INSPIRATIONAL ENGINEERING FROM STEAM ENGINES TO SELF-DRIVING CARS.

Institution of MECHANICAL ENGINEERS

Professor Richard Folkson FIMechE
Presidential Address 2015

Improving the world through engineering

KEY MESSAGES

- People who become engineers are inspired by people or technology that encourage them to develop creativity and ingenuity.
- The pace of technological change means that what inspired previous generations of engineers will no longer be relevant for today's new intake of future engineers.
- Every engineer should be involved in encouraging those who follow in their footsteps, not assuming that it is a role to be delivered by others.

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George Stephenson
President 1847–1848

INSPIRATIONAL ENGINEERS

Almost all Institution of Mechanical Engineers Presidential Addresses start by referring to our first President, George Stephenson, and this is entirely appropriate because of the legacy he left in showing the importance of technical competence and engineering standards for our profession. Engineers are inspired to follow their chosen careers by heroes who influence them throughout their careers, but these may be people or artifacts that reinforce their decisions, rather than the famous people that we normally associate with being engineering heroes. All of us will have different memories of the people or things that have had an impact on our careers, but we have all experienced positive influencers to help us throughout our lives.

My earliest memory of expressing an interest in engineering came at the age of 11, when the headmistress asked if there were any questions I wanted to ask that I had not learnt the answer to at school so far. I asked where metal came from, and maybe not surprisingly my teacher at the small prep school I attended did not have a clue. To her credit she went and found a book that she gave me to read, which explained how metal ore was extracted and then converted to molten metal. This sparked my interest.

The next major life-shaping event happened when my family visited my godparents when I was about 13. My father was a doctor of medicine and my godfather was his best friend from medical school, but his hobby was making radio-controlled model boats in the days before radio control could be bought from any hobby shop. He had a metal turning lathe in his garage and asked me if I wanted to have a go at making something. I was immediately fascinated by the turning process and how a piece of metal could be machined into a useful part. I made a spinning top from a piece of brass bar stock.

That was the day that I decided I wanted to be a Mechanical Engineer, changing from my previous desire to follow in my father's footsteps. My father knew absolutely nothing about engineering and lacked any practical abilities. He put screws into the wall to hold up shelf brackets using a hammer but no wall plugs. They did not stay up for long. Despite this lack of family background, my parents were very supportive of my career choice and supported my decision to do metalwork GCE O-level. This was not a subject normally chosen by academically capable students at my school in Sussex.

At the age of 15 my father bought me a metalworking lathe and a Black & Decker drill and stand for me to start making model engines in the garage. My next engineering hero was Mr Roué, the metalwork master. He was very supportive of my efforts, encouraging me to build a Stirling Cycle hot air engine made largely from the tubing from an old bicycle. After many hours of effort, particularly to remove friction so that the engine ran "like oiled silk", it ran smoothly for the first time. My interest in model engines was a significant driver towards my career in mechanical engineering and has led to a lifelong involvement in model engineering. Today's students may be less motivated by Stirling cycle or steam engines, and we need to find new ways of encouraging them to embrace technical interests.

My Stirling Cycle Hot Air Engine (L) and my steam engine (R). Circa 1970

Today, it is hard to imagine students being inspired by books when the majority of information they access is on the internet

The point of these stories is to show that engineers can be inspired by ordinary people rather than the normal stereotypes of famous engineers.

During my secondary school education, I was presented with a number of books as school prizes, which reinforced my career decision and told the history of technology and machines. Today it is hard to imagine students being inspired by books when the majority of information they access is on the internet.

While studying for my O-levels, I decided to seek work experience in an engineering environment during the summer holiday before my A-levels. Fortunately my parents had a friend who had the letters MIMechE after his name, and he arranged three-weeks of work at MB Metals in Portslade, Sussex. I think I was paid about £3.50 per week. This was a general engineering company with a large variety of machine tools including lathes, milling machines, drilling, tapping machines and surface and cylindrical grinders. I was given jobs on all of these, which was invaluable experience, particularly when I went for interviews at universities and for potential industrial training. This was the beginning of over 40 years' association with the Institution of Mechanical Engineers and was the point at which I knew that I wanted the letters MIMechE after my name.

