Closing the gap

'Regulatory Tools for Gender Equality in Mining' were in the spotlight at a joint webinar hosted by the Intergovernmental Forum and the Responsible Mining Foundation. **Andrea Gaini** reports.

The *2020 Responsible Mining Index (RMI)*, released by the Responsible Mining Foundation (RMF), reveals disparities in how gender equality is addressed by mining companies and mining-affected communities.

The report assesses the economic, environmental, social and governance policies and practices of 38 large-scale mining companies that operate in more than 780 mine sites and, together, account for 28% of the world's mining activity by value of production. The report also assesses 180 individual mine sites in 45 countries against 10 basic indicators of responsible mining.

The document notes that most companies are taking action to track and report the percentage of women at board and senior management levels. However, it finds less evidence of companies addressing issues like the provision of gender-appropriate personal protective equipment (PPE). Only six of the 38 companies analysed provide PPE that is considered effective, safe and ergonomic.

A notable outlier are South Africa-based firms, where a 2013 revision of the Mine Health and Safety Act specified that protective equipment needs to be suitable.

Jennifer Rietbergen-McCracken, a Senior Advisor at the RMF in Switzerland, discussed the issue of PPE during the recent Intergovernmental Forum-RMF webinar on 'Regulatory Tools for Gender Equality in Mining'. She described, "A few years later, the country's Mine and Health Safety Council issued detailed guidelines of the interpretation of this legal provision, [outlining] how companies can ensure that the PPE they provide to women workers is fit for purpose and safe for use.

"At around the same time, the Department of Mineral Resources also published guidelines on the preparation of a mandatory code of practice for PPE for women workers, similarly outlining how companies can collaborate with women workers to assess the risks of wearing PPE that is inappropriate, and to actually recommend changes to better fit our needs."

She noted that this change in legislation has influenced most South African companies, who consequently perform better on this issue in the 2020 *RMI*.

Rietbergen-McCracken continued, "Perhaps an even more striking result is a generalised lack of action to protect women workers from sexual harassment and gender-based violence.

Evgeny Haritonov/Shutterstock

We know that studies and surveys continue to show that these risks are still a daily reality for many women mining workers, but the problem is still vast compared to the action that has taken place on it."

She noted further that "looking at gender actions at the community level, we see a very straightforward result – less than half of the companies can show that they are ensuring that their community engagement activities reach out to women as well as men. And it is clear that without such special measures, women are often excluded from the discussions and the decision-making."

Regarding local procurement, 30 of the companies surveyed in the report are looking to develop opportunities for local businesses, but only nine have taken steps to ensure that female entrepreneurs are included.

Meeting the challenge

Marie Paz Rodríguez Mier, Gender Equity Leader at the Ministry of Mines and Energy in Colombia, revealed how the Colombian government has developed an action plan to increase female participation in the formal mining workforce, is collecting and analysing gender segregated data, and is working with a "gender team" to promote gender equality in mining.

She explained that the Ministry has created guidelines so that entities can integrate a focus on gender balance into their policies, plans and projects.

For example, "the first one has to do with engagement of women in direct and indirect employment, decision-making positions and the value chain. [Then] we have a second pillar that has to do with culture for gender equality…the way we do business and the way organisations are developed from private enterprises, as well as our public entities."

The Ministry has also formed a partnership with companies in the sector called Transforming Energy, as "they are our branches into territories", said Mier. This initiative has helped the Ministry gather information about how women participate in the sector and the types of challenges they face.

"We found that in the [country's] mining and energy sector… participation of women is still below the national average…at 27%, when in the national arena, it is around 39 or 40% of participation. And only 12% of the companies have a gender equality policy."

Mier highlighted how superstition and cultural barriers are also still prominent reasons for why fewer women are working in the mines. "It is considered bad luck that a woman enters a coal mine, which doesn't make any sense, but it still happens."

It is hoped that by sharing best practice between companies through this partnership, it could help propel change in those firms that are further behind in tackling these issues.

No time to lose

Another study by the Natural Resources Governance Institute and the World Resources Institute, published this year, examines extractive sector laws and policies that refer to gender or women within a sample of 12 countries – Argentina, Canada, Colombia, Ghana, Indonesia, Kenya, Mongolia, Morocco, Nigeria, Peru, Sierra Leone and Tunisia.

Speaking at the event, Aubrey Menard, Senior Policy Advisor Extractive Industries at Oxfam America, reported, "Several countries from our study have provisions in place that prohibit women from working underground, working at night or working in the extractive sector at all. In the countries that we analysed, we found laws prohibiting women from working in mines in Argentina, Morocco, Nigeria, Sierra Leone and Tunisia.

"Because women have been so long and pervasively excluded from the mining sector, we have a constructed view of mining as men's work, and it is difficult to imagine women performing physically demanding jobs in underground mines."

Menard noted that while women make up 47% of the global workforce, they represent only 22% of the oil and gas workforce and only 14% of the industrial mining workforce.

She suggested that governments and mining companies need to make ambitious and bold commitments to improve on these numbers. "Many of the documents that we reviewed contain gender provisions that were unambitious. So, for example, [some] quota requirements only require a woman or two to be included on a single board. Even if well implemented, this sort of requirement will do little to transform gender relations in a country's extractive sector or beyond."

She added, "These quotas provide for nominal women's representation on governing bodies. However, provisions often do not require that women appointed to these positions have any particular qualification or have historically represented women's interests in any demonstrable way. And so, this is a little bit tricky, because while overly rigorous requirements can be used to justify the exclusion of women from these positions, with no requirements stated, it's also possible that women may be appointed, or chosen, to fill these quotas specifically because they're likely to be compliant with dominant cultures," she explained.

"[South Africa's] Department of Mineral Resources also published detailed guidelines on the preparation of a mandatory code of practice for PPE for women workers, similarly outlining how companies can collaborate with these workers to assess the risks of wearing PPE that is inappropriate and to actually recommend changes to better fit our needs."

"Research shows that in order to effect gender transformative change, there needs to be a critical mass of women, which is defined generally at more than one-third in leadership positions. Otherwise, women are stereotyped, tokenised, they're easily overshadowed and dismissed. It is not until this critical threshold is reached, that perceptions begin to shift and fundamental change begins to occur."

She suggested that if countries are to use quotas, they should do so in significant quantities across the entire governance structure and supply chain. And "documents should be ambitious about creating systemic change. For example, [they] can be designed to require transparency on benefit impact agreements, promote the collection and transparency of data on local procurement and employment, and even to build interventions to deal specifically with the gender differentiated impacts prevalent in extraction-effective communities.

"And more than having ambitious goals for women and gender minorities participation, documents should also be bold in...changing the way decision-making occurs in extraction-effective communities to realigning economic power.

"Reform of the extractive sector has the potential to drastically impact the lives of people in affected communities and countries and, as such,...governments should carefully consider what the desired and likely impacts of the documents may be in creating ambitious gender transformative change".

Balancing act

The *2020 Responsible Mining Index* report outlines six steps for companies to achieve gender equality:

- Develop a company-wide gender equality policy.
- Review existing policies, procedures and systems to check for any unintended gender bias and to ensure that gender equality issues are adequately addressed.
- Establish a zero-tolerance policy for harassment and gender-based violence.
- Ensure gender-appropriate personal protective equipment and health and sanitation facilities.
- Establish systems to ensure operations conduct regular gender impact assessments and act on the results of these assessments.
- Track and report gender-disaggregated data on recruitment, retention and representation in the workforce; local employment and local procurement; health and safety of workers and local communities; and workers' wages.

Source: Responsible Mining Index

The future of 'green skills'

Andrea Gaini puts questions to industry and academic representatives about securing the skills we need to power a 'green economy'.

Panellists

Representatives from the IOM3 Resources Strategy Group (RSG) and IOM3 Sustainable Development Group **(RSG/SDG)**

Sam Alvis, Head of Green Renewal at Green Alliance **(SA)**

Jenny Young, Head of Strategy, Policy and Insights at the Engineering Construction Industry Training Board **(JY)**

Dr Sarah Gordon, Exploration Geologist in the mining industry, CEO and Co-Founder of Satarla **(SG)**

Bhavina Bharkhada, Head of Policy & Campaigns at manufacturing trade body Make UK **(BB)**

Professor Matt Davidson, Head of the Centre for Sustainable and Circular Technologies, and **Professor Andrew Burrows,** Head of the Department of Chemistry, University of Bath **(MD/AB)**

Professor Paul de Leeuw, Energy Transition Institute at Robert Gordon University **(PDL)**

How would you define 'green skills' and why are they important?

RSG/SDG: At its most literal, 'green' is epitomised by plant photosynthesis. The second most basic aspect is an awareness of how normal industrial processes differ from photosynthesis. Typically, normal industrial processes use high temperatures and pressures with enormous losses of energy – strictly speaking of exergy – and usually the quantity of waste far exceeds that of the desired end-product. This awareness implies a correct appreciation of the relevant thermodynamic principles.

A 'green' industrial process tries to imitate desirable features of natural photosynthesis – mild conditions, the use of water rather than organic solvents, and benign or even beneficial by-products rather than toxic or polluting waste. Recognition of the importance of green skills implies recognition that we cannot continue with business as usual.

SA: Green skills cover any role we know will be important to the future of our economy, an economy that is positive for climate and the environment. That will be a mix of new roles, for example, those learning how to manufacture, install and maintain heat pumps, and those adding a green string to their current bow – a doctor helping to reduce waste in an A&E. Many skills will become 'green' by the direction of businesses, for example, someone who spray paints petrol cars will be practising a green skill by spray painting an electric car. It's important we focus on this full range of green skills so the UK Government can ensure businesses are equipped for the future economy, regardless of their sector.

SG: Green skills can be interpreted in a number of ways, however, typically pertain to the ability to understand and manage sustainability – or environment, social and governance (ESG) factors. This can be done by understanding the impact that an operation may have on the environment or local community and proactively managing it so that any threats are eliminated or reduced; understanding the impact that the environmental and social context may have on your activities, both now and in the long term, and designing your operation so that it takes these into account; and understanding the broader governance and macro-sociopolitical trends and requirements.

BB: Green skills are effectively an amalgamation of environmentally conscious knowledge, strategies and abilities to support a sustainable and resource-efficient manufacturing sector. They are important to manufacturers because it is not only new jobs/professions that will require these skills, but existing jobs too.

JY: Green skills are often the same engineering, construction and project management skills we already have, but applied and/or adapted to 'green' projects, such as decarbonisation, clean fuels, fuel switching, energy efficiency and emissions reduction. Engineering construction is fundamental to many of the industrial heavy-emitting sectors that will need to decarbonise, as well as encompassing many of the renewable generation sectors. The required skills will become a core and integral part of engineering construction skills rather than a distinct, ring-fenced engineering base.

MD/AB: Training PhD students in fundamental concepts of sustainability is at the core of [our] training programme. It is vital to have this broad interdisciplinary understanding of what 'green and sustainable' is, as well as the disciplinary depth of a PhD

research project. We do this through cohort-based PhD training and close involvement of a wide range of external partners – industrial, government, NGO and learned society. Exposing PhD students to all of these perspectives and publics is vital to hone their understanding of the complexity of the problem and to develop their advocacy skills as future leaders in green chemistry and sustainability. In terms of undergraduates, it is essential for students to understand the principles of green chemistry and how they can be applied in the real world.

PDL: We define green skills as those skills and capabilities that have a direct, positive impact on addressing the challenges associated with the climate emergency, with improving the planet and with accelerating the transition to a sustainable, net-zero world.

What specific skills are required?

RSG/SDG: IT skills – better data will help better decision-making. Life-cycle analysis (LCA) skills will help us design with end-of-use in mind and enable circular systems to become normative, but we will need new technical skills around chemical recycling, carbon capture and storage, and materials handling and transition management, as well as communications and behavioural change skills. This is a huge step-change for staff, owners and the general public so we need to take everyone with us.

SA: There is currently a big focus on manufacturing skills for net-zero infrastructure and goods. This is welcome, but we also need to think about the skills required to minimise and manage our resource use. To keep products going for longer, we need higher numbers of people able to repair goods, remanufacture them and also encouraging recycling. Similarly, new types of technology will need a battery of people involved in their upkeep and maintenance. The other area often overlooked is in the natural environment.

SG: The circular economy and energy transition is a very exciting time for the extractives sectors as it heralds the need for greater volumes of a far more diverse array of commodities than ever demanded in the past. However, for the sector to deliver, we need to ensure that we do so in line with sustainability principles, otherwise we risk creating a larger problem than that which the circular economy is attempting to solve.

Skills required include: specialist skills in ESG; an understanding within technical disciplines as it is typically the geologists and engineers who deliver on the sustainable outcomes; engineering skill to design a sustainable operation; financial experts inclusive of inhouse finance teams, investors and insurers that focus on the impact and action being taken regarding ESG; policy setters and regulators that have an understanding of the above skillsets and requirements.

