stem ambassador and gave a speech to the Made in Dagenham machinists.

**Angela George**
**MECHANICAL DESIGN ENGINEER, DIAMOND LIGHT SOURCE LTD**
Former apprentice

As an engineer at Diamond Light's synchrotron facility, George specialises in "insertion devices" – 20-tonne precision-engineered machines that generate x-ray beams accurate to less than one-millionth of a metre. As an apprentice at Harwell in the 1980s, she was the only woman on her team; her dedication and experience has made her a role model.

**Natalie Goodman**
**PERMIT TO WORK COORDINATOR, SPIRIT ENERGY** Former apprentice

Goodman finished her four-year mechanical apprenticeship early, was made operations manager of an oil refinery at 23 and is Spirit's first female employee to become an authorised issuing authority for permits to work. She volunteers as a community project supervisor with schools in Cumbria.

**Bethany Holroyd**
**PROJECT COORDINATOR, WSP**
Former apprentice

Holroyd has worked as a project manager in both the public and private sectors – perhaps her biggest project to date being the development of an asset management system for harbours on the Moray coast. In 2012, she was the first apprentice in the country to complete the ICE framework.

**Kelly Jeffery**
**CIVIL ENGINEER, JACOBS ENGINEERING**
Former apprentice

Ten years of experience in the UK and overseas gave Jeffery a passion for showcasing rewarding work in engineering. During her apprenticeship at WSP she completed a degree in civil engineering at Exeter; now at Jacobs, she sits on the steering committee for its global women's network.

**Grace Johnstone**
**PRINCIPAL ENGINEER, BAE SYSTEMS**
Former apprentice

Aged 16, working on Tornado and Hawk jets, Johnstone was the first woman on the 100-person team. She was named IET young woman engineer of the year in 2003 and, after a 26-year-long career, has now taken a senior role on the Typhoon team. Her recent appointment to chair of the Inspiring Women Network came as no surprise.

Top left: Jennifer Smith, principal engineer, MBDA. Above: Jenny Manning, additive manufacturing engineering lead at BAE Systems

**This year's Top 50 Women in Engineering highlights 22 current and 28 former apprentices**

**Charlotte Jones**
**TECHNICIAN, AECOM** Current apprentice

Now in her fifth year at AECOM, Jones is one of the scheme's top-performing apprentices, was its apprentice of the year in 2018, and also featured in AECOM's Where Women Work campaign. She achieved distinctions in her BTec, NVQ and HNC and is now studying part-time for a degree in civil engineering.

**Sharon Lane**
**MANAGING DIRECTOR, TEES COMPONENTS** Former apprentice

Lane began an apprenticeship after dropping out of university, and went on to gain a BEng with first-class honours. After a distance-learning MBA, she became GM, then MD, of Tees Components in 2005. Passionate about training, she has become a key role model in the north-east for women in engineering.

**Catherine Leahy**
**APPRENTICE CORROSION TECHNICIAN, TWI** Current apprentice

One of TWI's Arkwright scholars, Leahy already contributes to collaborative funded projects into new renewable solutions, and last year was interviewed by ITV about her work. The only woman on her course and team, she has a passion for research.

**Chloe le Grand**
**SENIOR DESIGN ENGINEER, MBDA UK**
Former apprentice

Having passing her HNC and HND in mechanical engineering with distinction in all areas, le Grand now shares her enthusiasm for engineering widely: as well as arranging apprentice placements in her team, she has for the past few years led a Robot Wars-style Rumble event for local secondary schools.

**Catherine Llewellyn-Jones**
**UNDERGRADUATE AEROSPACE ENGINEERING APPRENTICE, AIRBUS**
Current apprentice

Llewellyn-Jones was working as a graduate teacher when she made the switch into engineering; she now specialises in aircraft ribs, and her work has been implemented in Spain and the US. A case study for TUC and Unite and a champion for women making career changes, she has successfully campaigned to change university hours for students with caring responsibilities.

**Sylvia Lu**
**5G TECH LEAD, U-BLOX UK** Former apprentice

After completing an apprenticeship at Toshiba, Lu quickly rose to prominence as an expert in the internet of things. She currently serves on the advisory board for the UK5G network. The first female board director at Cambridge Wireless, Lu was named a finalist in the science and technology category of the Asian women of achievement awards last year.

**Judith Mair**
**MANUFACTURING LABORATORY TECHNOLOGIST, ROLLS-ROYCE PLC**
Former apprentice

Having moved to Derby from rural Aberdeenshire to undertake her apprenticeship, Mair excelled on placements and graduated first-class, as well as being named best of British engineering and apprentice of the year at the Semta awards last year.

**Jenny Manning**
**ADDITIVE MANUFACTURING ENGINEERING LEAD, BAE SYSTEMS**
Former apprentice

Additive manufacturing (3D printing) is a relatively new technology for BAE's Typhoon and Hawk jets, something Manning – named national apprentice champion of the year and the Royal Academy of Engineering's rising star in 2012 – noticed early on.

Clockwise from left: Billie Sequeira, technical apprentice at BAE systems; Courteney Stone, engineering technician apprentice at BMW; Catherine Leahy, apprentice corrosion technician, TWI; Natalie Asimeng-Gyan, engineering apprentice at GSK

Colleagues says she has been "instrumental" in the company's development for aircraft parts. Her innovative approach singles her out to senior staff as an emerging leader in her field.

**Raisa Matadar**
**TECHNICAL SUPPORT APPRENTICE, JAGUAR LAND ROVER**
Current apprentice

The primary contact for JLR's new Women in the Know events for budding female engineers, Matadar has excelled in her performance at the company. Colleagues noted her acumen and exemplary behaviour reviews as well as her diligence; she received distinctions in almost all her technical certificates for her level 2 assessments.

**Kirsty McDermott**
**DESIGN ASSURANCE ENGINEER, NATIONAL GRID** Former apprentice

The first-ever female apprentice recruited to the bus builders in her hometown of Blackburn, McDermott learned early on in her career how she would have to prove herself. She undertook a two-year apprenticeship at the National Grid, then was appointed technical lead on a £6m world-first project for robotics for inspecting pipelines. Now an engineer on the longest tunnel pipeline in Europe, she is also working towards IEng accreditation, as well as setting up a network for women in engineering on the National Grid.