When I went to the school careers office to find out how to achieve my goal, the first piece of advice I received, from my physics teacher, was that I should not become an engineer as I was too clever for that and should think about becoming a doctor, solicitor or accountant. They clearly did not understand the role of professional engineers. After I left the school I made several return visits to talk to students, so that they did not receive the same level of advice.

The final step of my career decision process was in the choice of Imperial College London to study for a BSc in Mechanical Engineering (BEng and MEng degrees were not introduced until after I graduated). At the interview with Imperial College I was advised that I would gain more from the course if I spent a year in industry before starting my studies. This was one of the best pieces of advice that I received. So I went back to the careers office at school and found out how to apply to various companies for industrial experience.

My first choice was with British Railways, as I had a long-term interest in trains through my model engineering hobby, and so I embarked on an extensive series of interviews at Marylebone Station, Derby, Crewe and back to London. This process took many months and although the signs were promising, it was getting very close to when I would need to either start work or begin my university course in October. I therefore applied to Ford Motor Company, Vauxhall Motors and British Leyland Group to improve my chances of gaining a training placement. Within a week Ford had called me for interview at its Regents Street office in London and I started work for them the following Monday!

The next week I received another phone call from British Railways asking me to come to another interview, but I responded that it was now too late and I started a 30 year career with Ford that changed my primary interest to automotive engineering.

Teams produce better results than individuals facing the same challenge or task

DRIVING INTO THE FUTURE

Characteristics of Inspirational Engineers

Vision

Throughout my career at Ford I realised the importance of a shared vision clearly communicated to all members of the team. This was first learned through an almost disastrous experience, when I was working on a new Ford heavy truck called the Cargo. I had been working diligently for many weeks designing the lowest-cost cab components possible for the new vehicle. I was then invited to attend a whole team meeting with the Director of Engineering at which I learned for the first time that we were designing a premium-quality truck to compete with Mercedes-Benz. Unfortunately nobody had told me that when I started work after graduation and I had been doing entirely the wrong things to achieve the team vision, but it was a lesson that I never forgot and, I hope, did not repeat during the rest of my career.

Several inspirational engineers have influenced me during my career at Ford, but probably the most noteworthy is Richard Parry-Jones CBE (FIMechE and winner of the 2014 James Watt International Gold Medal). RPJ, as he preferred to be known, was instrumental in changing the characteristics of Ford cars from cheap and cheerful "econoboxes" to become the industry benchmark for ride and handling, through his attention to the details of what made cars great to drive. He was able to communicate the importance of this to the engineers who worked for him, and shared his technical expertise in delivering class-leading vehicles, starting with the original Ford Mondeo and Focus models. This was achieved by defining the technical targets at the start of the development process that were necessary to achieve the best compromise between ride, handling, comfort and agility that all drivers would appreciate, and then measuring vehicle performance in great detail against these objectives. Parameters included geometry, spring rates and damping, suspension mounting stiffness and torsional rigidity, steering efforts and friction throughout the suspensions system. His attention to detail, which was demonstrated in everything he was involved with, led him to become the most senior engineer worldwide at Ford Motor Company, responsible for all global Product Development, and to his role as Chief Technical Officer. Although RPJ has now retired from Ford, his legacy of developing cars with exceptional vehicle dynamics continues in the latest products.

Persistence and Courage

Engineering is not always an easy path to successful outcomes, with many challenges including technical, financial and social presenting barriers along the way. The most successful engineers overcome adversity to achieve their goals – Sir Frank Whittle (Honorary Fellow IMechE) was well known for these characteristics in overcoming many issues in the development of the jet engine that transformed aviation on a global basis.

Analysis

A major differentiator in the most inspirational engineers is their use of scientific and mathematical analysis of engineering problems to produce fundamental changes in technology that improve previous design solutions. This is a key reason why the Institution needs to maintain its focus on academic standards for membership entry and in delivering the programmes of technical lectures and training. The link between industry and academia is a major role played by the Institution, ensuring that future generations of engineers continue to attain the highest standards of technical delivery, whatever the level of membership they attain.

Teamwork

It is proven that teams produce better results than individuals facing the same challenge or task. This has certainly been my experience gained at Ford Motor Company, working in large teams of up to 700 engineers to deliver major new products to the market on time and within budget. Every experienced engineer will recognise the importance of teamwork to produce the best results, and the Institution places great importance on this aspect when assessing competences for membership and in the development of competitions such as Formula Student and the Railway Challenge, which are so valuable in developing young engineers.