BB: Our research to date shows the skills needed can be split into technical green skills and wider, generic skills to make the transition. In terms of the technical green skills, these include, but are not limited to, carbon accounting, carbon emission minimisation, environmental impact assessment, and product/process design skills. In terms of the generic skills, this will include leadership skills to make the cultural changes required to become net-zero, but also management skills to implement the adoption of new green technologies in businesses that can genuinely make a difference.

JY: For the specialist engineering construction sector, the good news is that many workers in the UK supply chain already possess the core competencies needed and there is scope for adaptation and accelerated reskilling. The move towards net-zero requires contextualisation of existing skills for carbon capture, utilisation and storage (CCUS), hydrogen and biomass, carbon accounting, policy and finance, collaborative working and construction. So, the challenge our sector faces is about the anticipated increase in demand for skilled workers, but not necessarily new skills.

MD/AB: PhD students need to have the research project-based depth, coupled with broader perspectives and advocacy skills. We also instil a culture of entrepreneurship in our students to encourage the translation of disruptive research into commercial technical solutions. Exposure to entrepreneurial academics and to small, high-growth, high-tech companies, as well as global multinationals, is important to catalyse innovation.

PDL: In our recent *UK Offshore Energy Workforce Transferability* review, we highlight that the offshore energy workforce mix will change significantly in the next 10 years, with roles in decarbonised energies projected to increase from 20 to 65%. The review also indicates that around 200,000 people are likely to be required in 2030 to support activities including offshore wind, hydrogen, CCUS, and oil and gas. This compares to around 160,000 people directly and indirectly employed in the UK offshore energy sector in 2021.

Around 80% of the jobs in 2030 are envisaged to be in nine key job families – operations, technicians, engineering, projects, commercial/business development/marketing, procurement/supply chain management, finance, HR, and health, safety, sustainability and environment (HSSE).

Is progress being made to develop these skills?

RSG/SDG: Of course, we are training our sectors to be fit for their current role and as it adapts so we prepare them, but we need to plan for five years from now and start that training programme.

SA: The UK Government put skills at the centre of its recent Queen's Speech, and a core part of its levelling-up agenda. We are also expecting the findings from the Green Jobs Taskforce at the time of writing. It's important these things are put together. Government should set out a framework for skills it thinks will be required in the green economy, both the quantity of certain roles, and where they will be. This should then inform government policy for boosting skills, particularly in areas of strategic priority or where there is a particular dearth.

SG: Yes, progress is being made, however it could be faster. The massive increase in focus on ESG is leading to workforces changing in their skill make-up and further training beginning to happen. This training needs to take place beyond the operators, however, with those responsible for investing, insuring and regulating also requiring understanding. This will allow those outside of the operating environment to ask the right questions that will truly hold operators to account. With regards to the next generation, many mining-focused university degrees have been abandoned in recent years in the UK. We are beginning to see a change in this, with a big rethink regarding what role geosciences truly play in society, such as that led by the Geological Society.

BB: Progress to date has been slow, partly because government needs to identify the green skills needed. If our prediction is true, in the manufacturing sector alone, we would need to support the upskilling of 2.7 million people working in our industry. The UK Government's 10-point plan was welcome and, to date, the government has set up the Green Jobs Taskforce to support the transition to a high-skill, low-carbon economy by developing a action plan – details of this have yet to be shared, but industry stands ready to support where we can. In addition, the Institute for Apprenticeship and Technical Education Green Advisory Panel will shape and steer apprenticeship standards going forward. This is a welcome move to ensure we have the skills we need in the future embedded in our apprenticeship standards.

JY: Yes, the ECITB has initiated some programmes targeting the existing workforce and new entrants. In September, we will launch a new two-year ECITB Energy Transfer Technician Scholarship to help equip the next generation of engineers. Employers are looking at how to upskill their existing employees.

PDL: The UK oil and gas workforce are very well placed to take advantage of the new opportunities in the offshore renewables sector. Over 90% of the UK's oil and gas workforce have medium to high skills transferability and the majority are well positioned to work in adjacent offshore energy sectors. Particularly soft skills and other non-technical skills are generally highly transferable. New induction programmes and targeted upskilling programmes are being developed and many companies are already evolving to support the wider market. The expectation is that the future workforce will be more energy agnostic and will be able to support a more diverse range of energy-related activities.

What are the main challenges to upskilling?

RSG/SDG: A big challenge is the battle between competitive routes and technologies to net-zero which means that investments are widespread and potentially small-scale in adoption. Of course, this is all a part of the revolution that is under way as we rethink and attempt to solve the big questions in a short time.

SA: There are several:

- We do not have a framework that clarifies what skills and jobs we will need in the future, or defines what government sees as 'green work'.
- The public lack understanding. There is also concern that green jobs are a short-term political gimmick and is therefore a risky move.
- There is a strong political focus on reskilling, which cannot come at the expense of helping those with transferable skills, or pitching green courses and skills to those still in education.
- Local authorities lack the resource to develop green economic opportunities and match them with local skills supply. We need institutions that will mediate the transition between skills providers, businesses and government.
- There is not currently a strong incentive for the private sector to develop green skills. While we have strong targets, they are not accompanied by clear strategies and short-term sectoral targets. Without these, businesses do not have the confidence to change business models or develop new green roles.

SG:

- University degrees are either not including these skills or being shut down.
- Employers being willing to pay for training in times that will be tight economically and regarding free time available for learning.
- Confusing messages – there are currently hundreds of standards/guidelines/principles, etc. that could be adhered to – how do you choose which is the one(s) for you?
- The need to pull together skills from across disciplines.

BB: The biggest barrier lies in adapting existing education and training provision to meet this need. Make UK research shows that many manufacturers are keen to embrace digital skills and a more digital way of learning, through modular and flexible learning. But our current training routes are not designed to deliver this. We need to proactively create a system of lifelong learning which has agility and flexibility built into it to embrace current and future challenges.

JY: Currently, the pipeline and geographic spread of projects is still uncertain due to pending government funding, regulation and timeline announcements. Employers, particularly those further down the supply chain will want further certainty of orders before investing in upskilling. Large ECI decarbonisation projects are still at front-end design stage so further detail on specific skills gaps will emerge during detailed design and construction. There is a further challenge to establish sufficient post-16 training capacity to deliver the necessary skills at the scale, pace and location required. This will need to service demand from new entrants as well as demand from the existing workforce.

MD: Funding for doctoral students – we have always been hugely oversubscribed in what is an attractive and societally important area for research and training. We are not short of training or research capacity. We are short of PhD scholarships to fund as many of the best students around the globe as we would like.

PDL: There will be a need to maintain existing oil and gas activities, while developing the new low-carbon future in parallel. This will require a careful balancing act and the need to find the 'goldilocks zone', whereby public and private sector pull all the correct levers to get the transition 'just right'. It is key that UK and devolved governments work together to ensure the managed transition of skills and experience in a way that protects and sustains key UK energy jobs.

What further training and qualifications need to be developed?

SA: The required framework from the UK Government can inform education institutions that want to introduce new courses. This could be modelled on the Gatsby benchmarks used by the Careers & Enterprise Company. Government should work with universities to brand courses in the green economy, making sure they are advertised in colleges and schools to attract graduates before they make decisions to pursue other careers.

SG: More integrated courses that bring together different disciplines. By this I mean social scientists working with engineering and geology departments to equip graduates with what they need in the wider world. Easy-to-access ESG training that is practical and provides the learner with the tools and confidence to implement what is needed in their workplace.

JY: We will need localised site construction skills in the geography of industrial clusters once locations are known. Technicians will require more multidiscipline training. This could be delivered through bite-size, modular training, which can be delivered at the point of need for skills areas such as leadership, policy, finance, and 'green' technology for existing professionals.

How can government, industry and academia work together?

RSG/SDG: Success will only be achieved through cross-sector collaboration. This is not easy and not a matter of just making connections. But it ultimately comes down to the simple question – do we want to develop an economy that limits the impact and effects of human activity on the natural environment? If so, we need to have a well-defined plan on how this can be achieved.

SA: They can:

- Increase knowledge for people and training providers.
- Provide strategic funding to universities to launch graduate-level courses and grants to individuals.
- Increase security for retrainers through maintenance loans and expand eligibility of Job Centre courses to cover green skills.
- Better match skill demand and supply, through Local Enterprise Partnership (LEP) or a new institution-led convening on local labour markets.
- Support local authorities to recognise potential environmental economic projects. The Green Jobs Taskforce should also work with local authorities to deliver skills strategies that reflect dynamic local environments.

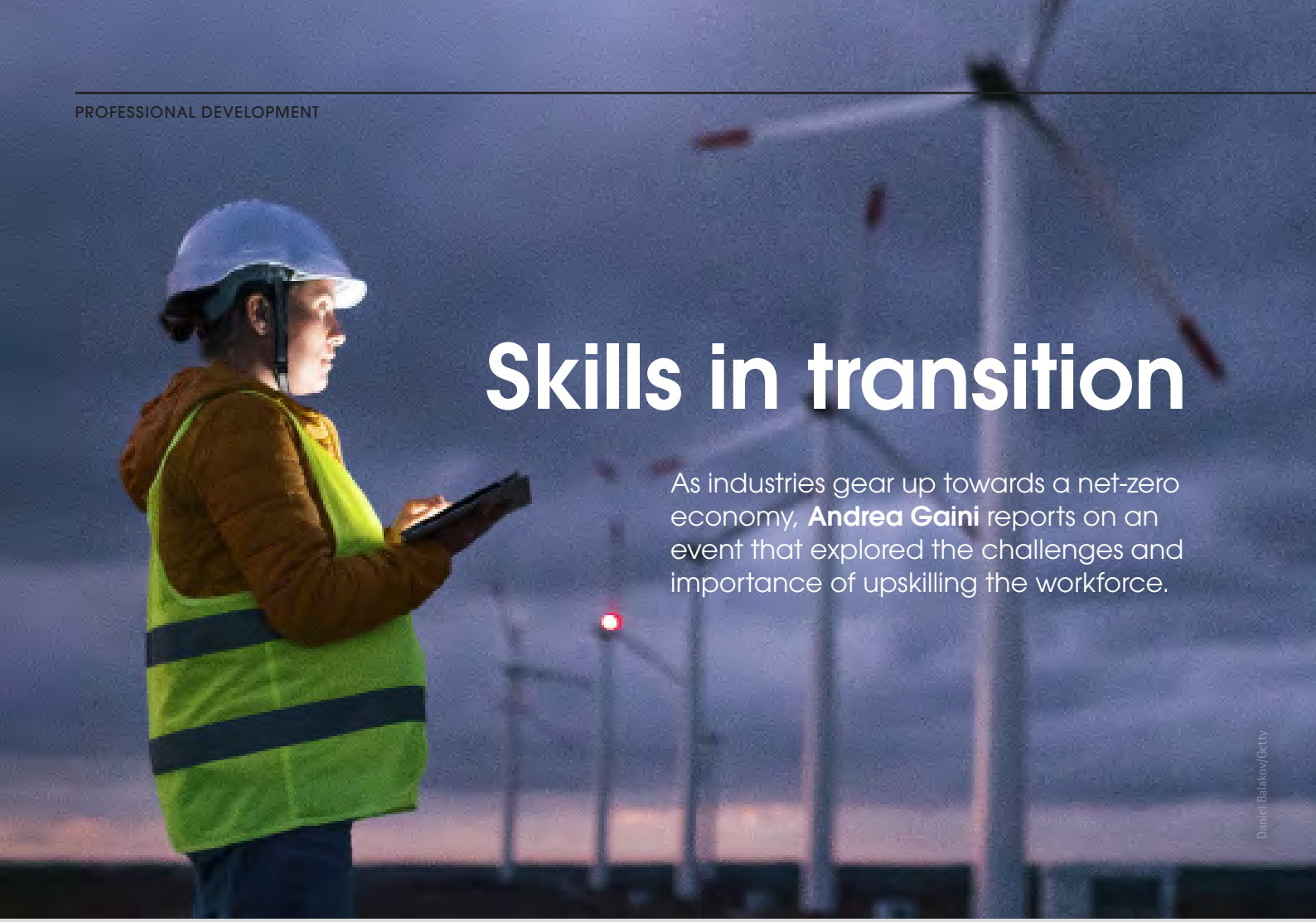
SG: Start with what good looks like and then work out who holds on to what lever to make it happen. No one stakeholder can make this happen. Investors need to invest in and reward the responsible operators, penalising those who do not take ESG seriously by not investing in them. In turn, the members those investors represent will hold the investors themselves accountable for this. Governments can support by leveraging existing laws and streamline permitting and other regulations so that the responsible mining opportunities are encouraged rather than bogged down in red tape. Academia should focus on the research that will have true impact in improving the extraction and processing of raw materials. When funding and carrying out research, this question of impact needs to be constantly revisited.