**Eden McGlen**
**APPRENTICE ENGINEERING MAINTENANCE TECHNICIAN, UNIPRES**
Current apprentice

McGlen's strong academic background made her an obvious candidate for university, but instead she applied for an apprenticeship with Unipres. One of just two women on her course, McGlen was invited to discuss the role of women in engineering at the House of Lords this year.

**While women make up approximately 12% of engineers in the UK, just over 7% of engineering apprentices are female**

Laurie-ann Sutherland Smith is a reliability engineer at Musk Process Services

**Paula McMahon**
**CHARTERED CIVIL ENGINEER, SIR ROBERT MCALPINE** Former apprentice

An RSA and ICE fellow, McMahon uses her experience on high-profile projects such as the Thames Barrier in her work as a civil engineer. She previously managed the highways structures department and had significant input into Highways England's system for structural asset management. She currently mentors more than two dozen candidates, and has been named a Wise role model.

**Lauren McNaughton**
**APPRENTICE BUILDING SERVICES ENGINEER, ARUP**
Current apprentice

Now in her final year, McNaughton has impressed colleagues and peers by taking the lead in automating many of Arup's design processes and chairing workshops for engineers on digital design. Her performance has also caught the eye of the Construction Industry Training Board, which has recently put her forward for a regional award.

**Lois Medley**
**ELECTRICAL APPRENTICE, WSP**
Current apprentice

A member of WSP's electrical team since the age of 16, Medley has key responsibilities on its HS2 project for software that calculates cable sizes, detects calculation errors and manages models of the electrics. Last year, she was interviewed about her work on BBC Breakfast, and has also taken part in a roundtable with Damian Hinds, the education minister, on policy around apprenticeships.

**Sarah Mulvanny**
**BIM TECHNICIAN, ARUP**
Current apprentice

Since joining Arup's building information modelling team, Mulvanny has gained experience on international projects including stadiums, airports, homes and hotels. She recently completed a secondment to develop her skills in digital visualisations, and having completed an EngTech is now studying for a degree in building services engineering.

# Top 50 Women in engineering

**Lesley Nutter**
**SENIOR ENGINEER, ENGINEERING APPRENTICESHIPS, BAE SYSTEMS**
Former apprentice

After graduating from the women-only TESS scheme in 1992 and working as an engineer for 17 years, Nutter joined BAE's early careers team just before it introduced the new aerospace engineering degree apprenticeship scheme in 2015. Under her guidance, now a fifth of its apprentices are women.

**Emma Roberts**
**APPLICATIONS ENGINEER, FAIRFIELD CONTROL SYSTEMS** Former apprentice

At just 25, Roberts has already achieved a first-class degree and assisted Fairfield on some of its biggest projects. Most notably, she helped refurbish the control system for the world's first rotating boat lift, designing and assisting in the building of new control panels. She has also represented former apprentices at the House of Commons.

**Billie Sequeira**
**TECHNICAL APPRENTICE, BAE SYSTEMS**
Current apprentice

When Sequeira joined BAE she'd already been placed in the top 10% nationwide for maths, and since joining, colleagues say she's outperformed in her role as an apprentice on BAE teams. She was named apprentice of the year by her training provider and is a keen Stem ambassador.

**Jennifer Smith,**
**PRINCIPAL ENGINEER, MBDA**
Former apprentice

The first female apprentice in the engineering department of MBDA's Stevenage site, Smith was IMechE young mechanical engineer of the year in 2017; she was praised for setting up an in-house training opportunity for engineers in the same year.

**Sophie Smith**
**BUILDING SURVEYOR, ATKINS**
Former apprentice

With 10 years' experience under her belt, Smith's mid-career sector switch gave her expertise in both social housing and building control. As well as studying for a degree part-time (and graduating with first-class honours), she has also fought back against barriers such as ill-fitting "unisex" personal protective equipment by developing her own range.

**Sarah Speir**
**PROJECT ENGINEER, SP ENERGY NETWORKS** Former apprentice

When Speir first started at SP on a year in industry programme after school, she expected to go to university afterwards. Instead, she stayed to earn an HNC on a three-year apprenticeship. Now in a full-time role as an engineer, she commissions power system protection and large-scale control systems apparatus, while studying for a degree.

**Courteney Stone**
**ENGINEERING TECHNICIAN APPRENTICE, BMW GROUP MANUFACTURING**
Current apprentice

Self-confessed petrolhead Stone is the only woman on her work's Mini Challenge racing team. She mentors other apprentices and volunteers as a charity champion, and after she graduates she hopes to stay on to improve production processes for the Mini body shell.

**Former apprentice Sophie Smith is a building surveyor at Atkins**

**Laurie-ann Sutherland Smith**
**RELIABILITY ENGINEER, MUSK PROCESS SERVICES** Former apprentice

Sutherland Smith has a flair for making significant improvement to processes in short timescales at work, and she's wasted no time applying her skills to improving equality at Musk. After Wise's ten steps campaign, she produced a strategic proposal and action plan for the company.

**Charlotte Tingley**
**QUALITY ENGINEER, BAE SYSTEMS**
Former apprentice

As a former WES young woman engineer of the year winner, Tingley has gone from strength to strength. After completing an advanced technical apprenticeship, at 20 she led the production team for the Eurofighter Typhoon helmet. She's now known as an industry expert in FRACAS, making her a key asset to her new role on the team for the inceptor systems of the F-35 jet.

**Tammy Whelan**
**ASSISTANT TECHNICIAN, ARUP**
Current apprentice

Whelan joined Arup's infrastructure team in Belfast after a career in the armed forces and graduated from a BTec last year. She was named learner of the year by her college and Northern Ireland's apprentice of the year. As well as representing women in apprenticeships, she is also a green champion, and has founded a steering group to improve sustainability in her workplace.