Automotive Technology

Changes in automotive technology since the invention of cars at the turn of the 20th century have occurred continuously over time, but the pace of change is exponential in terms of the developments being made in more recent years. Since emissions legislation was first introduced in the late 1960s, noxious tailpipe emissions have been reduced by 99% and will continue to be reduced, with further technical improvements to internal combustion engines removing oxides of nitrogen and particulate matter which are known to be harmful to health.

Carbon dioxide emissions have also been reduced dramatically in recent years, driven by concerns over global warming from a fleet average of about 185gm/km in the year 2000 to 124gm/km by 2014, a 30% reduction towards the target of 95gm/km by 2020. Longer term cars need to achieve a fleet average of about 70gm/km to stabilise global warming at no more than a 2°C average temperature increase based on today's global vehicle population. However this may not be sufficient to offset the growth of car sales in newer markets such as China and India, which may require a further reduction to a CO_2 fleet average of about 30gm/km. Putting these numbers into perspective, Tony Harper, Research Manager at Jaguar – Land Rover, presented data at an IMechE seminar on Lightweighting Vehicles for Low Carbon that showed a person walking at 4mph emits the equivalent of 61gm/km and cycling at 9mph equates to 34gm/km.

This may seem to be an almost impossible target, but the application of multiple technologies will allow further reductions in carbon dioxide emissions. These include weight reductions, improved aerodynamic performance, friction reductions, smaller forced induction engines with increasing levels of electrification combined with energy recovery during braking, and potentially artificial or bio-fuels. However, cars will still need to be appealing to consumers and offer affordable solutions that deliver customer expectations for features, range and lifetime operating costs. We may eventually be able to power transport solutions from solar energy, as there is enough sunlight hitting the earth's surface every hour to meet all of man's energy needs for a year. Solar power could eventually provide a plentiful supply of cheap hydrogen, but this will need fundamental breakthroughs in chemistry and may not be achieved for the next 50 years.

Turning to vehicle safety, advances in technology, particularly since the introduction of seat belts, energy-absorbing body structures and airbags, have resulted in the lowest level of fatal accidents in the UK since records were first started. Further enhancements through active systems that avoid accidents, such as automatic emergency braking with camera systems and cars that can automatically steer around obstacles, will be introduced next year by Volvo. Cars will also become increasingly interconnected between each other and their environment, allowing smarter accident avoidance systems that will enable fatal accidents to be virtually eliminated.

While consumers increasingly expect cars that have a minimal effect on the environment and protect them from danger, they also require all of the latest features in terms of comfort and convenience that are precisely matched to their personal and family needs. This will result in ever greater consumer choice, made possible through more flexible manufacturing processes. Cars may eventually be purpose-designed and manufactured to individual customer requirements.

The ultimate automotive industry goals will therefore be cars that produce zero emissions, zero fatalities and consumer freedom of choice.

Self-driving Cars

Much has been written in the press and discussed in the media recently about self-driving, or autonomous, cars. The technology to deliver these is already a reality, but manufacturers will not suddenly introduce fully self-driving cars in the near future, but rather will progressively introduce more and more of the technology over the coming years. Many manufacturers already offer self-parking cars, which can locate and manoeuvre into a parking space using vision systems, proximity sensors and electric power steering. These allow the steering wheel to be turned much faster than can be achieved manually, so that cars can fit into tighter spaces that drivers may not judge could be achieved, as well as the convenience of the automated system, which eliminates the skills needed for parking. The next steps in this development will be to combine intelligent systems that communicate between vehicles and with their operating environment to actively avoid accidents. It is also now relatively straightforward to allow "platooning" of vehicles on motorways, where they can travel in convoy with greatly reduced distances between cars all travelling at the same speed to save fuel, increase safety and reduce driver stress or fatigue for long journeys. The remaining issues that now need to be overcome are legal and ethical, rather technical, to allow the technology to be introduced. However this is likely to happen over a relatively short time scale.

The continuing innovation and development of cars over the coming years will require the sector to find, recruit and develop engineers and technicians who share a future vision of moving people and goods, which is very different from what we have today. This challenge is not unique to the automotive industry, with many other sectors experiencing major changes in their development which will alter the way they operate in the future.

