The Royal Academy of Engineering

For the engineering leaders of tomorrow

Two lectures by Lord Browne of Madingley

President, The Royal Academy of Engineering 2006-2011

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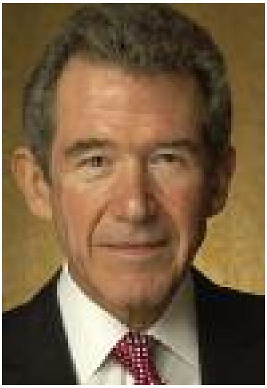
Contents

Introduction 3

Resources for humanity 5

The education of the engineer 17



Lord Browne of Madingley FREng FRS
President, The Royal Academy of Engineering

For the engineering leaders of tomorrow

Two lectures by Lord Browne of Madingley

President, The Royal Academy of Engineering 2006-2011

To mark the close of his term as President of the The Royal Academy of Engineering on 11 July 2011 and to celebrate the Academy's 35th anniversary, Lord Browne invited 250 early- to mid-career engineers to take part in two "In conversation" events.

This publication reproduces the two lectures with which Lord Browne opened each of the meetings. In the Chair were David Waboso FREng, Director of Capital Programmes, London Underground, and Paul Westbury FREng, Chief Executive Officer, Buro Happold.

To view the lectures and the wide-ranging question and answer sessions that followed, please go to www.raeng.tv

Figure 1: Founder Fellows at Buckingham Palace

Resources for humanity

The Royal Academy of Engineering, 30 June 2011

Our profession, engineering, underpins the progress of humankind. For thousands of years, engineers have unlocked the natural resources of the earth for the benefit of humanity. Engineers have given practical application to scientific endeavour – driving economic growth and bringing billions out of poverty.

In the future, it will be engineers using the earth's resources in new ways who continue that progress, solving the great challenges we face today.

But for engineers to succeed, they must play more than a supporting role – they must be at the forefront of society, as leaders capable of driving change, not following it.

That's why I am delighted to see you all here, as some of the best engineers of your generation, on your way to becoming the leaders of tomorrow.

In this lecture, I want to discuss what it means to be a leader and how being an engineer equips you for that role. In particular, I want to talk about the leadership role of engineers in marshalling two vital resources: water and energy.

But before we begin, I'd like to point out that this lecture is part of our celebrations of the 35th anniversary of this Academy.

In 1976, the Founder Fellows met at Buckingham Palace for the inaugural meeting of what was then the Fellowship of Engineering [Figure 1]. Among them were Prince Philip, Earl Mountbatten of Burma and 128 other distinguished engineering leaders including Sir Barnes Wallis, the inventor of the bouncing bomb, Ove Arup, the great architectural engineer and Sir George Macfarlane, the pioneer of radar.

Their vision was about how engineering can best be promoted for the national benefit, for progress in wider society and for the future of humankind.

I have had the pleasure and the privilege of serving as President of the Academy for the last five years. Next month, I hand over to my successor and I want to briefly reflect on how we are working to realise the vision of our founding Fellows.

Through its Fellowship, the Academy has been working to foster a much better understanding among the public and opinion formers of what engineers do and can achieve.

We are helping to create an education system that inspires and encourages young people to choose a career in engineering.

And we are supporting the kind of research and ideas that businesses can profitably turn into wealth.

There is still a long way to go, but I think we have made real progress towards the vision of our founders.

Above all, engineers are increasingly recognised by policymakers and society as essential to addressing the grand challenges that we all face.

One of the greatest of those challenges is providing adequate supplies of water – the first arena for engineering leadership that I want to discuss.

Water

The need to marshal natural water resources to serve humanity was behind some of the very earliest engineering. For the engineers of ancient China, the Roman Empire, and the Islamic Golden Age, water supply was the pre-eminent challenge.

Take, for example, the glorious Pont Du Gard [Figure 2]. Spanning almost 300m, 50m above the ground, and weighing 50,000 tonnes. It was constructed by the Romans 2,000 years ago, and is still standing today.