**Jade White**
**WELDING ENGINEER, SELLAFIELD**
Former apprentice

A specialist consultant in fabrication, welding and materials technology, White's expertise was highlighted last year after she was nominated for WES's Karen Burt award for newly chartered engineers. During her 10-year career at Sellafield, she has spoken widely on equality in engineering.

**Perdi Williams**
**ASSISTANT RESEARCH SCIENTIST, NATIONAL PHYSICAL LABORATORY**
Former apprentice

Williams is one of the key engineers behind the creation of the new Kibble (Watt) balance, the instrument that redefined the kilogram last year. Now 20, Williams started her apprenticeship just four years ago and has already spoken at New Scientist Live.

**Ambar Yasin**
**APPRENTICE, JAGUAR LAND ROVER**
Current apprentice

A rising star, Yasin has already been invited to present to the board of directors: not long after starting her placement, she managed to reduce time on one process by more than 80%. The youngest member and only woman on her team in the metrology department, she has a keen eye for improving efficiency.

**Daniela Zanni**
**STRUCTURAL TECHNICIAN APPRENTICE, ARUP** Current apprentice

At Arup, Zanni already has responsibility for the building information model of Manchester Metropolitan University's new arts and humanities building, and she is involved in training and running workshops for graduate engineers. Now studying for a BTec, she completed her NVQ in less than 18 months, and was shortlisted for this year's TARGETjobs apprentice of the year.

**"Congratulations to the UK top 50 Women in Engineering. You are an inspiration to the next generation of women in Stem. At GSK, we encourage our employees to achieve professional qualifications across the organisation, especially in science and technology."**
GSK

**"Congratulations to this year's WE50. WES is delighted to showcase engineering apprenticeships as the gateway to a rewarding career. All of the winners have gone above and beyond expectations and are also dedicated to supporting women engineers and apprentices."**
WES

# Construction

# ‘Subconscious stereotypes exist’

Does a notable gender pay gap and rigid working models stop female talent from reaching the top?

Ellen Manning

Encouraging women to join traditionally male-dominated sectors isn’t easy. But do women face even more hurdles when it comes to civil engineering and construction?

“From holding your own as the only woman in a room full of older men, to defying stereotypes and practicalities such as never having personal protective equipment (PPE) that fits, there are many hurdles faced by women in our industry,” says Kate Watson, associate director, structural engineering at Patrick Parsons. Those hurdles start early, says associate structural and civil engineer Victoria Martin, with physics and maths often dominated by boys, and parents being less in favour of daughters studying engineering than sons. “I can’t help but notice that a large proportion of the female engineers I know (myself included) have been educated in a single-sex environment, free of the daily reminders that they are something of an anomaly,” says Martin.

For those who do make it into engineering, achieving a professional status carries a lot of weight, she adds. “Women who want to combine a family with a rewarding career, if they haven’t achieved professional status prior to taking a break then this timeline can be further delayed. It meant a lot to me to get chartered and then promoted to associate before I had my first child, as I would then be returning with a level of credibility under my belt.”

A lack of parity when it comes to parental pay is another hurdle. “For a lot of families, the pattern of the woman as the main caregiver is established. This often comes at odds with the demands of the construction industry; operating at a high level is hard to balance with part-time or compressed hours.” It’s not impossible, though, she says, and thinks if both women and men were asking for flexible working hours there might be more of a cultural shift in attitudes.

For project engineer Daisy Partlow, the biggest problem is perception. “People just don’t know what to do with us,” she says. “There are subconscious stereotypes - in the office, nine times out of 10 if someone is trying to find someone they’ll walk past 10 other people and then come and ask me. That kind of thing puts people off.”

The sector recognises it has a lot of work to do - and has already started. Elizabeth Donnelly, CEO of the Women’s Engineering Society (WES), says their efforts include MentorSET, a mentoring programme to support women engineers throughout their careers, as well as support for Stem Returners to help them return to engineering after a career break. It also founded International Women in Engineering Day (INWED), an annual global celebration of women engineers.

The Institute of Coding (IoC) has created new flexible qualifications - designed to help women reskill - through its digital degree apprenticeship scheme. “All too often, stereotypes around courses, a notable gender pay gap and rigid working models mean that not enough female talent reaches the top, leading to a worrying lack of diversity,” says director Rachid Hourizi.

Elsewhere, training providers are teaming up with industry to encourage women into the sector. In the East Midlands, Access Training and Derby-based building firm Hodgkinson Builders recently expanded the Access Training Construction Academy to boost construction apprenticeships. Ian Hodgkinson, managing director at Hodgkinson Builders, says: “The Access Training Construction Academy will work to encourage all sorts of people to come in to the trade - not just men - to get the word out that the building industry is a great place to be, and to dispel the old thinking and perceptions that can unfortunately still be around.”

When it comes to encouraging women into the sector, Watson says: “I believe the best thing I can do on a personal level is to do my job as well as I can, and be seen to be doing so. I believe it is my responsibility to call out inequalities I see and encourage and support other women in the workforce. I hope that in the future we will see a further shift for women in our industry, but it’s certainly not a time to sit back - although we’ve come far in recent years, there is still a lot to be done and it’s a long game.”

***‘I believe it is my responsibility to call out inequalities I see and encourage other women at work’***

**Kate Watson**
*Patrick Parsons*

▼ *Returnship programmes often help build confidence and reinvigorate the desire to learn*

PHOTOGRAPH: GETTY

# Returnship schemes

# Helping women succeed after a career break

Whether it’s maternity leave, or simply just taking some time off, returnships offer an easy route for employees to come back to work

Georgina Fuller

There has been a phenomenal increase in the number of women choosing careers in engineering in the past few years, according to Elizabeth Donnelly, chief executive officer at the Women’s Engineering Society (WES).

“Our figures show the number of women in engineering was 650 in 2016/17, compared with 235 in 2005/6, an impressive increase of 277%,” she says.

Part of this is down to the success and popularity of returnships or mid-career schemes. “Returnships are a fantastic way for women to come back to a career they have previously had success in and possibly even a chance for them to make a switch to a different career with the skills they have already amassed,” Donnelly says. “These programmes build confidence, reinvigorate the desire for learning and development and upskill the individuals taking part.”