I will address the issue of sourcing and recruiting future engineers and technicians later in this Address. However, as a Professional Engineering Institution, we do have the ability to inspire the future cohort of engineers and technicians with practical applications that add to their academic studies, but also provide the elements of competition and excitement, two important motivators in my mind if we want to keep this future group of engineers and technicians in the profession.

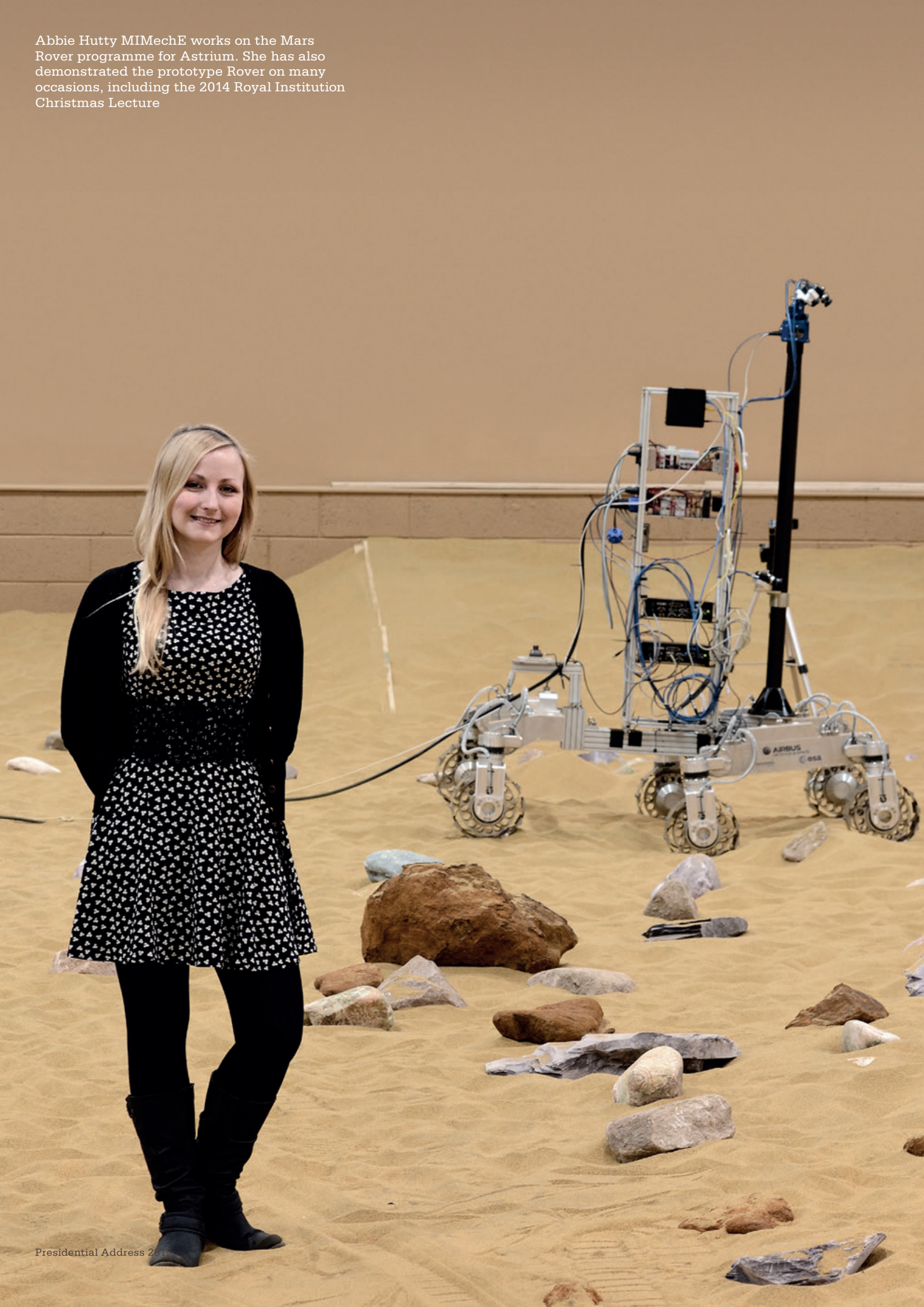
Formula Student/Railway Challenge/Unmanned Aircraft Systems (UAS) Challenge

The Institution provides a variety of team-based, technical challenges to develop future generations of engineers. These are superb competitions which have grown from small beginnings to become world-class events. Formula Student, now the largest student motorsport competition in the world, is in its 17th year with an entry of over 3,000 students in over 100 teams from 35 countries.