BB: The UK Government's new Local Skills Improvement Plans are key to getting this right. While these will be designed to tackle local skills mismatches, as well as ensure skills training is locally-driven, and can be tailored to the challenges and opportunities in specific areas – manufacturers will want to ensure this works with other areas of policy too, driven by data aligning to the skills needs of regional economies. Make UK has called for the establishment of a National Skills Taskforce, with a remit that includes the development of a skills programme to tackle these skills shortages. In addition, we are calling for a Green Skills Tax credit, which can support manufacturers who begin to invest in green skills.

JY: Coordination between government, industry and skills bodies, such as the ECITB, will be essential to build a geographically-nuanced picture of the skills demand and timing to deliver the commitments of the government's 10-point plan. The ECITB is represented on the Green Jobs Taskforce. We will also be working with the Industrial Decarbonisation Research & Innovation Centre in support of their skills knowledge-sharing activity across the industrial clusters. We are also supporting the new Green Apprenticeships Advisory Panel to consider how apprenticeship standards can reflect the requirements of net-zero in a coherent and timely manner.

MD/AB: I believe we still need better long-term models to leverage core public funding to unlock private co-funding in the area for PhD training. Industry's main contribution at undergraduate level is taking placement students. This is a great way for them to gain relevant experience as part of their programme.

PDL: The higher education sector will have a key role to play in upskilling and reskilling the offshore energy workforce and it is encouraging to see that universities, colleges and commercial training providers across the UK are developing programmes to support the energy transition, ranging from new technical courses to energy policy and energy system integration. Common standards, accreditations and career pathways need to be developed to ensure a more flexible and agile offshore workforce.



Skills in transition

As industries gear up towards a net-zero economy, **Andrea Gaini** reports on an event that explored the challenges and importance of upskilling the workforce.

Daniel Balakov/Getty

"Upskilling is an enormous job to do in a very short period of time. [But] if we get this right, that leads to tremendous economic growth and [the] delivery of two million green jobs by 2030," asserted David Symons, Future Ready Global Leader and UK Director at Williams Sales Partnership (WSP), and Chair of a Westminster Forum event on green skills development and job creation in the UK.

"At the risk of vastly oversimplifying [the issue, a green recovery] is [also] a good strategy," added Eliot Whittington, Director of the Centre for Policy and Industrial Transformation at Corporate Leaders Group, UK.

"Something we looked at [in the] last year, was comparing the value of different kinds of economic recovery efforts in response to the COVID-19 pandemic and the economic impact. And it's very clear, if you put up a fairly standard economic stimulus package designed to restore demand…and you compare that with spending the same amount of money…on a green recovery package – supporting home energy efficiency, accelerating the deployment of electric vehicles, rolling out tree planting, and other forms of green infrastructure – it gives you better, or as good, result, in terms of GDP.

"It also gives you much better results in…overall employment in terms of jobs created, and it delivers, of course, on the kind of green outcomes that we're looking at, it means that you'd have lower carbon emissions, and often cleaner air, cleaner water and a higher level of prosperity."

Commenting on the debate, Nick Molho, Executive Director at Aldersgate Group, UK, (a cross-economy organisation whose focus is on developing policy solutions to tackle some of today's biggest environmental challenges) while referencing the 2008 global financial crisis, said the economic evidence shows that those governments who pursued an environmentally-sustainable, investment-led recovery strategy were the most effective at getting their respective economies back into shape, stimulating growth and job creation.

He explained, "[Environmentally-focus recovery strategies also tend to be activities that are more productive in the long run, which is exactly what you want, as you recover from a crisis. The Oxford Smith School published a report last year showing, for example, that for every $1 that you invest in a renewable energy project, you create twice the number of jobs in the near-term, relative to what would happen if you invested in a fossil fuel project."

Signals to the market

One important aspect of developing green skills is using policy to encourage companies to invest more in training and that focuses on such skills.

"The more we learn about this transition, the more we learn [that a] green strategy…is not a silver bullet. Is it all about nuclear? Or is it all about carbon capture and storage? Is it about renewables? Well, actually, all of those are useful, [but], increasingly, we're understanding that what we're looking [for] is

systemic change," Whittington reflected.

He noted that, while designing policy approaches, the role of infrastructure and innovation will be essential in shifting the overall system and that "these transitions can gather momentum. When people used to think about climate action and green... economic strategies, they often thought about it in terms of costs...like [on] a shopping list [where] you buy the cheapest things first, and you kind of work your way up to this.

"Whereas increasingly, what we've understood, is that there is the potential for these transitions...to accelerate. And... it's about inventing and deploying new ways of getting that systemic shift," he said.

Molho added, "When we look at the recent failure of the Green Homes Grant...The problem was that we had a supply chain that was just not adequately skilled. And that, in itself, is a result of a lack of long-term policy drivers for many years now, which hasn't incentivised businesses and the supply chain to invest in skills both in energy efficiency, but also in low-carbon heat provision.

"We need clear public policy signals to...attract private investment at the necessary scale or the necessary pace and at the lowest cost of finance possible."

Strategy and Policy Director at the Construction Industry Training Board (CITB), UK, Steve Radley, echoed this view. He noted that "[the construction] industry...is dominated by small firms that actually face a lot of barriers to training".

He argued that collaborative action will be key given the clear signals that will make the training market "get itself in place to make sure that standards and qualifications react as required.

"And I think one of the things that we feel we can make a big difference on, is actually working at that local level with local authorities and housing associations to come up with specific plans for particular areas."

Radley mentioned that a notable first port of call in construction is investment to train retrofit coordinators, who have "that overview of the actions that we need to take in the 27 million homes and two million buildings that we need to retrofit".

Training and re-training

Both Radley and Molho agreed that the balance between training the new workforce and re-training the current one will be crucial towards a net-zero future.

"Our research showed [that] by 2028 we would need around 350,000 new construction workers...to deliver net-zero, some of the key areas being project managers, building envelope specialists and plumbers," Radley explained.

"Just looking at the scale of the challenge for an industry that struggles to attract all the people that it needs, a lot of the focus initially has got to be about retraining and upskilling.

"[This] creates a big opportunity to change the image of the industry and bring more people in over the medium-term but we need to be taking action now."

"I think the important thing here is [also] making sure that employers and employees are supported and able to take time out to take the right kind of reskilling courses, to allow them to adjust to the changing nature of their jobs, or to allow them to transition into different sectors."

To this end, Molho added, "I think the important thing here is [also] making sure that employers and employees are supported and able to take time out to take the right kind of reskilling courses, to allow them to adjust to the changing nature of their jobs, or to allow them to transition into different sectors."

He discussed how the Green Jobs Task Force, of which he is a member, aims to ensure that the future workforce currently in education are equipped with the right skills to work in a low-carbon economy.

"I think that that's going to require a fairly important rethink of the overall curriculum, of the way in which teachers are trained, and the way in which education institutions are assessed," he said.

"There's a big job to be done in terms of green careers promotion and promoting diversity within those careers and those topics. And Further Education institutions are going to need to be supported...to offer a more flexible array of courses that meets the need of that part of the workforce."

A wider talent pool

Rhian Kelly, UK Director of Corporate Affairs at National Grid warned, "Given the sheer number of jobs coming down the line, if we don't fill all these roles, we're going to miss our net-zero targets.

"But we're going to have to fill those roles by attracting people into the...sector, people who perhaps haven't in the past considered a role within [our] sectors. And this is going to mean attracting a more diverse talent, from a more diverse talent pool from across the UK, especially women, those from ethnic minority groups and lower socio-economic backgrounds."

Kelly urged, "I strongly think there's a role for business here. We can play a really important part in ensuring that students from disadvantaged backgrounds are presented with opportunities and skills they need for a career in STEM, should they wish to."

A role model is born

As a trans woman, **Dr Clara Barker** did not have a role model that she could relate to growing up. Years later, as a materials scientist at Oxford University, UK, she hopes to inspire others. To mark Pride month in June, **Andrea Gaini** chats with her about being an LGBTQ+ person in STEM.

Philippa James Photography

In 1988, Margaret Thatcher's Government introduced Section 28, a law that prohibited the "teaching…of the acceptability of homosexuality as a pretended family relationship" by local authorities. Clara Barker, a materials scientist at the University of Oxford, UK, was in school when the law was passed and remembers feeling like the "odd one out" and having to hide her identity as a transgender person.

She explains how in the 80s and 90s, "when I was growing up… there were four TV channels and no Internet. So, we didn't have the information, the knowledge, or the awareness of LGBTQ+ lives".

Clara recalls how the UK was starting to wake up to LGBTQ+ issues at that time, "however, the backlash to that meant that…Section 28… was introduced. So now, teachers weren't allowed to talk openly. If they were LGBT, they had to hide it, public figures had to hide it. You certainly didn't have anyone coming into school and saying I'm an LGBT actor or scientist".

She explains how the lack of visibility, openness and information translated to lack of support.

"So, you just felt you had to keep it to yourself. You felt that, because you didn't see any trans people in school, on TV and in the press, well you've got to assume that you're the odd one out.

"This is a big reason why it's so important that we are more open, and that we do see more role models, because it turns out, I wasn't the only trans kid. I probably wasn't the only trans kid in the school. I certainly wasn't the only LGBT kid in the school," she says.

Clara is now the Manager for the Centre for Applied Superconductivity in the Materials Department at the University of Oxford, where she seeks to inspire other LGBTQ+ people who are interested in a career in STEM.

When did you first become interested in STEM and how did you come to materials science?

I fell into science in school. I was always good at [it] and I always enjoyed it. But actually, I had a lot of trouble in school with my mental health. So, I didn't actually finish my A-Levels. I left school before I'd finished and I spent a few years doing different jobs.

And then I wanted to try and get onto a degree. So, I was trying to figure out what I wanted to do. I actually did a foundation course and then degree in Electrical Engineering [at Manchester Metropolitan University, UK]. I started out the engineering route. During my undergrad, I did a year placement in industry with a company that made vacuum deposition equipment, I went on to work there after my degree as a Development Engineer. But I really got into the process engineering side of it and a large part of that job became materials engineering.

Later, someone asked if I was interested in a PhD and I applied for it. I got offered this Materials Science PhD, making thin films using high-power impulse magnetron sputtering (HiPIMS), and [specifically], it was making transparent conductive oxides. I was working on aluminium-doped zinc oxide to try and make electronic transparent circuits basically. I was particularly interested in making them on thin, flexible, plastic substrates rather than solid substrates. And I was hooked then. The opportunity came up and I just evolved with it.

What did you do after your PhD?

During my PhD, I had got the opportunity to work with a group in Finland for a month. I was still working on transparent conductive oxides, but I was using a different technique to make them – atomic layer deposition. That was really interesting, because it gave me a contrast in two different ways of producing the same type of films, seeing what the differences are in the characteristics. I went back while writing my thesis to work as a visiting researcher.

I was then offered a postdoctoral position in Switzerland. I was making HiPIMS films there as well. I was mostly making hardness coatings there, so, titanium nitride, titanium silicon nitride and silicon carbide, things like that.

How did the role at Oxford University come about?

My PhD was a joint project, which was split with the University of Liverpool, Manchester Metropolitan University and Oxford University, so I knew a group leader there.

But the truth of the matter is that towards the end of my postdoctoral positions, I had severe depression because I knew I was transgender, but I hadn't transitioned.

And so, I sort of thought that I had to make a choice between science and transitioning, because I hadn't seen or met any trans scientists. In 13 years, I met two LGBTQ+ scientists, and no trans scientists.

I honestly thought I had to choose myself and my health and my happiness, over science.

So, I was actually ready to quit. I was looking at alternative career paths and I heard about this job at Oxford. To be honest, I only came to Oxford, to see what it was going to be like interviewing in STEM once I had transitioned. Seven years later, I'm still here. So that's something.

Could you share your experience of transitioning?

Admittedly, transitioning is a long process. It doesn't really end and there's still aspects of that now.

I started transitioning in Switzerland, but I was doing so in secret, which is not the healthiest thing to do. I was speaking to specialist counsellors out there for a long time. And then I actually ended up being prescribed hormones and started medically transitioning while I was there. But I wasn't out at work. I didn't tell anyone because I knew my contract was coming to an end and it just seemed easier to keep it to myself.

And so, it was very much that I was transitioning socially, telling my friends and family, but I wasn't doing so in work. As soon as I finished that job, I went full-time transitioning, and started changing my name.

In your career, you are putting yourself out there as a role model that you would have wanted to see when you were in school. Why do you think this is important?

It impacted me a couple of different times in my life. When I was young, you just didn't hear, [and] we didn't even have, the word transgender. You certainly didn't see any trans people around you at all, full stop.