Figure 2: Pont du Gard, France

Figure 3: Desalination Plant, Llobregat, Spain

At its peak, it carried 200 million litres a day to the citizens of Nîmes – feeding the prosperity and development of that city. The strength of Rome's empire relied, in many ways, on the ingenuity of her engineers.

In the intervening millennia, engineering our water supplies may have become less glamorous, but it is no less important to our health and prosperity.

The achievements of today's water engineers are just as impressive as those of their Roman forebears. For example, a single desalination plant in Barcelona [Figure 3] uses reverse osmosis to provide drinking water to more than a million people.

With projects like these, engineers manage to provide clean drinking water to almost six billion people on earth, a breathtaking achievement for humanity.

But big challenges remain.

Most shocking is that almost one billion people still live without a safe supply of water.

That is not an insoluble problem: it is technologically possible to provide clean water for everyone. But many communities do not have the financial resources or the political structures needed to implement solutions.

That means engineers have to create innovative systems that are not only technically adequate but are deliverable, given the financial and social resources available.

In many cases, that means building small-scale water systems that are cheap to deploy and easy to repair: systems such as the rainwater collectors used in Kerala [Figure 4], which can easily be built and maintained by local communities without external assistance.

Figure 4: Rainwater Collector, Kerala Prvoince, India

To an engineer, it is second nature to design systems like this that meet multiple constraints – technical, social and financial.

That is also a crucial skill for a leader. Whether delivering drinking water to a village in rural India or tackling larger-scale projects, the first step must always be to understand the context of a project and, in particular, the resources available.

Doing so allows you to define the purpose and the strategy of your organisation.

Providing access to those without water is not the only challenge that water engineers face.

Even greater is the problem of water scarcity – many regions have an adequate supply network, but do not have enough water to keep it flowing.

Water resources across the globe are strikingly uneven. The average American citizen, for example, uses more than 10 times as much water as the average citizen of Zambia.

The problem is most acute in developing countries, where population is growing most rapidly and lifestyles are becoming ever more water-intensive.

In many of those countries a pattern of water stress is already emerging.

Irrigation for agriculture, which underpins many developing economies, has to compete increasingly with new industries – particularly tourism and manufacturing.

Rapidly expanding urban populations add another pressure on water and sewerage systems. In pursuit of new jobs in new industries, the majority of the world's population now live, for the first time in history, in towns and cities.

And as a result of climate change, some of the world's poorest regions are predicted to experience less precipitation, worsening problems of water scarcity.

Water scarcity has serious consequences – it retards economic development, it damages health and hygiene and it leads to conflict in society as factions struggle over limited resources.

Addressing these challenges requires engineers to act not just as technical experts but as communicators – aligning diverse groups of policymakers, entrepreneurs and activists behind a project.

Nowhere illustrates my point better than the nation of Jordan, one of the most water-poor countries in the world.

I've seen myself how the once mighty River Jordan has been reduced by more than 90% to little more than a small stream in places [Figure 5] thanks to the extraction of water by Jordan, Israel and Syria.

As a result, the Dead Sea, which is fed by the River Jordan, is falling by about a metre a year; and the six million inhabitants of Jordan's capital, Amman, receive water only once or twice a week.

In response, Jordan is undertaking a massive engineering project – constructing almost 1,000 kilometers of pipeline to carry water North from the Red Sea: to replenish the Dead Sea, and to provide water for Amman [Figure 6].

Figure 5: The River Jordan and "Kfar-Hanasi" Bridge

The scale and complexity of this "Red-to-Dead" project are huge. The pipeline will eventually carry close to a billion cubic metres of water a year and cost up to $10 billion. The technical challenges for engineers are vast.

But just as challenging are the political and environmental considerations. Engineers have to design a system that can win the agreement of Jordanians, Israelis and Palestinians – no mean feat.

And they must satisfy environmentalists that they are minimising the impact on the ecology of the Red Sea, the Dead Sea and the Arabah valley in between.