The Railway Challenge has been running since 2012, with similar aims to Formula Student to provide team-based experience and encourage those interested in a railway engineering career. In 2015 the Aerospace Division will hold the first Unmanned Aircraft Systems (UAS) Challenge to achieve the same objectives for aeronautical undergraduates and has already attracted entries from 12 UK universities for the first competition.

Despite the success of these competitions, they will not be appealing to all young aspiring engineers, and we need to find new ways to connect with those motivated by other priorities.

Abbie Hutty MIMechE works on the Mars Rover programme for Astrium. She has also demonstrated the prototype Rover on many occasions, including the 2014 Royal Institution Christmas Lecture



INSPIRING THE NEXT GENERATION

While the achievements of past great engineers may have inspired many of us to follow careers in engineering, the people and achievements of history may not be so relevant in motivating future generations, particularly those who have grown up with computers, mobile phones and the internet. A recent newspaper article concluded that today's young engineers are "more likely to be inspired by Tony Stark (AKA Ironman) than Brunel".

The Institution of Mechanical Engineers and its sister Professional Engineering Institutions, such as the IET, ICE and IChemE, need to develop new ways of engaging with young people at school and university to encourage them to follow careers in engineering. There are some excellent examples of Institution members inspiring young people to pursue careers in engineering at all levels of technical achievement.

Jenny Smith, EngTech MIMechE, works as a Senior Product Definition Engineer for MBDA, an aerospace company in Stevenage. Every Friday afternoon after work Jenny goes into the John Warner School in Hoddesdon, Hertfordshire, to help enthusiastic secondary school children build robots to compete in a global competition called VEX Robotics (see vexrobotics.com), where teams use robots to compete in challenging tasks against the clock. Last year the team from the John Warner School came second in the world, beaten only by the US Navy team. The Institution supported the school by awarding a prize to finance further purchase of materials.

It is notable that a large proportion of the students are girls, because of Jenny's encouragement, including all-female team, and they have even invented a new word to describe what they do: "femgineering". This is a great way to engage today's students in an exciting mix of mechanical and electrical engineering tasks.

In December 2014 Danielle George, Professor of Radio Frequency Engineering at the School of Electrical and Electronic Engineering, University of Manchester, presented the Royal Institution Christmas Lectures entitled Sparks will fly: How to hack your home. This was an outstanding series of three lectures covering light and communications, with the final lecture covering electric motors and motion with a particular focus on robots. The content was truly inspirational and clearly excited the young audience in the lecture theatre.

During the final lecture, Institution member Abbie Hutty MIMechE who works on the Mars Rover programme for Astrium, presented the self-driving explorer that is being developed for launch to Mars in 2018. This showed the self-driving car operating in the lecture theatre and was a great example of vehicle technology at the leading edge of what is possible for the future.

A recent IMechE report identified five specific groups of students with different characteristics that could be developed into future engineers

LOOKING FORWARD

The next generations of engineers need to be inspired by different things from in the past. The Institution has recently published a report on this issue entitled Five Tribes, that identifies five specific groups with different characteristics that could be developed into future engineers.

The report responds to the identified underperformance in recruitment of new engineers, which falls 50% short of the future needs of the UK. It states that careers from STEM need to be described in terms of personal characteristics required, rather than our historical approach of "I'm an engineer …. Be like me." It advocates treating potential entrants like customers, and that understanding their values and beliefs could lead them to consider a career in engineering.