I had no one I could connect to, I had no one that made me feel, "this isn't just me. There's somebody else like that". So that made me feel like I was the odd one out and made me feel like I was weird.

And then in science, I'd worked in STEM for 13/14 years and I met two out LGBTQ+ people, no trans people.

So even if by this point, we've got the Internet and more than four TV channels, and I'd started to see trans people on TV, but you still didn't see any trans scientists. It doesn't mean that they weren't there. It doesn't mean that there weren't people who had transitioned. But there was less openness, less visibility.

And so, again, it made me think that, "okay, well, now society says I can transition but not in science, I need a different career". And so, who you see around you really impacts your sense of belonging.

I wasn't sure what the reaction was going to be from colleagues. And because I didn't see any LGBT people, I thought it was going to be negative, I thought it was going to be bad. And, actually, most people were more accepting than I expected. People didn't really care. Most people that I'd worked with previously, they just cared about my science.

But I didn't have anything to gauge that, because I had no way of seeing them interact with other trans scientists.

I did face some discrimination from some people that I used to work with, but the vast majority were really accepting and just didn't really care.

In 2018, you gave a TED talk about why we need to build trust to create diversity in institutions. What is trust in that context and how do we build it?

"I sort of thought that I had to make a choice between science and transitioning because I hadn't seen or met any trans scientists. In 13 years, I met two LGBTQ+ scientists, and no trans scientists."

I think for me, it plays in two different ways. And I will say, since 2018, when I gave that talk, some of my views have evolved a little bit, because hopefully we will always be evolving and learning.

For me, on trust, there's a couple of different things. One is that, with science, we have this idea that "we don't care who you are, just do the science". And we talk as if there are no barriers. But actually, we're starting to see reports that show that if you're a woman, [or] if you're black in science [for example], there are additional barriers that you're facing.

And so being open about those barriers is important. If there's a wall of silence, or if you're specifically saying that those barriers don't exist, then people like me who have seen those barriers don't trust you. This is why reports that are coming out, they're so important, because they're honest, they're saying these are the issues we're facing. That goes a long way into being able to trust these institutions – that they're not hiding anything, they're being open.

Also another thing is that we keep on saying is, "well, just be yourself". But if you are yourself, there will be people who very openly will oppose you. They are openly homophobic, transphobic, racist and some fields are worse than others. So, we're telling people to be themselves, but other people feel that they're able to say and do what they want. And so, in order for me to be able to trust, I've got to feel safe, I've got to feel your honesty, as a trans person.

In the UK, right now, if you're speaking out about being trans, you feel like you've got a target on your back. It is risky, and I don't recommend it for everyone. And so, if institutions and societies say, "be yourself", well, we need to trust that you've got our back, that you will hold people accountable for their words and actions, and that we can be ourselves.

The Mars Desert Research Centre in Utah, USA

Irinak/Shutterstock

Reaching new heights

Materials scientist *Marta Ferran-Marqués*, of Cranfield University, UK, is one of the all-female crew members set to visit the Mars Desert Research Station in Utah, USA. She chats to *Andrea Gaini* about venturing into space exploration, inspiring young women and her dream of becoming an astronaut.

When the all-female crew visit to the Mars Desert Research Station (MDRS) in Utah, USA, was first announced in June 2020, one of the aims was to fill "the data gap on women's performance in space exploration".

Marta Ferran-Marqués, a PhD student in manufacturing luminescent coatings for ultra-high temperature measurements at Cranfield University, UK, is one of the women involved in the mission.

She says, "The numbers of women are still very low. There was a European Space Agency (ESA) astronaut application [in 2021], and out of 22,600 applicants, I believe only 5,400 were women. So, with our project we're sharing our experience and our enthusiasm, hoping to encourage more girls to become space scientists."

Six female engineers, geologists and scientists, all under 30, are set to enter the simulation centre later this year for a two-week mission living in Mars-like conditions. This includes wearing astronaut spacesuits when they venture outside for extra-vehicular activity, dealing with delays in messaging transmission and following a strict diet as they would in space.

The desert area in Utah mimics the Martian landscape, and the station itself is said to be similar to one that could be built on Mars (see box-out on page 23).

During their time at the research station, Marta and the rest of the crew will be carrying out tests and trials on equipment. One of Marta's projects, developed with Cranfield University, is to test smart electrochromic windows programmed to switch on when there is sufficient light to collect energy and then turn off to save energy.

"For this project, we're going to be bringing three types of electrochromic windows – one which will be constantly on, another which is turned on during daylight, and finally, a smart electrochromic window that will detect when there's enough sunlight and turn on by itself."

A nano-start

Marta's professional trajectory towards space science started in Spain, where she was raised in Reus, a couple of hours' drive from Barcelona.

She studied at a Technological High School in Spain specialising in Biology, Maths, Physics, but by the end of her studies she was set on going into architecture.

"My mum was not really happy about that because when I finished High School, Spain was going through an economic crisis and my mum thought I would study for five years and then not be able to find a job," she explains.

But things took a different turn when Marta visited a nanotechnology exhibition in Reus, organised by the La Caixa foundation. She recollects falling in love with "all the little robots" and feeling inspired to pursue this route.

"I thought, wow, that's very interesting. [And] then, I found out that Barcelona was the only university in Europe, at the time, hosting a Bachelor's degree in Nanotechnology. And that's something that really sparked my interest because I'm a very ambitious person. I thought, I'm going to be one of the first people studying nanotechnology."

From there, the seeds were planted for an interest in using nanotechnology for space exploration, which led her to apply for a Master's degree in Aerospace Materials at Cranfield University. "After I finished [my] Master's, I was offered an industrial PhD at Cranfield University and working as a Materials Engineer for Sensor Coatings Systems (SCS)."

SCS in Dagenham East, UK, is developing a coating to determine the maximum temperature a gas turbine engine is operating at. The material is developed so that once exposed to increasingly higher temperatures, its structure and luminescence will gradually change after returning to room temperature.

If applied as a coating over a component surface, then differences in the regions based on exposure to temperatures can be noticed, meaning the material structure, and phosphorescent lifetime decay, will then locally and non-reversibly change. These changes in the detected lifetime decay can therefore be linked to the temperature experienced by the material.

The phosphorescent pigments – which enable the temperature memory effect – are made of oxide ceramics manufactured with a very low concentration of phosphorescent ions, which provide the luminescence.

The Mars Society/MDRS

> *"In my spare time, I tutor kids and I have one girl that is six years old who wants to learn Chemistry as she's not yet doing much Chemistry...So, we started these online sessions where we do science experiments with whatever you can find in the kitchen. And she really inspired me because she's improving a lot. And I decided to start a TikTok account with all the science videos that I do."*

Shooting for the stars

During her time at Cranfield University, Marta's interest in becoming an astronaut kept growing as she explored more about the materials applications. Until one day, an opportunity came up to train as an astronaut.

Marta explains that through LinkedIn she discovered a programme to train astronauts that could one day be hired to work for private companies in the space industry. She says, "At the moment you can only become an astronaut through a government programme, but this could change in the future and so this company, Advancing X, wanted to train astronauts."

While taking part in the online competition, where applicants had to post a video explaining why they wanted to become astronauts, Marta's contribution went viral – reaching around 500,000 views on LinkedIn. Although she didn't continue with the application, she was contacted by Laurène Delsupexhe, a Consultant Engineer who helped create the WoMars project, an initiative that seeks to coordinate all-female astronaut analogue missions, conduct scientific research, and provide women with hands-on experience in space analogues and extreme environments.

Delsupexhe spoke to Marta about the possibility of forming a group of six women to go to the MDRS in the deserts of Utah.

Soon after, the WoMars crew came together with Marta onboard. This was a team of aspiring space explorers dedicated to achieving inclusive Lunar and Martian settlements. The scope of the group, however, has now extended beyond the initial MDRS expedition.

Marta explains, "Right now, we've turned WoMars into an association. So that it's not only going to be going into different missions, like the one at MDRS, but also into schools to encourage young girls and say, 'Hey, you also can be an engineer!'"

Marta has also started a TikTok account to promote science

Bringing Mars within reach

The Mars Desert Research Station (MDRS) is a space analogue facility in Utah, USA, owned by the Mars Society, which supports Earth-based research in pursuit of the technology, operations and science required for human space exploration.

Mars analogues are, in fact, locations on Earth where some environmental conditions, geological features, biological attributes, or combinations thereof may have similarities to those thought to be encountered on Mars, either at present or earlier in that planet's history. Studying such sites aims to uncover new insights into the nature and evolution of Mars, the Earth and life.

In these Mars-like environments, field exploration operations are conducted in the same style and under many of the constraints as they would appear on the Red Planet.

This offers the opportunity to carry out field research in a variety of key scientific and engineering disciplines that will help prepare humans for exploration of the planet. Such research is vital, for example, to subject a spacesuit prototype to two months of real field work. Similarly, psychological studies of human factors, including isolation and habitat architecture, are also only useful if the crew being studied is attempting to do real work.

The MDRS was first constructed in 2001 as part of the Mars Analog Research Station (MARS) programme and its campus comprises six structures that can house seven crew members at one time.

The main habitat – also known as Hab – is a two-storey, 8m in diameter cylindrical building. A lower deck houses the extra-vehicular activity prep room with the spacesuit simulators, an exterior airlock, a shower room, toilet room and a rear airlock leading to tunnels, which access other structures. While the upper deck forms the living quarters.

There are two observatories on the campus. The Robotic Observatory is home to the 35.5cm Celestron Schmidt-Cassegrain telescope on a CGE pro equatorial mount. Attached is a 10cm refractor, which is used as a guide scope, and they both deploy a wide array of cameras for astronomical imaging. The telescope is housed in a 19cm automated dome that can be controlled onsite or from the habitat module. The Musk Observatory, formerly the only observatory on campus, has meanwhile been converted into a solar observatory for use by crews.

The research station hosts an eight-month field season for professional scientists and engineers as well as college students of all levels, in training for human operations specifically on Mars. The relative isolation of the facility allows for rigorous field studies as well as human factors research.

Most crews carry out their mission under the constraints of a simulated Mars mission. Most missions are two to three weeks in duration, although the site has supported longer missions as well.

The campus is surrounded by a landscape that is a geologic Mars analogue.

Source: Mars Desert Research Station

with the younger audience. She says, "In my spare time, I tutor kids and I have one girl that is six years old who wants to learn Chemistry as she's not yet doing much Chemistry at school.

"She just got a book about Chemistry and the parents said, 'We can't explain this to her.' So, we started these online sessions where we do science experiments with whatever you can find in the kitchen. And she really inspired me because she's improving a lot. And I decided to start a TikTok account with all the science videos that I do."

On a mission

For Marta, the importance of WoMars lies in setting an example for young women.

"I think when you're a little girl, you do not see a lot of women go to school to study Engineering or become pilots.

"For me, my brother was my inspiration there. He did Engineering, and I always wanted to follow his path. But I think this is a problem that we don't see a lot of women when we are young, doing things like that…I think the only way to solve this is to encourage more people to do it."

Marta talks about walking into a space congress and looking around to see a room filled with men, often more experienced, and the almost instant feeling of imposter syndrome. "And because of that, then you feel a bit shy when you go to congresses, thinking that everyone thinks the same way, and you don't have lots of support, because there are almost no women there.

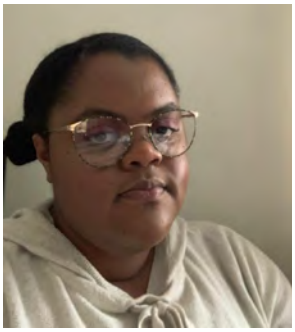
"But now I think the best way to deal with these situations is to just continue going to congresses, and continue talking to people, because there will be people that are going to help you."

The mission to the MDRS was temporarily paused due to the COVID-19 pandemic, but is set to take place in 2022. In the meantime, the WoMars team has been busy visiting schools and talking to young women as well as training in survival skills.

Cultivating a change

Andrea Gaini speaks to three diversity and inclusion advocates about how the STEM community can do better to welcome all under-represented minorities and tackle experiences of Imposter Syndrome relating to lack of diversity in the workplace.

Natalie Cheung, Civil Engineer and TED-Ed Speaker (NC)



Karel Green, Astrophysics PhD Student and Founder of POC² (KG)

Shaun Woodman, Materials Scientist (SW)

What has been your experience of Imposter Syndrome relating to diversity since you started studying and working in STEM?

NC: Early in my career, I joined women's networks and events from different organisations and found Imposter Syndrome was a hot topic. While there were many experiences discussed that I could find relatable, the expectation that almost all women experience Imposter Syndrome was overwhelming. I would recommend the recent *Harvard Business Review* article *Stop Telling Women They Have Imposter Syndrome*.