Figure 6: Red to Dead Canal Route

The engineers working on "Red-to-Dead" are not just technicians and experts – they are diplomats and negotiators.

Those abilities are crucial to successful leadership: leaders must be able to align multiple parties – both internal and external – behind their strategy to achieve success.

Energy

In life, there are few resources as important as water. But one other comes close – my second topic in this lecture and the focus of my career – energy. Energy is essential for heat, light, and mobility, as well as food, communication and consumer goods. It underpins economic growth and the spread of social progress.

Throughout history, engineers have developed new sources of energy.

They started with biomass in the form of wood and feedstuff for working animals.

In the industrial revolution, they started to unlock the vast energy trapped in fossil fuels: first coal, then oil and then natural gas.

And in the last few decades, engineers have introduced a new generation of energy sources: nuclear and renewables.

The unlocking of new resources has repeatedly revolutionised our economic, social and political lives, changing the way we work, live and travel.

But today we face a formidable challenge: to maintain the supplies of energy that underpin human progress.

Energy demand continues to grow strongly, driven by population growth and increasing prosperity. The International Energy Agency estimates that the world will consume 40% more energy in 2035 than it does today.

At the same time, conventional supplies are becoming increasingly concentrated in the hands of a few nations [Figure 7].

Three nations – Saudi Arabia, Iran and Venezuela – control more than 40% of global oil reserves; while Russia, Iran and Qatar control more than half of the world's conventional natural gas reserves.

In recent months, political events in the Middle East and North Africa and the subsequent rise in the price of oil have demonstrated how this concentration jeopardises our energy security.

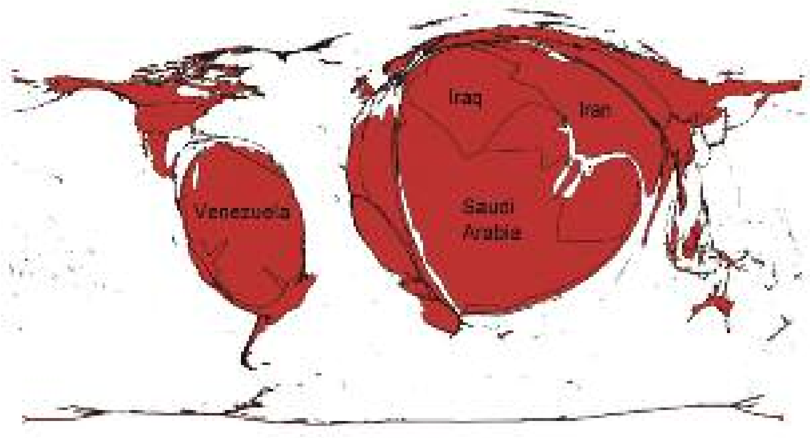


Figure 7: Area Proportional to Proved Oil Reserves 2010

Meanwhile, as we strive to meet growing demand and guarantee energy security, we must also drastically reduce the greenhouse gas emissions of our energy production.

As engineers have unlocked energy from the earth, they have also unlocked carbon – with unprecedented and uncertain risks for our climate.

It is a profound truth, only now being recognised, that we cannot grow first, pollute second, and clean up third.

So the challenge is great – to meet the world's energy demand in a way that is affordable, secure and clean.

There is no easy solution. We have to make very difficult decisions involving uncomfortable trade-offs; because every source of energy comes with significant risks.

Take, for example, natural gas.

Technological innovation has made it possible to extract natural gas from places previously thought impossible.

The most significant development has been a fall in the cost of a process called hydraulic fracturing – injecting water and sand into a well to fracture underground rocks and release the gas trapped inside.

That has made it economic to produce gas from shale formations. Thanks to these shale resources, the US is now self-sufficient in natural gas, an unthinkable prospect only a few years ago.

Elsewhere around the world, shale gas presents an opportunity for countries to develop secure domestic supplies – for example in Lancashire [Figure 8].

Figure 8: Shale Gas Exploration, Preese Hall, Lancashire

But shale gas, like every source of energy, has inherent risks.