Five broad categories ("Tribes") of adolescent attitudes to STEM within the UK are identified:

- Two of the Tribes, "STEM Devotees" and "Social Artists", are present in different proportions across all ages. They express very different attitudes and ambitions but are more focused in their goals than other Tribes.
- The three remaining (smaller) Tribes are found across different age groups, although the size of each Tribe is variable at different age stages.
- The "Enthused Unfocused" Tribe emerges as a potentially valuable source of engineering talent. They are passionate about STEM but lack confidence to achieve success in the subjects.
- Social Artists are a large female-dominated and creative section of the population who seem to have little affinity with STEM. Their rejection of STEM is mainly driven by absence of interest rather than lack of confidence. Social Artists are the second largest and a potentially influential Tribe.
- The "Individualists" are independent innovators and future entrepreneurs. Although they value creativity and consider it evident in engineering, they do not see engineering as being for them.
- The "Less Engaged" Tribe reflect a section of the school-age population who are relatively less connected to school and appear to have low interest in wider social values in comparison to the other Tribes.
- Technology appeals overall to some Tribes more than others. Though there are clear differences in the profile of the technologies that appeal to individual Tribes, greater disparity is evident between the interest expressed by young women and men within the same Tribe (girls in all Tribes find most technology less appealing than boys).

The report provides a great opportunity to change the way that engineering is promoted to young people and particularly girls.

GIVING BACK

All engineers should be concerned about passing on their enthusiasm for their chosen career to others. There are many ways that this can be achieved.

- Get involved with Institution activities.
- Talk to young people about your enthusiasm for engineering.
- Arrange work experience in your engineering organisation for 16 to 21-year-olds.

It is evident that although the Institution of Mechanical Engineers is doing well in growing its membership and providing a strong support for the development of engineers, there is a great deal more that needs to be done in the near term to encourage more young people into engineering careers. We need to double the current numbers of people coming into the profession each year, and the shortfall of female entrants is an obvious area for improvement.

This year the Institution of Mechanical Engineers will achieve its highest membership numbers ever at about 111,000, but this falls well short of the number of eligible engineers who could join us. If every current member could encourage at least one, if not two, new people to join us this year, we could double the size of the organisation. This would greatly increase our capability to both influence the future of engineering and provide better services and facilities for our members.

My challenge to engineers: encourage at least three additional young people including a minimum of one girl to study engineering over the next year, and be able to tell me their names!

SEIZING THE OPPORTUNITY

In this Address I have discussed a number of Institution activities and initiatives that are helping to inspire people to either enter, or pursue a career in, engineering. These are all worthy projects and we need to continue to develop, promote and build on them in the future.

Outside of the IMechE there are a myriad of other projects, initiatives, campaigns and events which are staged each year by Government, schools, clubs, institutions, companies and members to encourage more people into the profession. But while many have value and are making an impression on the students who participate, the basic fact is that the number of people joining the science and engineering professions isn't rising by anywhere near numbers needed.

This is not a criticism but a fact. A fact that many people in our profession will find uncomfortable and perhaps do not want to hear. However, even after all these initiatives, the simple truth is that the number of people entering engineering is not keeping up with the number leaving the profession, and certainly isn't keeping up with projected demand for engineers and technicians over the coming decades.

My concern is that all the rhetoric from many quarters about promoting the STEM professions is little more than hot air. Of the small number of positive initiatives and funding provided, the impact on the numbers entering engineering or the sciences is negligible.

In 2014, the Government celebrated 77,000 people taking A-level maths, the highest number in years. However, if we want to meet projected demand for engineers and technicians, based on figures by EngineeringUK, we would require every student who sat A-level maths to pursue a career an engineering, and then find an additional 10,000 more. This of course would also fail to address the shortages in the other STEM professions.

This skills shortage hasn't just happened overnight, but has been a trend for at least 30 years. We have all been tinkering around the edges of what needs to be a radical and fundamental change.

The last three decades have seen changes to our national curriculum which have steered people away from careers in engineering. We have directed children down routes which are easier, seem like more fun, provide more income potential or simply have a more fashionable image. We have also given schools and students too much choice, allowing them to move away from subjects which seem boring, too hard or irrelevant. Today the term "engineering" is almost non-existent within the curriculum. However, children are taught about careers such as law, accountancy, media and marketing.

In March this year, a report by the CBI found that 53% of teachers at primary school think the sciences are not a priority issue and that more emphasis needs to be placed on other subjects such as English. If we cannot spark children's imagination at this age, we can forget about any real change in their secondary years. Reflect on the story that was recounted earlier, when a primary school teacher was asked where metal came from. If the outcome from this experience had been different, I may never have followed the path to become President today.

This issue cannot be solved by the Institution or even multinational corporations such as Rolls-Royce or Jaguar Land Rover. This needs a national solution led by Government. Government, working together with teachers, need to reshape the curriculum so that what is taught reflects the needs and demands of the nation.