KG: I would say it's been pretty strong throughout my time in STEM. The first thing that always comes to mind is how I have consistently been the only black woman in all of my work, and this has been consistently true even from my GCSEs (when everyone else opted out of doing triple science except for me). Even during my undergraduate and Master's, there were significant numbers of white women and South Asian students, but never any other black people.

SW: How many times have I looked around the room and asked myself, "Why does no one here look like me? Am I good enough to be here? Am I just filling a quota?" The answer is too many times. I have often sat in board rooms feeling isolated and under-represented. These internal battles influence your output significantly because your confidence is shattered, and your success is never truly celebrated. I've even stopped myself from applying for certain roles or scholarships because I felt that I wasn't the right candidate for the role.

How do you think the under-representation of certain communities in STEM impacts Imposter Syndrome?

NC: It's easy to feel like you don't belong somewhere if you are one of the 'only' in a working environment. This all feeds into the Imposter Syndrome someone might feel.

KG: It for sure makes it worse. Practically, it impacts the most the higher you go in the academic career ladder, making the idea of jobs like lecturing or applying for research grants almost unbearable knowing you're going to have to assimilate into the cis-het-white* group that will no doubt have all the money and resources.

SW: Diversity must be a cornerstone for every organisation because representation allows individuals of different communities to feel that they belong and that they are valued. Isolation of individuals will often lead to feelings of anxiety when dealing with groups that are more represented in the community. Although it may be internal, it feels as if our voices are not heard, or worse, not respected. In my own experience, under-representation has been a common thread when dealing with mid-to-senior level managers. I have little or no reference point to any person or group which makes me question my own position as a leader.

What sort of behaviours or environments do you think can trigger these feelings?

NC: Although there are many ways we can boost our own confidence to overcome Imposter Syndrome, someone doesn't just feel like an imposter – they are made to feel like imposters. The blame and onus is not on the individual with these feelings. In particular, scenarios where people feel the pressure to perform, are not recognised for their work, or feel like they do not receive the respect they should, can trigger feelings of imposter syndrome.

KG: Again, being the sole black woman in any space sets you apart. Unlike other marginalisations that are not literally surface level, skin colour is not something you can hide and reveal as and when you feel safe, so it leads to a lot of constant anxiety.

SW: As an engineer, I feel that the engineering environment can often trigger feelings of Imposter Syndrome. Intelligence and competition go hand-in-hand in the engineering environment, so it can often trigger feelings of inadequacy or self-doubt in individuals. It may be more triggering for women, people living with disabilities and members of the LGBTQ+ community as the typical demographic is very cis-male orientated. This goes back to the previous point about representation in communities and how lack thereof can impact Imposter Syndrome.

What effect can this have on an individual personally or professionally?

NC: It affects every individual differently, but some effects include overworking to chase perfectionism or prove their worth, not feeling confident to be their authentic self and feeling uncertain when contributing new ideas.

KG: The effect is Imposter Syndrome. So, you feel like you should not be in a space that adds to the anxiety in your mind. Professionally, this also compounds with bias in career progression. We know the shocking statistics on how BAME people (especially women of colour) are chronically under-hired despite having the same level or better qualifications. So, a person thinking they're not good enough and then not being able to progress due to reasons outside of their control feeds into the idea that they can't achieve what they want to because of who they are, when the truth is outside influences are systematically biased.

SW: Imposter Syndrome can be damaging to your personal and professional life. Even though you may continue to function at an acceptable level, your true potential may never be realised because you feel paralysed by feelings accompanied by Imposter Syndrome. In some instances, individuals may feel underservant of their positions, or worse feel like a fraud, even though they truly belong in those positions based on their merits and skills.

"Putting people of colour into the equation"

Karel Green, Founder of POC^2, reveals how the group is working to improve diversity in academia.

"It originated from the fact that myself and a couple of my POC^2 colleagues in undergrad found our representation...sorely lacking, both in terms of people of colour (POC) in the undergraduate physics, staff cohort at postdoc and professorship levels, and in terms of the fact that there were practically no POC individuals mentioned in our curriculum – the vast majority of scientists we learnt about were cisgender* white men.

"In addition to this, we realised that all the scientific experiments and institutions we learnt about were based in the West. The aim of POC^2 is to bolster POC representation in STEM, particularly at PhD level and beyond as this is where people go from paying to attend university to being actually paid to do research".

POC^2 are working towards tackling these issues. "We have developed three programmes...where we will work directly with universities to make changes via practical and systematic solutions," their website reads.

"We're also working towards the goal of having institutions themselves lead this work, not underprivileged Black Minority Ethnic (BME) undergraduates."

"We are working to fundamentally change how staff are hired for paid PhD and academic positions as well as call out and remove the numerous number of unethical practices currently featured in mainstream STEM curriculums. Finally, we highlight the lesser-known stories of BME (especially of women of colour) in STEM via our blog to encourage others to consider applying for PhDs," it concludes.

"[Employers should] talk about how they are actively working against racial bias in hiring and fighting racism in the workplace. Make sure more people of colour are on the panels at networking events. Make sure the hiring room is diverse and actually welcoming."

How can employers, networking events' organisers and institutions create a more welcoming and inclusive environment for all communities?

NC: There isn't one quick fix as it is an ongoing journey involving every single one of us. To start, I think it's important to have buy-in from all levels of the organisation, not just HR and not just senior management and not just those in diversity networks. I would also expect to see recognition of individuals' contributions and sharing praise where it is given.

KG: Talk about how they are actively working against racial bias in hiring and fighting racism in the workplace. Make sure more people of colour (POC) are on the panels at networking events. Make sure the hiring room is diverse and actually welcoming (putting a sole person of colour on a panel is a token gesture if they themselves do not acknowledge there is a systemic problem and are not inclusive in their views).

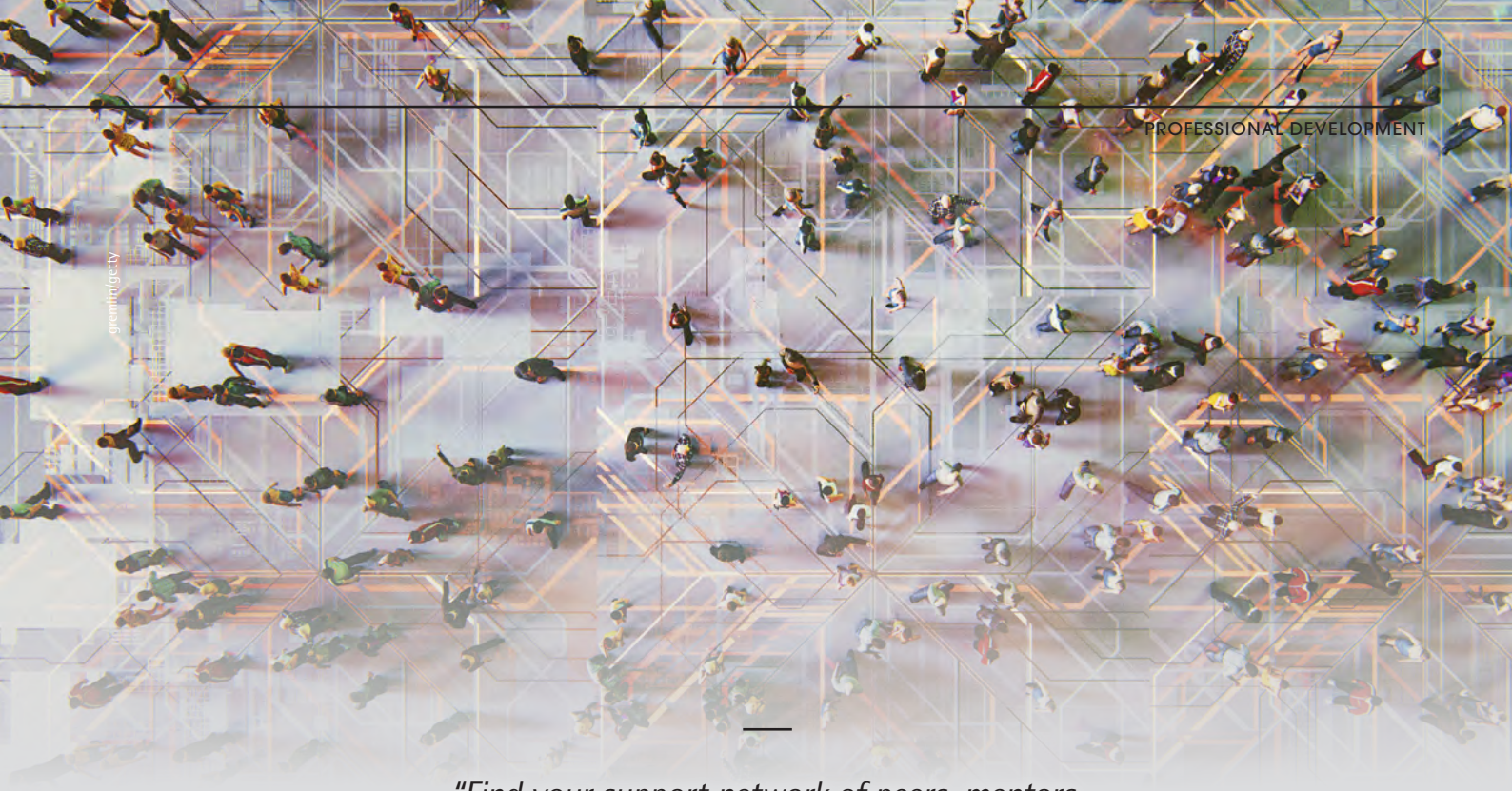
SW: Employers/institutions/organisers need to take a proactive approach to inclusion and representation. Address issues and topics as they arise (e.g. Black Lives Matters, International Transgender Day of Visibility, disability representation, etc.) to show their employees/students/members that they are represented and that their stories matter.

What can the STEM community do to enhance its reach to under-represented communities?

NC: STEM organisations connect with under-represented communities in many ways, possibly as employees, members, consumers, the local community, and more. It is important to include members of the under-represented communities in your work from planning stage and through delivery. With continued work, over time, you can create a space where honest feedback will be shared, allowing your organisation to improve and succeed.

KG: Hire more people of colour to do research, and pay them for taking part in outreach events. Have a more diverse curriculum where the achievements of scientists of colour are prominently featured and also shine a light on the racism and biases of white scientists (more information about this can be found on the media section of the POC^2 website). Have an Equality, Diversity and Inclusion (EDI) team which is properly diverse and gets paid for their work, and support groups specifically for people from ethnic minority backgrounds. At the end of the day, people need money to pay their bills under capitalism so no amount of one-day events or training sessions are going to help if you give yourself a pat on the back after and don't actually commit to paying people so they can survive.

SW: In my personal experience, the STEM community is scattered with individuals from under-represented groups, but we're not connected. We need to create safe platforms and spaces where these scattered individuals can connect to create communities that share research, life experiences and mentor young STEM enthusiasts on their career path.



gremlin/getty

"Find your support network of peers, mentors, sponsors and role models from within your under-represented community or outside it. From conversations with those you admire, you may be surprised to hear they also face the challenges of Imposter Syndrome."

What advice would you give to people from an under-represented background trying to cope with Imposter Syndrome in STEM?

NC: Find your support network of peers, mentors, sponsors and role models from within your under-represented community or outside it. From conversations with those you admire, you may be surprised to hear they also face the challenges of Imposter Syndrome.

KG: I still struggle with it myself and I have not made it particularly far in the field. I coped by making sure to apply to as many PhD positions as possible and picked my choice based on how the environment in the office and department felt. Also, I have a few friends who are doing PhDs as well as me, and being in contact with them even to just chat about the day-to-day stuff over WhatsApp voice notes keeps me going. Lastly, I keep hobbies outside of academia. This reminds me there is a whole world out there and that the one plot that isn't working right now is not the end of it.

SW: You are your ancestor's wildest dreams. Every late night studying, every social gathering missed, every exam sat has prepared you for where you are right now. This is your time to shine, so be fearless and know that you belong here!

What work do you do to tackle these issues?

NC: I have worked to tackle my own Imposter Syndrome, and the best action which has helped take the pressure off has been recognising that I am not alone in my feelings. Tracking progress and successes has helped me value my experience and let go of perfectionism. In the workplace, it has been useful to have honest conversations with employees and managers. I use my experience to deliver workshops to develop the understanding of Imposter Syndrome with universities, STEM membership organisations and corporate employers.

KG: It is my opinion that Imposter Syndrome is not the fault of those who suffer from it. I manage it for myself as best as I can, but in terms of tackling these issues, a PhD student who already does so much activism and outreach (a majority of the time for free) in many other ways should not have to deal with this issue. Fixing it is down to the research councils, universities and experiments that have made such a toxic environment in the first place for people like me.