In 2017, the government pledged that it would provide £5m to fund returnships, but diversity and inclusion initiatives are also making a difference. Many large employers - including Amey, Arup, O2 and Vodafone - are now offering returnship schemes as part of their diversity strategies.

***‘I’ve seen women being promoted to senior leadership roles after returning from career breaks’***

**Ellie Zemani**
*Spirit Energy*

Natalie Desty, founder of Stem Returners, says such schemes have a positive impact on company culture. “It allows line managers to see for themselves that returning employees are just as capable after a break, and also opens minds to flexible and home-working options, which benefits everybody,” she says.

Almost all (98%) of the people placed by Stem Returners have gone on to accept a permanent position with the company.

They operate in the mid-career sector because this is, Desty says, where there is the biggest recruitment dip. “These programmes welcome back experienced and capable individuals into the mid-career space with lots of valuable and transferrable skills they have learned while on their break.” They often have the edge over younger employees because of their experience.

Ellie Zemani, an engineer and returner at Spirit Energy, says the best thing a company can do to show its commitment to women returners is provide strong role models. “I have two boys and took a year off for each. I came back full-time but worked reduced hours for the first couple of months,” she says.

Zemani was inspired by other women in her organisation. “We have had a couple of great examples, where women were promoted to senior leadership roles after returning from maternity leave or career breaks. For me, this sends the message that women - as well as men- can take a parental leave and stay on track.”

PHOTOGRAPHY: HEE

▼ *The gender pay gap is more prevalent in construction than in most industries*
PHOTOGRAPH: STOCKSY

# Civil engineering

## 'The key is to focus on long-term, sustainable change'

From stereotypes and bias to a lack of flexibility, the reasons behind the gender pay gap in civil engineering seem transparent. But how can we overcome prejudice?

**Ellen Manning**

The gender pay gap is everywhere, but nowhere more so than in construction. According to analysis by XpertHR, construction firms' data revealed a pay gap of 24% – compared with a national average of 8.6%.

Alison Fitch, HR manager at Invennt, a management consultancy that deals exclusively with construction, says there are a number of factors limiting the industry's ability to attract and retain female talent, including gender imbalance and a lack of flexible working arrangements that make it difficult for women to stay in work while caring for children. Michelle Gyimah, gender pay gap consultant at Equality Pays, agrees, saying civil engineering faces a double challenge: to attract women, and to retain them and enable their progress.

It's something associate structural and civil engineer Victoria Martin has experienced. While engineering consultancy is, for the most part, meritocratic, there are still too few women occupying technical and design roles that offer scope for progression, she says. "This skew towards the typically lower paid administration roles is then undoubtedly reflected in the gender pay gap figures." A 2017 report from the Association of Women in Property presented research carried out with pay gap analysis provider Gapsquare and executive research consultants, Rosemont Partnership, which surveyed representatives from all sections of the construction market. The research revealed that 30% of women left their jobs after two years or less, and only 12% of women were in a managerial role.

From stereotypes and bias to a lack of flexibility, the reasons behind the gender pay gap in civil engineering seem clear. But what steps should the industry take to change that? For Gyimah, the sector needs to address "bias in the workplace and confrontational behaviours, offering more equal gender hiring on apprenticeships and graduate schemes right through to better maternity packages, introducing shared parental leave and embedding flexible working arrangements".

> ***'A change in culture is required that is visible through practical changes in the workplace'***
> **Sue Ferns**
> *Prospect*

Writing in a blog post, Rachel Bell, chairman of the south-west branch of the Association of Women in Property, says: "At a time when flexible work environments and breakout spaces at universities are common, young people expect the same flexibility at work, too."

Change will take time, says Gyimah. "The key is to focus on long-term sustainable change. The gender pay gap has not appeared overnight, so it will take time to see sustainable change. Recent Equality and Human Rights Commission research shows that six in 10 women now use gender pay gap data as a deciding factor when it comes to job seeking. So if civil engineering firms are serious about addressing pay gaps, then ensuring that they have robust action plans in place is important."

Sue Ferns, senior deputy general secretary at trade union Prospect, says there are initiatives aimed at narrowing the gender pay gap, but they are not making enough difference quickly enough. "There's still quite a lot of confusion about what a gender pay gap is compared with what equal pay means. We need to educate people." In Ferns' view, effective dialogue is best achieved through union representation. "It's difficult for individuals to pursue this on their own. We all know about the leaky pipeline. It requires a change in culture that is visible through practical changes in the workplace. There is no easy solution, but there is a strong case for focusing on the issues that concern women most."

## Experience
## 'There were no industry mentoring sessions'

When architect Carol Stitchman was growing up, her career options seemed limited. Today, things are looking much brighter

**Interview by Mark Smith**

Growing up in a small mining town as one of six children, Carol Stitchman, design manager at Curzon Street station in Birmingham – the first intercity station to be built in Britain since the 19th century – spent every Christmas asking for a pony, but was told by her mum that if she wanted one, she was going to have to "get herself a good job".

Stitchman has certainly achieved just that. But back in the 1970s, the options for women in her career path were very limited.

"In those days, girls left school to be hairdressers, secretaries and nurses. There were no industry mentoring sessions, no visiting speakers. I lived in a then-thriving coal-mining area and most of the people I knew, including my family, worked in the mine."

Having set her sights on a career in architecture, after discovering a gift for technical drawing at school and a love for Lego, she became the first of her siblings to go to college and made it through university, despite running out of money.

"My final-year tutor advised that I should think about working as a technician and not an architect. He clearly didn't know me that well," she says.

Carol went to work for Boots as a project architect, while studying in the evenings, eventually realising her dream of becoming an architect after seven years of study. In 2000, she moved into the rail industry to work for Railtrack (now Network Rail). It had more than 30,000 engineers and 16 architects, with Stitchman one of just two women.

One of the projects she was involved in was the redevelopment of Birmingham New Street station, which she spent 15 years of her career. She cites its opening, four years ago, as one of the highlights of her career.