So what do we need to do? The UK needs more scientists and engineers to keep industry and the economy growing, so a clear-cut change would be to revise the curriculum and make STEM subjects compulsory for all students until the age of 18. This would mean more children would have the potential to pursue STEM careers, and would also give all individuals a better baseline understanding of science and engineering. A revised version of the baccalaureate system would be one potential model, where pupils pursue a greater variety of subjects and then focus on their particular areas of interest post-18.

I recognise that our education system has seen an array of changes and overhauls in recent years and is often treated as a plaything for politicians and parties wanting to make their mark. Teachers, parents and students have understandably become weary of the continuing movement of the goal posts. But what I am proposing, while probably unpopular to some people, would actually bring tangible economic benefits to the country. This wouldn't be a change based on personal or political ambitions, but a change that would benefit the UK as a whole.

But if the curriculum change is considered too hard for any Government to implement, and it would be a monumental task, then possibly a carrot approach may be an alternative solution. Currently many medical degrees are cost-free to the student, the costs being absorbed by the NHS/Government. This is because we recognised decades ago that we need doctors to keep our NHS and country operating. The payback is that doctors have to serve time in the NHS. If students today were told that undertaking a science or engineering degree was cost-free, I wonder how many would be persuaded to take this option, especially with an easy saving of about £36,000 over a four-year degree. This method is crude and has many obstacles, including potential resistance from the universities themselves who may feel they would not be compensated by Government. How would the students payback for their learning to the nation, as we don't have a national engineering service? But the idea has great support from the membership and, encouragingly, from the public, where many feel subjects of national-critical importance should be free or at least have reduced fees.

On the current spaces at university, should we allow these to be taken up by overseas students who pay considerably more to the university coffers and provide a vital income source, or should UK students have first preference in the national interest?

The big question is how you make this change. The Institution is only one voice. The profession does not speak with one voice, or even have one train of thought. The fractured voice of the profession, be it institutions, industries or multinational companies, creates a confused message to Government. If we can't get our message and concerns in order, why should they listen?

We cannot work in isolation and speak just from our perspective as engineers. We need to speak from the entire STEM community, jettisoning our own small issues and addressing the overall STEM shortage, irrespective of discipline. Only then can we show Government real direction and vision.

In Conclusion

We, as a profession, have a considerable uphill task over the coming years to reverse a downward trend in our industry which has lasted decades. However, I believe we are starting today from a far more positive position than even ten years ago.

Across the political spectrum, the main parties are all espousing the virtues of science and engineering. Manufacturing and engineering companies are now seen as exemplars of hi-tech, high-skilled enterprises necessary to cement the UK's future position in this ever-growing global economy. Today it is fairly commonplace to see the Prime Minister or Ministers make announcements or launch initiatives at engineering companies, even if what look like a forcefully gathered group of employees often seem slightly uncomfortable in the background!

On TV, in the newspapers and online, engineering and science coverage has also increased dramatically. Whereas only a few years ago you had Tomorrow's World and the odd engineering or science show on BBC2, today we have entire channels dedicated to our profession, showcasing the grand engineering feats of the past, the impressive projects happening today, and even programmes answering the basic question of "How do they make that?".

What is required is for the profession to capitalise on this situation, and I believe our Institution has an important role in achieving this. The coming years will be ones of exciting growth, diversity and, I hope accomplishment. I believe strongly that as an Institution we can and should position ourselves as a facilitator between the many interested and motivated parties for change, be a source of sound comment, expert knowledge and advice to industry and Government, a constant and consistent driver for the needed change, and overall promoter of this great profession throughout society.

Our Institution's founding father, George Stephenson, left the world his legacy. I believe part of our generation's lasting legacies should be to ensure the profession not only remains a vital cornerstone of our economy, but is at the heart of our nation's future success.

ACKNOWLEDGEMENTS

First, I would like to thank my wife Pattie and my family for their love and support in my progress towards the role of President.

I would also like to thank Ford Motor Company, and in particular Sarah Haslam MIMechE, for their assistance in producing this Address. Thanks are also due to the students and staff at the University of Hertfordshire for the Formula Student video, Abbie Hutty MIMechE for her help with the ESA Mars Rover material, and Jenny Smith MIMechE for her great work in inspiring the next generation at John Warner School.

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