SW: One technique I regularly practice is positive affirmations. Continuously reminding myself that I am a product of my own hard work, that I am qualified and that I can be a great leader. It's a process of remapping your conscious mind to fully believing in yourself. Another way I overcome imposter syndrome is to read old emails. Yes, this sounds weird, but many times I'll read old emails and I'll respond with 'Wow, how on earth did I know that?' or, 'Wow, I really am good at my job.' It's a weird technique, but it works for me.

**Cis- is short for cisgender, which refers to when a person's gender identity corresponds to their sex as assigned at birth. Het- is short for heterosexual.*

Open for business

Commercialisation is an area of research being pursued by universities up and down the UK. **Andrea Gaini** speaks to three professionals steering such programmes to find out more.

Panellists

James Baker, CEO Graphene@Manchester, UK (JB)

Adam Stoten, COO, Oxford University Innovation Ltd, UK (AS)

Andrew Tingey, Executive Director, Imperial College Innovations Ltd, UK (AT)

Why do you think commercialising is a good idea for researchers?

JB: Not every researcher is going to be motivated by commercialisation. And some researchers are totally motivated by that fundamental science and fundamental research. If you look at graphene, that didn't come out as a result of a commercialisation process. It was a 'fun Friday', playing with sticky tape and a pencil, driven by curiosity. So, we still want universities to do fundamental science – that real, curiosity-driven, new thinking. And that's core to the university sector.

At the same time, we also need to convert some of that science into products and applications. And that's where we can bring in organisations like the Graphene Engineering Innovation Centre (GEIC).

GEIC is not staffed by academics. It's staffed by people who may have a PhD in material science but have also got industrial experience. So, for me, commercialising is about getting the right people together in a room and it's not just the science bit, it's also all the filling in of forms, applying for grants, applying for loans, registering intellectual property (IP), etc.

Another thing we are working on, is making sure that academics get credit for their commercialisation, because if we can demonstrate that a key part of an academic's career is commercialisation, then that will motivate academics to take more interest and focus on this area.

AS: Modern academic research has societal impact as a major goal and translating the outputs of research into new products and services is a great way of generating this. In years gone by, there may have been a degree of stigma associated with academics engaging with industry, the vast majority of researchers today see translation and commercialisation as an integral part of being a world-class academic.

While the primary motivation is usually societal impact, there can also be financial rewards for researchers associated with commercialisation. Oxford University sets out in its regulations what share of future royalties from a given deal will be given to academic inventors.

AT: I'd prefer to use terms like applying, generating impact or translating – the word commercialisation sometimes has negative connotations for people, although it can be the primary reason why researchers are looking to explore this area. These days it's not an either/or situation, many academic colleagues pursue commercial interests that sit happily alongside – and in many cases reinforce – their academic careers.

Looking for impact has become mainstream and a translational strategy is often a core part of grant applications. In terms of why people are interested, it could be factors such as an interest in how research results could solve problems faced by industry, a general interest in IP and how it works, a desire to help patients (for medical applications), to achieve commercial success, or simply to do something new and different outside the usual academic environment.

How do you protect IP?

JB: With graphene today, we're increasingly seeing that it's more 'know-how' and isn't a patentable thing. GEIC is trying to support people to get value from their IP, [to help them] get some return from it, rather than trying to own it and stifle it.

AS: Oxford University Innovation (OUI)'s role is to work with researchers to help them understand whether their innovation potentially solves a meaningful problem, what the commercial market might be for their solution, and whether we can manage or protect the associated IP in a manner that will facilitate finding a partner or investor.

If the answers to each of these is yes, then OUI is able to pay for the filing of patent applications to protect the IP. We work with a wide range of patent attorneys in different technology areas to provide the requisite


monkeybusinessimages/Getty

expertise. Beyond patents, we also commercialise innovations for which the IP is non-patentable, but still useful, for example, the copyright in software source code, or even database rights.

AT: I think some thought needs to be given to the type of IP appropriate to the project – IP is a lot more than just patents. Software, for example, can often be protected by copyright – or there could be design rights, or know-how that is not in the public domain. When we know more about the technology and the situation, we can think about the right type of IP. If the IP is to be registered, for example, by filing a patent or a registered design, we engage external professionals to draft and file the appropriate documents. This ensures we file high quality IP and give ourselves the best chance of being able to partner or attract investment for the asset in the future.

How do you approach IP on collaborative projects?

AS: Academics are highly collaborative, and where IP is generated with the input of researchers from other institutions, the normal approach is to decide which institution is best placed to lead the process, and then for that institution to take assignment of the rights owned by others, so that a single party is able to market and negotiate deals on the IP. The assigning parties will typically receive a share of any future revenues associated with commercialisation of the IP.

AT: It depends. There is no one size fits all solution, and it depends on the partner, who is contributing what to the project, the overall objectives, etc. Every situation is different. There are a number of more common models we can use, and we have to strike a balance between not holding anything up and not committing to fudged, unclear or conflicting terms that will simply store up problems for later.

"I'd prefer to use terms like applying, generating impact or translating – the word commercialisation sometimes has negative connotations for people."

How is a proof-of-concept developed and what is required from a project before it can convey these plans?

JB: This is based on the principles that I call make or break. It can take you many years going through the cycles to take a product to market. But at GEIC, we have been working on using our facilities to do very rapid design and speed up the process. So, we start by figuring out how much graphene we need to add, what formulation needs to go into a rubber to then produce prototypes or sample material rapidly, to then test and iterate that innovation cycle once, twice, 10 times, 50 times.

We discuss the risk and reduce the overall time for a product development. They're all quite rapid. You get an

"Even before an academic makes the discovery that might one day become a spin-out, the university provides increasing opportunities for entrepreneurial training."

idea, make something, test it. If it works, then develop it, or if it fails – fail fast, learn and move on to really challenging the whole innovation cycle for a new material.

AS: Much of the IP disclosed to OUI is early stage and needs proof-of-concept work to take it to a level of maturity and validation required to attract a commercial partner. Our proof-of-concept funds are therefore invaluable in undertaking such work. [They are] based on feedback we have received from potential partners to help define exactly the experiments we need to conduct for the IP to be market ready. The nature of this work varies greatly depending on the technology, but OUI is fortunate in having a £5mln fund to support this work, typically granting awards of a few tens of thousands of pounds, but in exceptional cases up to £250k.

AT: Again, this is very dependent on the technology. Proof-of-concept in medicine means a very different thing than in process chemistry for example, there is often no such thing as *the* experiment or test result. Proof-of-concept is usually about de-risking a project enough to attract the next tranche of funding from whatever source – and it is important that sources of this funding (which is, by its nature, very high risk) is available to fledgeling projects. When considering publishing, it is important that IP aspects are considered because a public disclosure can seriously affect our ability to protect inventions by filing patents.

What defines which project gets licensed and which ones become spin-outs?

JB: Manchester University does have some intellectual property or family of IP, which is available to licence. But GEIC tends to be more about creating something with the idea. So, there is some background IP, but our business model at GEIC is that the partners own the know-how, and we get a royalty.

AS: OUI always tries to define the optimal route to market for a given technology. In some cases, it may be obvious from day one that a technology has the potential to support a standalone new business, whereas others may only ever be destined to be a bolt-on licence for an existing enterprise.

For others, there could be opportunities to go either way, in which case, the entrepreneurial interests of the academic inventors may determine whether a spin-out is formed or not. With the increasingly entrepreneurial culture in the university, coupled with greater support for this activity, spin-outs are becoming an attractive option for academics, although often represent a much more time-consuming activity.

AT: It is all about dialogue with the inventors, although there are certain characteristics which may favour one or another route. It's important to know that the IP is always licensed, it's a question of whether the licence is to a third-party or the inventors' own start-up.

Typically, if a project is niche, or requires specialist resources to develop it, or there are already dominant market players in the sector, a third-party licence would be appropriate. Conversely, if the inventor really wants a start-up, the technology is more of a platform, or the sector is one in which a start-up can make an impact, etc., then it would be appropriate to think about a start-up. It's important to fully discuss and agree the way forward with our academic colleagues.

What support is given to academics on this entrepreneurial journey?

JB: We have a graphene post-doctoral course, and we support that with a commercialisation course. And so, 10% of their year two, or year three, is devoted to commercialisation. We have speakers who come along who talk about commercialisation and pitching your ideas.

AS: OUI supports academics to understand the market for a technology and the likely licensees or investors. Where a spin-out is the desired route, we can help academics develop a business plan, identify potential executive management and approach investors. At Oxford, we have an associated venture fund, Oxford Sciences Innovation, that has raised more than £600mln to invest in Oxford spin-outs, so they also represent a great source of both capital and expertise.

Even before an academic makes the discovery that might one day become a spin-out, the University provides increasing opportunities for entrepreneurial training via the Oxford Foundry – the recently-established student entrepreneurship centre – and the Said Business School. OUI also runs an Innovation Fellows programme to help budding academic entrepreneurs understand more about the nuts and bolts of commercialising IP.

AT: At Imperial, the support we give ranges from the practicalities of organising IP protection and commercial discussions, through to advising on business plans, providing entrepreneurial training, access to seed investment funds, incubator facilities, consultancy advice and specialist support on working with industry. Whatever our academics are interested in doing, we can help them.

Jill Jennings/University of Manchester

Vivek Koncherry paving the way for waste tyre rubber recycling with the SpaceMat

University of Manchester

Spinning out of waste

Born from a desire to tackle tyre waste, SpaceBlue is a spin-out company from the University of Manchester, UK. **Andrea Gaini** catches up with its CEO **Dr Vivek Koncherry.**

"Inventing stuff is my hobby, [and I don't just work with] rubber products or composites, I also do robotics, artificial intelligence and many different types of inventions," says Dr Vivek Koncherry, an Impact Fellow at the University of Manchester, UK.

And so in 2019, when reports started flooding in about copious amounts of waste rubber from used tyres being traded with Eastern countries instead of being recycled, Koncherry immediately thought of an idea to tackle the issue.

Within a year, he had launched the first prototype of the SpaceMat. The floor mat, which is suitable for outdoor and indoor spaces, is made using 80% of waste tyre particles mixed with 20% graphene-enhanced natural rubber, which is then compressed under heat and pressure inside a mould.

Koncherry explains that using graphene solved the problem of reduced performance often found in recycled materials. He says that graphene enhances the rubber's durability and creates a sustainable product that is also high quality.

By using just a fraction of a percentage of graphene, Koncherry also managed to increase performance and eliminate a common issue in floor mats – the weak binder material that causes rubber crumbs to fall off the edges.

Adding graphene to the chopped tyres and polyurethane, made the binder strong enough to hold the tyre particles and increases the rubber's strength four-fold, essentially solving the issue at its root.

Negating the end-of-life consequences was also a priority for Koncherry. He says that in the same way that waste tyres are chopped up to create the mats, the firm can recycle the mats and create new product from it.

On the mat

On the UK research sector, Koncherry says it is "world-class" but lags behind other countries when it comes to commercialisation. "Traditionally, the scientific community in the UK is focused on fundamental research and not commercial products," he admits.

The Graphene@Manchester programme aims to tackle this and ensure that Manchester and the UK play a leading role in developing the potential of graphene. James Baker, CEO of Graphene@Manchester, describes how since the material's first isolation in 2004, the UK has built a great reputation for inventions, and now it's time to put that to fruition.

Baker says that their work is to help people who have great ideas and that need technical or business support to succeed. "We're trying to build an ecosystem of people making graphene and using [it to make] products…a graphene city. He says, "We want Manchester and the north-west of the UK to be known for its reputation for inventors [and] for innovators."

Koncherry adds, "The challenge is the investment from start-up to medium-scale company. There is a gap, and bankers and investment firms don't want to take the risk."

Therefore, once developed into a viable prototype, Koncherry made contact with the Graphene Engineering Innovation Centre (GEIC) about his idea, prompting Baker's involvement. "James loved the idea and immediately decided to back the project," Koncherry explains.

Normally, for Koncherry, such inventions would have been a hobby, but Baker's enthusiasm pushed the idea towards something he had never really imagined – commercialisation.

SpaceBlue took flight. Koncherry received funding for the testing and validation of his SpaceMats from the Bridging the Gap, European Regional Development Fund (ERDF) – a programme that engages Greater Manchester-based SMEs to explore and apply graphene and other advanced 2D materials in a range of applications.

Looking ahead, Koncherry says challenges exist around their use of an international supply chain. Mats are produced in India, where 500,000 units are created every month. "Currently, we make and send a pre-mix graphene to a third-party factory in India that already has several compression moulding machines."

He explains that initially his main goal was to get a finished minimum viable product to market at the lowest cost possible because he didn't have any investors, but moving forward, he says that "because waste tyre is in the UK…we want a factory in Manchester".