"With more than 1,000 contractors, we worked overnight to open the station to the public, and I watched people through bleary eyes as they moved through the space, this new station that had been my baby for so long."

In 2016, Birmingham New Street station won more than 20 industry awards. Her own personal achievement was being awarded the best woman architect award in the Women in Construction and Engineering (WICE) awards, and being chosen from more than 300 finalists as the most distinguished winner.

She then joined engineering firm WSP, which went on to win the bid to design Curzon Street, and so Stitchman found herself back where she started.

"It felt like I was coming home to manage the design of my second multimillion-pound rail project in Birmingham.

More importantly, though, did she ever get that horse?

"I bought my first horse 20 years ago and now have five horses and five dogs. I'm also currently renovating an old farmhouse – so life has been good."

> ***'In the olden days, girls left school to be hairdressers – and most people I know worked in mines'***
> **Carol Stitchman**
> *WSP*

PHOTOGRAPH: FRASER MCGEE

▲ *Carol Stitchman, design manager at Curzon Street station*



▼ *Modern engineers work across a variety of different sectors*
PHOTOGRAPH: STOCKSY

# Diary of a new starter

## 'I've never felt like an outcast as a woman in engineering'

Seven female engineers working in their first job share their experiences

**Abby Young-Powell**

Think of an engineer and what comes to mind? Perhaps a man who is working outside and wearing a hard hat and overalls? But engineering is a lot more than that. Modern engineers work across a variety of sectors – from light and audio, to renewable energy, to building whole new cities. They also work around the country in different cities, as well as rural areas, working in everything from computer coding to chemical engineering; some even have jobs in fashion, creating wearable technology.

The profession is still male-dominated, however; according to the Women in Engineering Society (WES), just 12% of the UK's engineers are women. But the number of women entering the profession has grown in recent years and many young women are thriving in the industry.

We spoke to a range of young female engineers working in their first jobs to find out how they're getting on. Some said they enjoyed being able to express their creativity through engineering, while others felt they thrive on being part of projects that have a positive impact on the world. Here's what each of them had to say:

> ***'I used to be quite shy before, but I feel like I've found confidence in myself through this role'***
> **Zeinab Mohammed**
> *Assistant services engineer, 21*

### Zeinab Mohammed, 21
*Assistant services engineer at Pick Everard*

I design things such as lighting – I like being able to use my creativity and put my mark on it. I'm the youngest in the team and there's definitely a bit of an age gap because I'm 21 and the second-youngest is 33. They never make me feel like I'm asking a silly question, though. There's a lot of banter that goes on in the team. They joke around with me when they make a reference to old films that I haven't seen. But I joke around with them, too, because they don't always understand the lingo of the younger generation. It's a two-way thing and we laugh a lot. I was a shy person before I started at Pick Everard, but I've found confidence in myself through this role.

### Jennifer Opal, 28
*Junior software engineer at BT Group*

I was at university in London, where I'm from, studying business and French, but I dropped out to do this job. Code First: Girls visited my university and were offering free eight-week courses to give people an insight into coding and web design. From the first day, I fell in love with it. Once I typed my first line of code, it was like: "Wow, I really want to do this". I found my passion. Then I was offered this job. I felt like I'd been given an opportunity to develop my skills and make an impact, and if it meant I had to leave university and leave London then I decided to take that chance. I have no regrets about leaving London to do this.

> ***'I fell in love with coding as soon as I typed my first line of code. I've definitely found my passion'***
> **Jennifer Opal**
> *Software engineer, 28*

### Lucy Allen, 23
*Graduate infrastructure engineer*

We build roads, drainage, and water supply. The projects I'm working on are in the UK and overseas, in places such as the Middle East. The scale varies from one building to building whole new cities, where there's no infrastructure, so we're designing how to get water in, how to get rid of waste, and all the road networks. It's really exciting, but also quite overwhelming at times. My job has been really sociable, because 10 of us started together in the past year – so we never feel alone. The company organises social events for graduate engineers, such as softball matches against the architects, which really helps us bond and get to know each other better.

> ***'My job has been really sociable, because 10 of us started together – we never feel alone'***
> **Lucy Allen**
> *Infrastructure designer, 23*

> ***'I was intimidated at first, but there's a relaxed atmosphere and everyone's really supportive'***
> **Priya Nirmal**
> *Digital engineer, 23*

### Priya Nirmal, 23
*Associate digital engineer at Capco*

I'm a developer, so I work on websites and apps. I went into engineering for the creativity – you're constantly making and designing things, which is my passion. I've always liked to be artistic and can show that through engineering. I was intimidated when I first started, I didn't really know what to expect, but there's a relaxed atmosphere and people have been really supportive and welcoming. There's a lot of things I can explore here. I've learned so much in five months and it doesn't feel like my education has ended yet – I'm still learning every day. Learning is part of the job, which means you're never bored.

> ***'We've even worked with the Golden Globe awards – we made a special trophy for them'***
> **Olivia Ojuroye**
> *Electronic engineer, 25*

### Olivia Ojuroye, 25
*Electronic engineer and product manager at Digiseq*

We work with fashion brands to create wearable technology – such as watches, bracelets or rings – and we insert chips so you can use them to make contactless payment devices. It's a really interesting sector of engineering, where fashion and wearable technology combines. We also worked with the Golden Globe awards. I don't think many people know this, but the 2019 trophies have a chip inside. We put that there so in the future you can know it's a real trophy and not a fake. Technology is being embraced and that's great for engineering, because it encourages people to enter, and that means more diversity.

### Elizabeth Elliot, 29
*Civil engineer on the graduate scheme at Bombardier*

My company makes trains and rolling stock – for example, we're doing the Crossrail trains. We make sure the trains work and that they last. I fell into recruitment when I graduated and was recruiting engineers for Bombardier, where I work now. But recruitment wasn't scratching the itch for me any more and I wanted to be in a technical position. Bombardier was looking for someone for their graduate scheme and I thought: 'This is my chance'. One of the highlights has been doing a site tour with Jeremy Corbyn. He got to go on one of the trains and met us because we're a new generation of engineers.