In particular, the industry is struggling to win public acceptance for its use of hydraulic fracturing. Although historical evidence points to the safety of the process, many fear that it could contaminate water supplies, and concerns have already led to bans or moratoria in New York State, Quebec and France, halting exploration in its tracks.

For that reason, we cannot rely too heavily on natural gas as a solution to the energy challenge.

New sources of oil also have the potential to introduce variety to our supplies.

There are particularly promising resources in the deep waters of West Africa, Brazil and the American Gulf of Mexico, where the gigantic Thunder Horse Rig [Figure 9] is based. For some idea of the scale, its surface area is the size of three football pitches.

Figure 9: Thunder Horse PDQ, Ingleside, Texas

On land, Canadian oil sands and North American shale have tremendous potential.

But at these frontiers there are significant risks.

There are operational risks, when people, systems or processes fail, as we saw with devastating consequences in last year's oil spill in the Gulf of Mexico.

There are political risks, which can be unpredictable, sudden, and deeply damaging.

And there are strategic risks. Partnerships and acquisitions can rapidly turn sour, even after the most rigorous due diligence.

Figure 10: Aerial Photograph of Fukushima Power Plant before the Tsunami

What these risks have in common is that they cannot be eliminated. Exploring unchartered territories with innovative technology and untested partners is an inherently risky activity.

Nuclear power is another important alternative, but the terrible events at the Fukushima power plant in Japan [Figure 10] have cast its future into doubt. Germany, for example, plans to shut all its reactors by 2022.

In my view, that response is misguided. Abandoning nuclear power would likely mean increasing our use of coal – a far more dangerous source. Every year, thousands of coal miners die in accidents and air pollution from coal causes hundreds of thousands of premature deaths.

But the catastrophic potential of nuclear power understandably generates fear and makes public acceptance very difficult.

Alongside insecure fossil fuels and unpopular nuclear, renewable power looks increasingly attractive, both for its environmental benefits and its ability to provide secure domestic energy.

Experience in the industry is growing and costs are falling. Over the last five years, annual investment in clean energy has grown fivefold to more than $250 billion, and the price of solar cells, for example, has fallen by three quarters.

But despite that, renewable technology remains, in general, far more expensive than the conventional alternatives.

So, we face an energy landscape of tough choices, with expense and risk wherever we turn. Whatever sources we choose, we will be criticised by someone.

In the end, we will not find a single source of energy that solves all our problems. We will rely on a new mix of sources that balances the environmental and financial costs of different technologies and reduces risk through diversity.

In my view, fossil fuels, nuclear and renewables will all form part of that mix.

Delivering a new mix requires a revolution in all aspects of our energy production and consumption.

In Saudi Arabia, for example, water desalination is responsible for more than half of domestic consumption – or one in every 50 barrels of world production. The Saudi government is now beginning the transition to solar powered desalination – realising that it makes both economic and environmental sense.

Transformations like that must take place across the world. And it will be engineers who drive that process.

Engineers will develop the technology to exploit the renewable resources at our disposal. Wind, wave and nuclear power are already providing exciting new opportunities for UK industry [Figure 11] .

Engineers will build the systems to make fossil fuels plants cleaner and more efficient, and potentially to capture and store the carbon emitted.

And engineers will improve the efficiency of energy consumption across every industry – ensuring that our economic prosperity is sustainable in the long-term.

In every case, engineers have a unique skill that makes them invaluable: an ability to execute solutions with a grasp of both technical details and commercial reality.

That means not only understanding how a system works, but understanding how to implement complex change, how to manage risk and how to keep control of costs.

That capability must be at the heart of society if we are to deliver the new energy mix successfully and affordably. That is why engineers must act as leaders, not followers.

Leadership

I believe leadership requires three core skills: the ability to define a vision that fits your context, the ability to align diverse parties to work towards that vision, and an ability to execute that vision efficiently.

Engineers, by the very nature of their training and their work, are equipped with these skills better than any other profession.