A guide to apprenticeships

Apprenticeships allow students to get their foot in their chosen industry door and for businesses to find and raise talent in-house. Here **Andrea Gaini** puts questions to the **Institute for Apprenticeships and Technical Education**, UK, to find out how prospective students can access the most relevant apprenticeship for them and advice for companies looking to create such a scheme.

For potential students

Who would you recommend apprenticeships to?

Apprenticeships are a great way of launching into successful careers. Apprentices learn the knowledge, skills, and behaviours that employers need, gain valuable work experience, and are also paid a wage. Apprenticeships are therefore great for young people looking to learn new skills and build up work experience. They can also work well for people who want to retrain later on in life.

What apprenticeship levels are there available?

There are over 630 apprenticeships currently available. They range from entry level 2 and 3, which is equivalent to GCSE and A-Level, up to levels 6 and 7, which is degree level. You can look through them all on our website.

As of September 2020, there are also now T Levels. T Levels are new two-year courses that will follow GCSEs and will be equivalent to three A Levels. They have been developed in collaboration with employers and businesses so that the content meets the needs of industry and prepares students for work.

All apprenticeships and T-Levels are based on occupations recognised by employers. The 'occupational maps' featured on the website bring these together to show where technical education can lead. A Standard, explaining what someone in the occupation does and designed by groups of employers, has been written, or is in development, for most of these occupations, although some await interest from employers.

The maps feature groups occupations with related knowledge, skills and behaviours into pathways, making it easier to see the opportunities for career progression within that particular route. Within each pathway, occupations at the same level are grouped into clusters, to show how skills learnt can be applied to other related occupations.

To ensure the occupational maps remain up-to-date, each map is owned by a route panel, made up of industry experts. Route panels use the maps to support decision making on apprenticeships, T Levels and route reviews and to help them identify additional occupations that need to be developed.

How do you choose the right apprenticeship?

Our advice would be to do your research. We recommend using the 'Find an Apprenticeship' website service at www.gov.uk/apply-apprenticeship to find out what apprenticeships are available in your area, or searching through employers' websites and other job portals. There is also advice for people considering an apprenticeship at www.apprenticeships.gov.uk. You can also ask your local college or university for further guidance.

You can be an apprentice in such a huge variety of occupations these days – a solicitor, a policeman, a nurse, or even a space engineer. There are so many opportunities out there, so make sure you find out as much as you can about them.

What makes a good apprenticeship?

All apprenticeships are now designed by groups of employers to standards, brought together by the Institute, to make sure apprentices learn the skills that are really needed in the workplace and have weight with employers to set them off on long and prosperous careers.

Top quality apprenticeships require a mixture of quality on-the-job training with employers in the workplace and off-the-job training with colleges, private providers, or universities.

Employers and training providers are expected to sign-up to provide first-rate training and support through commitment statements with apprentices.

Below: Apprenticeship levels in the UK

Apprenticeship type	Level	Equivalent
Intermediate	2	GCSE
Advanced	3	A-level
Higher	4, 5, 6 and 7	Foundation degree/above
Degree	6 and 7	Bachelor's or Master's

For companies who want to run apprenticeships

What should companies be looking into when developing an apprenticeship scheme and recruiting apprentices?

Developing an apprenticeship needs time and commitment. However, it is a rewarding process. You will be helping to ensure apprenticeships deliver the knowledge, skills, and behaviours employers in your sector need. All apprenticeships are now developed by groups of employers to ensure they fill the nation's skills gaps.

Trailblazer Groups are responsible for developing apprenticeships. To become a Trailblazer Group, you must be a group of employers recognised by the Institute for Apprenticeships and Technical Education and representative of employers of the occupation.

We expect Trailblazer Group employers to employ apprentices in the occupation once it is developed. We also ask that you actively promote the apprenticeship.

If we agree that an occupation is suitable for an apprenticeship, we will support you in developing the occupational standard and end-point assessment (EPA), as well as getting funding evidence to inform our funding band recommendation. Developing your occupational standard and EPA plan together ensures a coherent apprenticeship.

Training and retraining is more important than ever as the economy starts to recover from COVID-19. The recent *Build the Future Apprenticeship Survey* was hugely encouraging. 70% of business leaders in England believe that apprenticeships and work-based learning will be vital to their organisation's recovery from the pandemic. 89% of business leaders in England who hire apprentices agreed that apprenticeships enable their organisation to proactively build its future.

The best place to start if you are looking to recruit apprentices is by visiting www.apprenticeships.gov.uk/employers. Apprenticeships are jobs, so the employer is responsible for on-the-job training and paying apprentices' wages. You will also need a training provider to run the off-the-job training, which should take up at least 20% of apprentices' working hours. The above website provides a roadmap to a quality apprenticeship with advice on identifying the business need; selecting the right candidate and identifying their learning requirements; making arrangements for off-the-job training and selecting a training provider; developing a commitment statement for learning outcomes, roles and responsibilities; access to mentoring and training support; EPA; and progression after successful completion.

The employer and the training provider work together to support the welfare of apprentices and ensure they are ready for the EPA at the end of their training programmes.

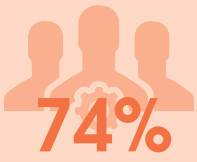
The National Apprenticeship Service also has a very useful employer guide on their website that will take new employers through all of the steps they need to complete to hire an apprentice. The Institute's panel of apprentices is also due to launch its best practice guidance which will help to raise the standards of training.

What benefits can firms gain from an in-house apprenticeship scheme?

Apprentices are great for business. They generate a huge amount of loyalty among trainees and provide companies with a great opportunity to train future generations through high-quality training programmes that are endorsed by their respective industries. Employers typically report apprentices providing a new lease of life to their workforce, filling skills gaps, and satisfaction at training the right people to fulfil their organisation's skill needs.

For more information, visit the Institute for Apprenticeships and Technical Education website at **www.instituteforapprenticeships.org**

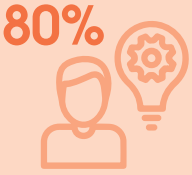
Boosting business



74% of businesses with an apprenticeship scheme report boosted retention in their organisation

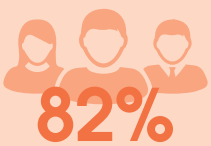
77% see increased productivity

80% note the transformative impact of apprenticeships on the learner



78% report a transformative impact on their organisation

75% of organisations in England who hire apprentices say it allows them to forge relationships with their local area



82% believe they are important for all ages and that they should be delivered across all levels of education

Source: The Open University, *Build the Future Apprenticeship Survey*

Below the surface

This year, the first cohort of students are studying for the Materials Process Engineer Level 7 apprenticeship standard, developed by the Surface Engineering Leadership Forum (SELF). **Andrea Gaini** finds out more about the skills opportunities this brings to the sector.

"In order to remain competitive in today's global marketplace, companies in the surface engineering sector need to undertake a transformational journey, which involves [various] phases of growth, initially, to become much more match fit, then to move to best in class, and finally to become world class," says Dave Elliott, Chair of SELF, during a webinar exploring the sector's new degree-level apprenticeship standard.

"The Material Process Engineer Level 7 apprenticeship standard will meet the high demand for technical specialism combined with commercial and problem-solving skills," explains Geoff Hale, SELF Secretariat. "The apprenticeship will enable postgraduate engineers to develop specialised skills, in areas such as surface engineering and coatings, heat treatments, and surface treatments with a specific emphasis on improving business peformance."

Jeff Rao, Professor at Cranfield University, UK, and Course Director, adds, "Upskilling employees drives future growth [and our] course aims to equip employees with the knowledge, skills and behaviours that are required for today's high-tech industries. By upskilling your workforce, you're creating future success in your business, [it means] the benefits to your business are in terms of improved productivity, improve product, profitability, making you…match fit."

A learning experience

The course was developed by industry in collaboration with Cranfield University and is designed to minimise time away from the workplace "to work around you and to support you", Rao explains.

Approved by the Institute for Apprenticeships and Technical Education, the course spans over 30 months part-time and is delivered through taught modules, group and individual projects, and case studies, to be followed by an end-point assessment. Much of the work required is conducted within the apprentice's workplace, and it is predicted to take up no more than around 20% of their time.

Rao says, "The first phase of your journey is to establish the toolkit to learn the knowledge, skills and behaviours as defined in the apprenticeship standard.

"As you progress, the learning gives [you] a sandpit where [you] can apply those knowledge, skills and behaviours in a safe environment…to an activity in the workplace and being mentored by both your employer and Cranfield University." This gives apprentices a chance to practice on a real-life case study.

"And then we come to the in-house project, which you agree and decide on with your employer, it is a project which addresses a genuine problem or issue within the business."

In the making

The apprenticeship standard was developed from an industry workshop held in July 2017 at Cranfield University.

The event attracted over 30 surface-engineering related companies and a number of universities who all expressed a passion…for skills and training.

Hale says, "A Trailblazer Group was established initially with support from the surface engineering and advanced coatings community, including its trade bodies – British Coatings Federation, Institute of Materials Finishing and the Surface Engineering Association – but quickly expanded to include representation from other bodies active in materials processing technology – Cast Metals Federation, Institute of Materials, Minerals and Mining, Manufacturing Technologies Association and The Welding Institute.

"In addition to strong business support, the proposed standard had university input provided by Cranfield University, Loughborough University, Manchester University and the Henry Royce Institute. The Institute for Apprenticeships provided advice and guidance during this period."

He explained that concurrently with the initial work on this level 7 standard, industry trade bodies, research and technology organisations, and professional engineering institutions active in the Trailblazer Group created SELF to promote the use of these technologies in industry, and to interface with government on developments and funding. SELF was officially launched in February 2019.

The next course at Cranfield begins in January 2022. Closing date for applications is 1 November 2021. For more information visit ***www.cranfield.ac.uk/mpe*** *or contact J.Rao@cranfield.ac.uk*

What the apprentices say...

"I've done a science degree in the past, and I've worked as an engineer for the last eight years, but doing this course gives me an opportunity to advance my skills and knowledge and hopefully open doors for future professional progression."

Anna Bents, Engineering Team Leader, TSTL

"I was interested in this course because I thought [it would complement] my job role really well and be good for my professional development. So far, I'm enjoying the course three modules in. Long term, I'm hoping this course will develop my knowledge and skills to aid my professional progression and allow me to move into a management role in the future."

Natalie Parry, Team Leader, Turbine Surface Technologies

Work life in mining

What is it really like to work in the mining industry? **Andrea Gaini** catches up with three IOM3 members.

Chris Sangster FIMMM, Non-Executive Director/Consultant, Ariana Resources PLC, Western Tehyan Resources

How would you describe what you do to friends?

I am currently a Non-Executive Director (NED) of one publicly listed junior mining company with joint venture gold production interests in Turkey, as well as a significant potential gold/copper project. I recently became Non-Executive Chair of a fledgling (unlisted as yet) exploration company based in Kosovo, looking to explore regionally in the western section of the Tethyan metallogenic belt. I am also a Director of another potential junior mining start-up looking in Portugal at present.

Up until a few years ago, my roles had been more operational/executive focused and the change from that to NED/consultant has been an interesting transition. Now out of the direct firing line, one's approach differs somewhat, in that the role is more to assist/contribute/guide/advise the Executive team, rather than 'do and direct'. Of paramount importance to the NED role is appropriately representing and safeguarding shareholder interests, as is ensuring a suitable company approach to Environmental, Social and Governance (ESG)/Corporate Social Responsibility (CSR) matters.

I also consult in a technical capacity to those companies I am involved with, in areas that they may not have direct operational or relevant technical experience in. I am also an Associate Consultant to a couple of UK based consulting groups and an advisor to the Board of a Canadian listed company which is starting to develop its interests in Scotland.

What are your key responsibilities in your role?

As both NED and Consultant, I can have many hats to wear. I have had a wide exposure to the industry in different commodities, locations and techniques within both multinational and junior companies – mostly with an operations base. Hence, other than perhaps the more traditional roles of an NED mentioned above, I am able to advise and guide on a broad range of technical issues within the industry, which is of significant benefit to some junior companies who do not necessarily have that experience in the industry on their boards.

From a consulting point of view, I am a generalist rather than a specialist, and fit the old saying regarding a mining engineer being 'a jack of all trades and master of none', and so my input is, and has been, usually either at a review stage or managing multi-disciplinary early-stage *Preliminary Economic Assessment (PEA)* or *Pre-feasibility Studies (PFS)*.

How did you get the job?

I have had a diverse career in the industry starting with a pre-university year in the South African gold mines in the mid-70s, which confirmed the mining industry as my choice of career. Post-university, I spent a number of years back in the South African gold mines, which at the time, provided solid training on which to base a future career.