> ***'A career highlight has been doing a site tour with Jeremy Corbyn, where he met the new engineers'***
> **Elizabeth Elliot**
> *Civil engineer, 29*

### Kulsum Ahmed, 27
*Safety and risk consultant at Environmental Resources Management*

My job is to look for ways to prevent potential oil and gas hazards. It's nice to use my engineering degree in a way that protects people and the environment. Every day is completely different and I get the opportunity to work with a large variety of clients. The first time I went to a client workshop, though, I was so nervous I spilt a cup of tea all over my manager's laptop. I had to turn it upside down and sit with it that way for the rest of the day, but it was fine in the end. I've been very lucky. I've never felt like an outcast as a woman in engineering. I've always felt like I've been given equal opportunities.

> ***'As a woman, I've always felt like I've been given equal opportunities in engineering'***
> **Kulsum Ahmed**
> *Risk consultant, 27*

# Future engineers

## 'Teachers can be the ones who can change things'

Education professionals are key to solving the engineering skills shortage, says Yvonne Baker, chief executive at Stem Learning

**Helena Pozniak**

If a teacher hadn't encouraged her, Yvonne Baker might never have gone into engineering: "She inspired me at a time when it was unheard for girls to consider it."

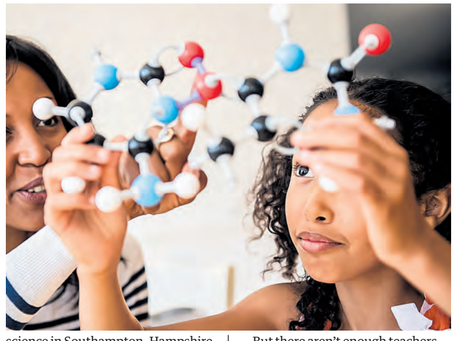
Baker's glad she made that choice – as a chartered chemical engineer, she now leads efforts to persuade people to choose science, technology, engineering and maths (Stem).

"Teachers can be the ones who can change things – they're a key part of solving the engineering skills shortage and encouraging more girls," says Baker, who now heads Stem Learning, which provides education and careers support.

Worried about a lack of maths and physics teachers, the government is focusing on finding more and hanging on to them, with a new recruitment and retention strategy launched this year. This supports teachers and offers flexible working. With phased bonuses of up to £10,000, the government hopes to encourage maths teachers to stay on after training – in total, £406m is being invested specifically on maths, digital and technical education.

"I wouldn't leave now if you paid me," says science teacher, Helen Staton, who teaches biology and

▼ *Informing children about the science and maths careers available is vital in attracting interest*
PHOTOGRAPH: GETTY



science in Southampton, Hampshire. She joined via Teach First in 2016, a charity that focuses on recruiting for shortage subjects. "For me, it's about teaching what science actually is," says Staton. "Kids don't understand the amazing careers available."

> ***'My teacher inspired me to get into engineering at a time when it was unheard of for girls'***
>
> **Yvonne Baker**
> *Stem Learning*

But there aren't enough teachers like Staton. Just half of maths and physics teachers stay on in state schools beyond five years – that's worse than the overall retention rate of 60%, a 2018 report from the Education Policy Institute shows.

Today, there are more pupils – now nearly 17 per teacher, up from 15.5 in 2010. By 2025, a population bulge means there'll be 15% more pupils in secondary schools than in 2018.

Not even half of maths and physics teachers hold a relevant degree. "If it's not your specialist subject, you're less able to inspire pupils," says Dr Rhys Morgan, director of engineering and education at the Royal Academy of Engineering.

And this is bad news for engineering. "Half of all A-level physics students go on to study engineering," says Morgan. "But only 20% of A-level physics students are girls. We need to address this early on in schools." Some universities have dropped the physics requirement for their engineering degrees in order to widen entry to more women, but this risks marginalising physics as a subject in schools, says Morgan.

Since 2010, the number of girls taking Stem A-levels has risen 26%, and in the latest intake the government recruited 5,900 science and maths trainees – up 500 from the previous year. Entries to GCSE computer science are rising faster than for any other subject.

But the salaries science and maths teachers earn fall below those of the private sector – maths teachers in their late 20s earn about £4,000 less than their graduate peers.

Engineering companies have a role to play, too, says Baker. And a scheme to bring in teachers to summer work placements has been successful. "It helps when you can say: 'I met a person who did this,'" says Morgan. Teachers are also more likely to stay if their skills are boosted by training – and Stem Learning's subject-specific development makes it 160% more likely that science teachers will remain in their profession.

"Industry says we need more engineers," says Morgan. "But I believe we need to divert some of them into teaching."



# Maths anxiety

## 'People are scared of looking foolish'

Two in three students who feel maths anxiety actually do well in the subject. Does a lack of awareness of their abilities limit pupils' career prospects in Stem industries?

**Sean Hargrave**

Nearly everyone will know they have felt anxious about a maths question at some time in their lives. What may not seem so obvious is that many other people have felt the same way and that maths anxiety is a real problem.

So much so that the Maths Anxiety Trust has been set up to raise awareness of the issue. It points out the problem could be contributing to a quarter of 11-year-olds being below the standard expected of their age group and nearly a third of students failing to obtain a grade 4 (grade C in the old grading system) or higher in maths GCSE exams.

The trust believes these statistics reveal what academics have known for many years. A poll for the trust, conducted last year by Ipsos Mori, found more than a third of 15- to 24-year-olds feel anxious when shown a maths problem. The same applies to one in five British adults.

Despite this high prevalence, the same research showed that 80% of adults have never heard of the term maths anxiety.

This comes as little surprise to Celia Hoyles, professor of mathematics education at University College London (UCL). She helps with the trust's work because she feels it is vital people recognise maths anxiety is real and needs to be addressed if more young people are to study for qualifications that lead to careers in Stem industries.

"With maths, there's a right or a wrong answer and that's why people can feel so anxious – they're scared of looking foolish," she says.

"It's why people end up thinking they're not good at maths, which means we get fewer people studying it after GCSE."