Every day, engineers create plans to fit their context. Like those designing rainwater catchment tanks in India, they appreciate the resources available to them and the constraints they face.

Every day, engineers align diverse parties to reach a common goal. Like those planning the Red to Dead project in Jordan, they understand how to communicate a vision with broad appeal.

And, every day, engineers execute solutions efficiently. Like those working on the energy systems of the future, they grasp how to manage risks and control costs.

For too long, engineering has been seen by others somehow as a supporting profession. I am afraid that, too often, engineers have gone along with that perception, when in fact, engineers, with their unique skillset, are leaders and need to be the drivers of change.

As engineers, in whatever field, we have a unique and crucial role to play in transforming the natural resources of the planet into benefit for humanity – a role that has never been more important than it is today.

We live in a world more interconnected and intertwined than ever. That adds complication but it also multiplies opportunity: a leader in one place can make a greater difference than ever before.

Your challenge is to take this opportunity and make the most of it. Work with us, with your professional bodies. Equip yourselves with the skills and experience you need to become the leaders of tomorrow.

Figure 11: Scroby Sands Wind Farm, Great Yarmouth

The education of the engineer

The Royal Academy of Engineering, 5 July 2011

I am delighted to see you all here, as some of the best engineers of your generation, on your way to becoming the leaders of our profession.

As a young man, I chose a career in engineering because I wanted to make my mark in the real world. I imagine many of you are driven by that same goal.

In this lecture, I want to explore what skills equip an engineer to maximise the impact they have on the world around them.

In other words, what makes a great engineer? And how do you educate one?

Throughout my career – at BP and here at the Academy – I've worked with many great engineers and seen them achieve a wide range of extraordinary things.

Whether it's constructing a 1,800 kilometre pipeline in central Asia, developing breathtaking 3D geo-imaging software or developing innovative forms of solar power, these engineers have made significant contributions to the progress of humanity.

To me, these achievements are striking not only for their diversity, but for the common capabilities that have made all of them possible.

I believe that successful engineers share certain characteristics. In particular, I believe a great engineer is four things:

- an expert with a broad base of knowledge.
- a strategic thinker with an eye for detail.
- an innovator.
- and a communicator.

The education of an engineer should be designed to instil and develop these skills.

An expert with a broad base of knowledge

Last month I was in Beijing, at a conference to discuss innovation and low carbon growth.

There, we discussed the words of the Chinese philosopher Lao Zi who said, "All difficult things have their origin in that which is easy; and great things in that which is small."

That is certainly true for engineers: every great engineering accomplishment is built on the technical mastery of a specific discipline.

But, to my mind, specialisation for an engineer should not come at the cost of broad understanding.

In the real world, engineering challenges do not come neatly labelled "civil", "mechanical" or "electrical". In fact, the most innovative solutions often emerge when ideas from these separate disciplines collide.

A good example is a recent winner of the Academy's MacRobert Award – the i-LIMB Hand – a prosthetic device that looks and acts like a real human hand [Figure 12].

Figure 12: iLIMB Hand

It has five individually powered digits, heralding a new generation in bionics and patient care.

That innovation was made possible by bringing together cutting edge mechanical and electronic engineering with groundbreaking software and state-of-the-art plastics.

Of course, it was designed by a team of engineers who each had their own specialism. But success relied on communication and co-operation between them; it required that each understand the technical language used by the others, and the basics of each field.

An engineer cannot be an expert across the board, but a great engineer is equipped with enough knowledge of each field to understand how the system operates as a whole.

There is an analogy here with physicians. We recognise that before a doctor can specialise, they must understand how the whole body – the whole system – works. In my view, that same breadth of knowledge should underpin the education of the engineer.

A strategic thinker with an eye for detail

But, of course, engineering is about far more than knowledge. An engineer's core business is to turn theory into practice; to translate scientific progress into commercial and social value.

That requires more than technical competency. It requires an ability to juggle the competing demands of a project – managing risks, controlling costs and keeping to time.