I left South Africa to broaden both my technical and managerial experience with positions in the UK (tin) and then Canada (gold), before returning to the southern African diamond mines in South Africa, Namibia and Botswana, which again provided hugely varying technical and cultural environments. Subsequent to a spell in Head Office for De Beers and also Anglo American in the New Mining Business division, I returned to the UK for a couple of years for my first real foray with a junior mining company whose small gold project in Scotland was to become a significant focus for me later on in my career.

The BreX gold scandal put paid to the financing of that project for a while, and I set off again for a spell on the Zambian Copperbelt. I then joined a well-known firm of Australian-based consultants, back to the diamond industry briefly, before co-founding a junior mining company focused on the gold project I had previously worked on in Scotland. I was CEO for seven years and continued with them as a NED until recently. During the latter period, I took up a similar position in another junior mining company and am still active in the junior mining sector with some recent potential start-ups.

Describe a typical day

As NED and also a Consultant, no two days are really the same. A typical day might involve reviewing project data/ *PEA/PFS* or a *Bankable Feasibility Study (BFS)* for potential participation/acquisitions, the terms for an agreement to achieve such, or the latest exploration results from one of the companies I am associated with, as well as assisting with the press release in terms of regulatory requirements. I might also be assisting to design a community engagement plan for a new area for exploration.

When possible, it's great being either onsite looking at operations and their particular technical challenges and how they have been addressed, or in the field looking at what the geologists are excited about. This means that up until March 2020, I was travelling a reasonable amount. I am a geologist's worst nightmare – a mining engineer who thinks they know something about geology! As such, I interact with a wide range of people from operations, technical, consultants, government bodies and, last but by no means the least, the communities within which our operations are based or hope to operate.

What are the most challenging aspects of your role?

From a personal/consulting point of view, I am not quite semi-retired (but getting close) and the pace of change in the industry is getting faster and keeping relevant is almost a full-time job. From a NED perspective, it has been a challenge from 'being the boss' to 'not being the boss', and means certain adjustments to one's approach are necessary to adapt to that role and curbing one's enthusiasm to perhaps be more assertive/prescriptive in one's views as to the appropriate course of action, requires a careful balance.

What is the biggest misconception about the sector you work in?

The mining industry has had bad press for a long time with legacy environmental, societal and other issues and, historically, perhaps deservedly. Even when at university, this was recognised within the industry and, yet 40-plus years later, it remains a significant topic. Mining is a primary industry and, if it isn't grown, it is probably mined, and the contribution that the industry makes to society as a whole is greatly underestimated and poorly appreciated.

The recent public focus on CSR/ESG matters has to some extent enabled many mining companies to highlight their contribution to global society in a more forthright manner, much of what is now expected of the industry has been practised for a long time but just poorly communicated/ understood. The inevitable changes in terms of the requirements for the change in our economies in relation to climate change will put further significant pressure on the industry to 'get its act right', and woe betide those who do not subscribe to evolving new values and expectations and implement them meaningfully.

Pictured: Kimberley, South Africa, 10th April 2019. Mine shaft head from old diamond mine

Rich T Photo / Shutterstock

What is the best part about your job?

Continued involvement and interaction in the industry as it tackles the challenges of the 21st Century and helping to meet those challenges. The industry has needed to change for a long time. We have been too reluctant for various reasons to accept/adopt new technologies and recent advances, and the ongoing changes with respect to reduced reliance on fossil fuels and other climate issues have, by necessity, forced the pace of change to accelerate. The industry and its participants must keep learning and developing to meet those challenges – exciting times!

What has been the most memorable moment in your working life so far?

There have been many highlights during my career, starting at a junior level contributing to ongoing innovative projects within the industry and, as time progressed, taking a more senior role in developing initiatives and seeing them implemented, or the course of action recommended embarked on successfully. Midway through my career, I was involved in a small gold project in Scotland that was placed on care and maintenance after BreX and a subsequent decline in the gold price. A number of years later, I co-founded the junior company that acquired the project, which, by then, was included in Scotland's first National Park – the Loch Lomond and Trossachs National Park. Subsequent to listing on ASX and later on AIM, we progressed the project and, after an initial refusal, gained planning permission in 2011 to establish Scotland's first commercial gold mine in the park. Although I have recently left the company, the mine is now in the production ramp-up phase and producing gold.

Richard Ogle MIMMM, Mine Manager – Barrow Mine, British Gypsum

How would you describe what you do to friends?

When I describe my role to friends, I play on the old adage, 'if it can't be grown it has to be mined'. I explain that, working for British Gypsum at Barrow Mine, the gypsum we mine makes up the majority of the raw material that goes into making plaster which is widely used in the construction industry here in the UK. I remind them that if their smooth walls have pink plaster then we mined it!

What are your key responsibilities in your role?

The key responsibilities of a Mine Manager on a daily basis are to ensure safe, legally compliant production, meeting the demands of the customer and within budget. Due to the challenges of mining, there is also significant future planning that is required with the help of the Geological and Mining Team (technical services) to make sure that the mine plan maximises the use of the reserve. Mining is also a highly skilled job, so making sure that we have competency and succession plans to develop and recruit our existing and future employees is becoming more and more important.

How did you get the job?

I landed in the mining industry quite by accident. While at the University of Exeter, UK, at the Cornwall Campus, I was given the opportunity to swap courses and complete a Mining Engineering Degree and become an Associate of Camborne School of Mines, and since then I've never looked back. I completed a student placement with British Gypsum, before ultimately starting my career with Glencore, formerly Xstrata, at Mount Isa Mines in the outback of Australia. Following an excellent graduate programme, the opportunity to return to the UK and British Gypsum came up – having worked for them before, I had no hesitation in taking it.

Describe a typical day

A typical working day is catching up with how the previous 24 hours of production and quality have been with the Mine Production Manager, before moving on to see how we are doing with our capital, development and improvement projects that we have on the go. We are, at the moment, waiting on the delivery of two lithium battery haulers – the first machines of their type in Europe – as we move towards reducing the amount of diesel engine exhaust emissions (DEEEs) that our workforce is exposed to, which will also help towards our target of net-zero by 2050. Other tasks that crop up are many and varied, and include engaging with the local community, recruitment and training to develop competency, identifying efficiency improvements, managing the mine budget, reviewing risk assessments, auditing operations, etc.

What are the most challenging aspects of your role?

One of the hardest aspects of mining gypsum is the variability in gypsum purity in the reserve we are mining. My team does an excellent job balancing where we mine and how to provide the factory with rock at the correct specification for making plaster.

What is the biggest misconception about the sector you work in?

I think the biggest misconception about mining, specifically in the UK, is that it is all about coal mining for the energy industry and less about the need for coal for steel manufacture and for carbon filtration. Mining has a reputation of being dirty and damaging to the environment. Mining is going to be vital in providing minerals to help support new technologies as we try to reduce our reliance on fossil fuels. Specifically, one of the challenges that the mining sector in the UK has, is that it is not visible and considered as a career. Most children in Australia are aware of how important mining is to their economy, whereas, using myself as an example, I had never even considered mining before fortunately going to university in Cornwall.

What is the best part about your job?

I think the best part of my role is that no two days are the same. On the one hand, you have the technical challenges posed by mining in an underground environment, with the addition of geological and other variables, to the challenges of making mining in the UK an attractive career opportunity.

What has been the most memorable moment in your working life so far?

During my student placement, I was told by a couple of people that it is easier to go from the operational side of mining to the technical side rather than the other way round. Whether this is true or not, I set myself the goal of becoming a Mine Manager and it was a memorable moment when I was offered this role.

Chloe Lam AIMMM, Graduate Geotechnical Engineer, Knight Piésold

How would you describe what you do to friends?

When I tell my friends that I am a Geotechnical Engineer, I mostly explain what my current job entails, which at the moment is largely looking at tailings storage facilities. Most will ask for further explanation as they don't know what tailings are, so I give examples such as designing enclosed dams for storing waste material produced from mining. I also like to include the fact that this is mostly done for the protection of the environment, and that a lot of the times these tailings are often vegetated to blend in with its surrounding area so that it can look natural.

What are your key responsibilities in your role?

My role is to support my team, as well as global mining companies, with mine waste management. This involves reviewing the tailings storage facilities by performing site visit inspections, computer modelling and reviewing monitoring data. Comments and recommendations are provided in a report, which identifies whether the tailings storage facilities are designed and maintained according to local and international guidelines, and how to mitigate any potential concerns.

How did you get the job?

I originally studied a BSc joint honours in Geography and Geology at Kingston University, UK, and then decided to study purely Geology. This led to the desire of wanting to enhance my knowledge and skills in engineering, and during this period, I was fortunately sponsored to undertake an MSc in Applied Geotechnics at Camborne School of Mines, UK.

After graduation, the first four years of my career primarily focused on early-stage UK-based gold projects, mainly in Wales and Northern Ireland. This experience enhanced my attention to health and safety, where I was able to volunteer as a Mine Rescuer in Northern Ireland. I later transitioned my career as an Exploration Geologist to geologically map for base metals in Serbia over three months. This allowed me to discover a different culture and experience their way of working and lifestyle.

Based on a friend's recommendation, I attended one of London's Sundowner events to speak with representatives of Knight Piésold. From there, I was introduced to the tailings management industry and was offered a position as a Graduate Geotechnical Engineer. I have now cultivated my career with Knight Piésold for over two years.

Describe a typical day

I like to start my day with a cup of tea. Due to COVID-19 restrictions, I am able to work from home twice a week. However, I try to go into the office every day to get back to the norm. When I do go into the office, I mostly travel by public transport, or if I am up to it and feeling super energised, a good scenic cycle on my bike. I like to take my lunch breaks from 1pm, as I feel like it balances out my day. My work in general varies throughout the day with multiple tasks that need to be completed for different projects. My work could include the following:

Desk study:

- Researching background information for current and future projects.
- Researching and liaising with sub-consultants to receive quotations for specific services, such as site investigations and laboratory testing.
- Understanding project requirements and the different local and international guidelines.
- Computer modelling.
- Performing capacity assessments of as-built and/or designed tailings facilities.
- Performing options studies to provide feasible tailings facility designs that meet the client's needs, in accordance with local and/or international guidelines.
- Performing stability assessments of as-built and/or tailings facility designs under various loading conditions, such as static, pseudo-static and post-earthquake to assess the Factor of Safety, in accordance with local and/or international guidelines.
- Performing dam-break assessments on assessed and identified potential breach locations of as-built and/or tailings facility designs, and establishing the dam classification in accordance with the Global Industry Standard Tailings Management (GISTM) guidelines.

Other things I do:

- Teamworking with colleagues by discussing and problem-solving for various projects, as well as learning techniques and mitigation options for future projects.
- Undertaking office administration work, such as organising required documentation in preparation for site visits and managing office supplies.

Pictured: Tailings storage facilities

RONEDA/Shutterstock

What are the most challenging aspects of your role?

I suppose every job has its own challenges. For me, solving problems, such as issues that I have not encountered before, can be challenging. I mostly find this due to the lack of experience, however, I do not view this as a negative, I see it as an opportunity to approach my colleagues to explore different solutions.

In my industry, there are many colleagues who have majored in different fields, i.e. we are a team of Civil Engineers, Geologists, Geotechnical Engineers, Hydrologist and Soil Mechanics, whom all use different terminology and/or abbreviations that may not be familiar to others or myself. This can sometimes be a challenge, as there is a lot of technical language that I am required to become familiar with, particularly as a Graduate who is still learning about the various disciplines of the industry I work in. However, once the terminology and/or abbreviation is explained/ defined, I gain a new understanding of what people from different fields are trying to put across.

What is the biggest misconception about the sector you work in?

There is no denying the risks associated with improper management of tailings facilities. I think storing tailings is often perceived to not be a mining company's priority and is possibly viewed as a task to consider at a later stage. However, more and more mining companies across the globe are spending more time and money in proper tailings storage design, disposal, monitoring and long-term management.

New advancements in disposal technologies have also contributed to alternative storage solutions, such as the use of a filtered tailings product, where the tailings are de-watered to allow for the construction of dry stack facilities that eliminate the risks associated with high volumes of water on a conventional, slurry-style, tailings storage facility.

Tailings management should be considered as soon as there is a conceptual plan to exploit an interested area. This is so that, should a tailings facility be designed, various factors, such as feasibility, consequences and mitigation can be considered to reduce the risk level.

What is the best part about your job?

A typical day at Knight Piésold varies and I appreciate that I am able to develop my engineering skills and continue my passion in geology. I enjoy discovering interesting projects worldwide, especially if there is an opportunity to undertake site visits to observe various mine site operations. I am very motivated in expanding my computer modelling knowledge and skills too and, in general, assist others, when possible.

What has been the most memorable moment in your working life so far?

The steps and obstacles that I had to take to be where I am today. I very much appreciate and value the experience and multi-disciplinarity of the mining industry. This has helped grow my understanding in the different fields and broaden my problem solving skills. I hope with my experience I will be able to support the future geologists and engineering generation.