One issue that needs to be tackled is how maths is taught. Hoyles says that experts need to think beyond algebra and equations and understand how they can help young people realise that maths can be used to solve problems and widen their career choices.

"We need teachers to be great communicators as well as fantastic maths teachers," she says. "That can be tough because we've always had a shortage of great maths teachers in the country, as there are so many other careers available to people who are qualified to teach maths. We need teachers to be empathetic and to see other points of view, to understand where pupils are finding aspects of the subject difficult so they can be encouraged to overcome those hurdles."

This is a crucial point for Ros McLellan, lecturer in teacher education and development at the University of Cambridge. She was recently part of a research team from the university that worked with the Nuffield Foundation to better understand maths anxiety.

▲ *Parents and teachers can be unaware of a child's anxiety* PHOTOGRAPH: STOCKSY

The study included a quantitative overview of maths standards and anxiety, as well as qualitative work with individual primary and secondary school pupils who kept diaries of their experiences studying the subject.

"We found that two in three of the pupils who were living with maths anxiety were actually doing well in the subject," McLellan says.

"This makes it tricky because it can mean that parents and teachers aren't aware of a child's anxiety. However, it does mean that students are more likely to drop the subject and not take it up at A-level or beyond."

The other major take-out for McLellan was more encouraging: maths anxiety can come and go.

"People can feel maths anxiety and then overcome it," she says.

"McLellan's advice is to instil in children that if they don't understand a maths problem, that doesn't mean they're bad at the subject.

Teachers must also help pupils overcome difficulties and never allow them to feel like they are no good at the subject. It's that feeling of failure that can lead to maths anxiety and young people dropping the subject and, in so doing, limiting their future career prospects in the Stem industries.

▼ *Apprenticeships give students the opportunity to get a degree and industry experience at the same time*
PHOTOGRAPH: GETTY

## Apprenticeships

# 'We're missing out on the talents of 50% of the population'

Could improving awareness of Stem degree-level apprenticeships increase uptake among young women?

**Sean Hargrave**

Apprenticeships as a whole have an even split between men and women, but only 9% of Stem apprenticeships are taken up by women. It is a worrying statistic that the government says it is trying to correct by making more young women aware of the wealth of opportunities opened up by a degree-level Stem apprenticeship.

Lucy Rigler, deputy director at the Institute for Apprenticeships and Technical Education, points out that, although the uptake seems low, there has been an improvement of 1% among women in the past four years.

"There is still a lot of work to do and so we are working with the Department for Education to help encourage more women on to these apprenticeships," she says. "The fact they can earn as they learn and gain work experience is an important consideration for young women who want to progress in their careers."

Much of the blame may lay with society and schools, according to Sarah Peers, deputy president at the International Network of Women Engineers and Scientists, and adviser to the Institute of Innovation and Knowledge Exchange.

> ***'Not only do you get a degree but you've got five years of experience in the industry'***
> **Hajra Bibi**
> *GSK apprentice*

"Girls tend to choose fewer options around Stem, but this leaky pipeline starts earlier, with primary school children who are fed messages about their role in society," she says.

"We need to inspire teachers, parents and employers to understand these issues and understand why it is important to them. If your recruits and apprentices are mainly men, then you're missing out on the innovation talents of 50% of the population."

Hajra Bibi counts herself as "one of the lucky ones" who heard about degree apprenticeships at school. She will finish a five-year degree course in applied bioscience this summer through a degree apprenticeship scheme at pharmaceuticals company GSK. She believes the role has given her more than university could have, and without the debt.

"I thought about university, but I chose to get my degree while earning so I wouldn't start my working life with huge debt," she says.

"The great part of apprenticeships is that not only do you get a degree, but you've got five years of experience in the industry. The sandwich year students we have here always comment on how they'd have loved to graduate with so much experience and no debt. Many people haven't heard about apprenticeships or, if they have, don't realise how they've now evolved to be comparable to going to university."

## Experience

# 'Maths creates so many opportunities'

Short of maths teachers, education director Georgie Hart discusses whether schools could benefit from digitising the subject

**Interview by Helena Pozniak**

Dr Georgie Hart was a reluctant mathematician - English was her favourite subject at school, but she took a maths degree because she was good at it. But not until maths research led her to work for the World Health Organization did she begin to truly enjoy herself.

"I was analysing which interventions against tuberculosis were most effective. That was the moment I fell in love with maths. I'd discovered the little-known area of operational research - which is about using statistics and maths to make better decisions - with a massive emphasis on human interaction with technology. I saw how maths could solve real-world problems."

After a PhD in operational research, she's been working with education experts and coders for the past eight years to perfect education technology, which helps secondary school children learn maths.

She's spent enough time in classrooms to know the value of good teaching. "You'll never replace the richness of teachers interacting with pupils. But even the best teacher in the world can't know what every pupil gets stuck on at any moment."

She's now education director at technology company Sparx, where specialists have spent eight years developing education technology, which tailors maths tasks to individuals' differing abilities - in line with a wider shift in education towards personalising lessons to stretch every pupil at whatever stage they are.

"We knew technology could make a difference but we didn't know exactly how," says Hart. "Over time, we've been brave and thrown out what doesn't work, and have drawn on cognitive science and learning research, and have eventually built something that teachers love using."

UK schools have been chronically short of highly qualified maths teachers, and disadvantaged pupils haven't performed as well as the national average - some 58% of students eligible for free school meals have failed to achieve maths GCSE grade A*-C (now 9-4).

But technology in the classroom often gets teachers and parents hot under the collar, prompting dire predictions of "robot teachers" replacing real people - and many education technology products have been launched with great fanfare in the past few years only to fall by the wayside. Simply digitising how maths is taught with appealing graphics and games isn't enough, says Hart - learning technology needs to be designed with deep understanding of how pupils learn and a healthy reality check around how teachers want to use it.

Beware of bandying terms such as artificial intelligence (AI), she says. "AI can be a very disempowering term for teachers, it's not helpful. But the concept of adaptive teaching allows teachers to do more of the job they love." And data doesn't always give the full picture, she says. "If a pupil scores highly at, say, ratios, but still feels very unsure, a teacher needs to know that. Or if a child is overconfident on a subject, but scores badly, a teacher must address that too. You need human intervention; it can't just be a case of 'the computer says no'. It has to be a blend of a human being and technology."