In other words, it requires an ability to combine high-level strategic thinking about a system with a scientific precision on specific issues.

For example, when I was at BP, we built the Baku–Tbilisi-Ceyhan pipeline, stretching 1,800 kilometres from the Caspian Sea to the Turkish Mediterranean [Figure 13].

The technical challenges were legion: the pipeline climbs up to 3,000 metres, and crosses 1,500 rivers and roads. It had to be buried along most of its route and negotiate five seismic faults.

That project was delivered on time and on budget, not only because BP's engineers were technically excellent, but because they were among the best in the world at managing a complex project subject to numerous commercial pressures.

As the Academy's research has shown, that ability to think strategically cannot be learnt from a book; it has to be developed through practical experience.

Figure 13: Baku-Tblisi-Ceyhan Pipeline

Figure 14: Constructionarium: Scale Swiss Re Tower

It can only be achieved through "learning by doing": getting students to work on real engineering problems and properly consider the consequences of their approach.

In an increasing number of universities, this process is guided by real-life expert practitioners, the Academy's Visiting Professors.

Senior engineers from industry are appointed as Visiting Professors, to enrich the undergraduate curriculum with experience of real-world engineering problems.

The feedback we receive suggests that they are making a real difference.

In my career, I learnt a lot about strategic thinking from great people who took the time to coach me.

I also learnt a lot from my setbacks.

Learning from mistakes is at the heart of another great engineering education initiative – the Constructionarium.

Students are given access to what is essentially a building site – with real equipment and staffed by real construction professionals. They are given a project to build – for example, a scaled-down version of the Gherkin [Figure 14]. Then they are essentially left to get on with it.

They get to apply their theoretical knowledge in the field and, crucially, they get to make mistakes.

They develop the capacity to integrate the technical, operational and business aspects of the job.

Practical education like this is expensive, but the benefits to young engineers are very valuable indeed.

An innovator

Learning by doing breeds another skill in engineers: the ability to innovate. Successful engineers are not only competent, they are inquisitive, interrogative and creative.

These skills cannot be taught – there is no recipe for innovative thinking. But it is possible to create an environment in which innovation can grow and flourish.

Last month, I met a man who knows how to create such an environment.

Kai-Fu Lee used to be head of Google China, and before that Microsoft Research, and has now set up a company called Innovation Works, an incubator for young Chinese companies.

He has a portfolio of more than 30 companies, all run by CEOs under 30, and all producing applications for Android phones. So far, only two have failed, and many are enjoying great success.

According to my reading of his analysis, an innovative workplace needs four things:

- A leader who is ideally a "despotic founder", but is at least very strong-willed. He or she must be able to give the company a single clear purpose.
- Supportive staff. In his case, these are the very best software engineers in China – intelligent, hard-working and creative. They are encouraged to constantly challenge one another with new ideas.
- Aligned incentives. Paying people according to the success of the company rewards innovation.
- Tolerance of failure. Innovation depends on taking risks, and failures are an inevitable by-product.

In my view, Kai-Fu Lee's analysis is spot-on, and it applies just as well to education as the workplace.

We must create a learning environment in which students are encouraged to challenge received wisdoms, in which examinations reward novel solutions to old problems and in which students have no fear of making mistakes.

Human minds are naturally full of ideas. An education system that allows those ideas to flourish will create the innovative engineers of the future.

Two important trends mean that those innovative engineers will be able to change the world more rapidly and dramatically than ever before.

First, more and more innovation takes place in the sphere of applied engineering, rather than fundamental science.

In past centuries the greatest innovations were intellectual. Today they are technological or organisational; they are in the domain of the engineer.

Second, innovation spreads more quickly than ever before. It took at least 100 years for printing to gain 50 million users; the internet achieved the same success in only four.

In an advanced and connected world, a single great idea can have the most incredible impact.

A communicator

The final crucial engineering skill I want to discuss is very different – it is the ability to empathise and communicate.

As my colleague, Lord Darzi, has put it, "Engineering is about finding technological solutions to human problems."