Through thousands of individually made video tutorials, Sparx helps explain concepts and provides an hour of bespoke maths homework for each student every week. "So if a child is really strong, he or she can explore, while others can use the video to address gaps in their knowledge," says Hart.

She'd like to see more links between industry and schools to inspire pupils and bring the maths curriculum to life. As a young mathematician, careers advisers pushed her towards accountancy - but, on graduation, she happily discovered her options were far broader. "Maths genuinely creates so many opportunities."

And if teachers could communicate the relevance of trigonometry, algebra, and other mathematical concepts in everyday life, then pupils could be more inspired earlier on, she says. "How does an architect use maths, for instance? Having someone say why that fractions class could be useful in the future would be so worthwhile."

> ***'You need human intervention - it has to be a blend of a human being and technology'***
> **Georgie Hart**
> *Sparx*

## Experience
# 'We talk about programming during Christmas dinner'

Two pairs of parent and daughter duos explain their personal relationships with engineering and what inspired them to get into the industry

Interviews by Abby Young-Powell

### Trevor John, 68
*Consultant and retired systems engineer*

I grew up in south Wales and my grandfather was a miner in the Welsh valleys. In his spare time, he fixed radios and clocks, and that fascinated me as a child. I was keen to get into his shed and see what he was doing. That developed my interest in finding out about things, making them work, and fixing them.

That followed through to my daughter, Ruth. She always had an interest in understanding things. We had a computer in the early days of computers and we'd use it together. We'd do anything from setting it up to artistic stuff, such as drawing pictures together.

With time, that interaction has increased, not decreased, which is wonderful. She might ask me to look at some maths, or to tidy up a bit of code. It's good because it's kept me up to date with technology – I'm learning as much as I ever taught her.

I have a wife, three daughters and a son. My son is also an engineer and Ruth's elder sister is a mathematician. My wife and other daughter will joke about how they feel a bit left out at times, but it's a good family dynamic.

I'm proud of Ruth. In particular, I'm proud because she's not been afraid to operate in a largely male-dominated profession, and I imagine that must be hard. Engineering is changing [in terms of becoming more gender-equal] and that's good. I think my grandad would have been proud of Ruth, too.

### Ruth John, 37
*Self-employed digital engineer and computer programmer*

Because dad worked with tech there was always tech around when I was growing up, and we always had a computer in the house. In the early days of computers, we'd get the computer out at weekends and it would be a special occasion. Dad would build the computers – he didn't just buy them off the shelf.

When I was a teenager, the internet came along and me and my elder sister would play games together. We were always comfortable using computers, they were just normal to us.

Mum also taught her daughters that we could grow up to do anything. She would do things such as edit Enid Blyton stories when she read them to us to make sure they all went on adventures. The girls don't actually go on adventures in Blyton's stories – I only realised that when I reread them as a teenager.

We talk about engineering a lot at home; when we're having dinner at Christmas, for example, we can get into quite in-depth conversations about programming or audio. It's really good to get my dad's perspective, but everyone else gets annoyed with our geeky conversations.

I love making things digitally. You can do whatever you want once you learn to code.

▼ *Trevor and Ruth John bond over their mutual love for engineering*
PHOTOGRAPH: EMLI BENDIXEN

*'It's great to get my dad's perspective – but everyone gets annoyed with our geeky conversations'*
**Ruth John**
*Digital engineer*





▼ *Louise and Gemma Taylor (l-r) inspire each other*
PHOTOGRAPH: AMIT LENNON

## Experience
# 'Engineering gives us a common link'

### Louise Taylor, 50
*Commissioning officer at Dorset County council*

As a child, it never occurred to me to go into engineering. Then I got a part-time job in a design office [where engineers worked]. I was working really hard for other people and I wanted to do what they were doing. So I used to go into my boss's office every week and ask him to send me to college, so I could become an engineer, too.

Finally, after five years of nagging, my boss said he would send me to college. That was his retirement present to me. I had only just had Gemma [my daughter], so initially I thought it was the wrong time, but I made myself do it anyway.

I found the course interesting and stimulating. What I love about my job now is you can improve people's working and living environments. For example, it's your job to make sure there's enough light and air inside a building.

Gemma originally wanted to become an architect, but I think that was just to annoy me – architects are more form and we're more function, so there's always a balance to strike between the two. Engineering gives us a common link, so we're not just mother and daughter and can have interesting work discussions.

### Gemma Taylor, 25
*Building physics and services engineer at Services Design Solution (SDS)*

I work on the stuff that's hidden within buildings. So that means if nobody's complaining they're too hot or too cold, I've done a good job. Growing up, my mum was a role model to me and I felt like there were no bounds to what I could achieve.

Since the age of about five, I would go in to work with her. It never crossed my mind that she was one of only about two women in the office, though. Sometimes I'd sit and draw pictures. Other times I'd make cups of tea for everyone. One of her male colleagues even gave me a teddy bear once and I've still got it to this day.

*'We're always interacting – my mum helps me with my work and we bounce ideas off each other'*
**Gemma Taylor**
*Service engineer*

When I was a bit older, we went out on building sites. We'd put on hard hats and boots and walk around. I noticed mum wasn't afraid to say if something was wrong and that it needed to be redone, and that people respected her because it was her job.

At first, I wanted to be an architect, but I think I was just fighting against the trend and mum probably always knew I'd end up being an engineer. She doesn't realise how much she's helped me. We're always interacting and we talk on the phone most days. She helps me with my work and we bounce ideas off each other. She's my mum so we work in a similar way. She talks herself down, but I just want to make her proud.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# Women in Engineering

**At GSK, we invest in the next generation of scientists, engineers and leaders, no matter what their gender. Together we're building an environment where everyone can thrive to fulfil their potential.**

**#WE50 #TransformTheFuture**

**Emily**
Engineering Apprentice
Ulverston