That means engineers must appreciate the social, political and even emotional context of projects, and design solutions that meet those human needs.

They must also be able to explain the benefits that a project can bring, in order to align diverse parties behind it.

The Baku–Tbilisi-Ceyhan pipeline project is once again a good example.

The route crossed three countries – Azerbaijan, Georgia and Turkey – and impacted on more than a hundred different ethnic groups. In total, some 750,000 people in 450 different communities were affected by the construction.

We knew that the success of the project would depend on the support of those groups – there had to be economic, social and environmental benefits for all those involved.

Engineers working on that project had to understand the human context of their operations, to listen to local stakeholders and employees [Figure 15] and to explain the benefits to all those affected.

The ability of BP's engineers to do so was essential to the success of the project.

In the UK today, the situation for engineers is very different, but the need to act as a communicator is just as important.

There are few areas of policy, for example, that do not have an engineering dimension to delivery.

An increasingly important focus for the Academy is to actively get involved in designing policy.

Earlier this year, for example, we convened a roundtable of industry experts to talk about the barriers to a flourishing offshore wind supply chain.

In areas like this, engineers must be aware of the political and human implications of their advice and proposals – technical perfection is insufficient.

At the Academy, we are also working hard to convey the human impact of engineering to the wider public, especially to young people.

We promote engineering in the media every week. We attend festivals, events and debates. We help run The Big Bang Fair, now into its fourth year, which reaches 25,000 young people. And we are closely involved in the introduction of a new international engineering prize announced recently by the government.

Not only does that raise the profile of the profession and its work, but it inspires the next generation to choose a career in engineering.

Figure 15: Local workers, BTC Pipeline

The future

To conclude, I believe that it is time to reconsider what constitutes the skillset of a great engineer. I believe there are four crucial ingredients:

- a broad-based technical competency.
- an ability to think strategically: breaking down a challenge into component parts, understanding the commercial constraints, and managing risk effectively.
- a willingness to question and disrupt accepted norms, to bring new ideas and innovation.
- a sensitivity to the human context of every project, and a capacity to build support.

Together, these add up to create not only a great engineer, but in fact a great leader, whether in business, politics or academia.

In my previous lecture, I set out what I believe leadership means. I said that being a leader requires you to do three things: define your vision, align your team behind you, and execute the solution.

The education of an engineer, as I've described it tonight, equips an engineer to do all three.

An engineer who has learnt to question accepted norms, who has spent their career developing new ideas and embracing the risk of failure is a leader equipped to define a bold and radical vision.

An engineer who has learnt to understand the human context of every project, who has worked at building teams and support, inside and outside their business, is a leader equipped to align an organisation behind a common goal.

And an engineer who has learnt how to think strategically while considering the details, who has practised by making mistakes and solving problems is a leader equipped to execute solutions with control of costs and risks.

That is why I believe that engineers who hone these skills, who equip themselves as leaders, have the ability and the opportunity – more than any other profession – to make an enormous impact on the world around them.

That applies not only to all of us gathered here today, but to the next generation of engineers, yet to complete their education. In my view it is the duty of every professional, at the right point in their career, to pass on their expertise and experience to the next generation. I hope many of you will do so when the chance arises, whether through employers, professional bodies or universities and schools.

Picture credits

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Figure 5: The River Jordan and "Kfar-Hanasi" Bridge (Beivushtang, CC BY-SA 3.0)
Figure 6: Red to Dead Canal Route (Original map by NordNordWest, CC BY-SA 3.0)
Figure 7: Area Proportional to Proved Oil Reserves 2010 (Data from BP Statistical Review of World Energy)
Figure 8: Shale Gas Exploration, Preese Hall, Lancashire (Copyright Cuadrilla Resource Holdings Ltd.)
Figure 9: Thunder Horse PDQ, Ingleside, Texas (Courtesy of BP p.l.c.)
Figure 10: Aerial Photograph of Fukushima Power Plant before the Tsunami (National Land Image Information (Color Aerial Photographs), Ministry of Land, Infrastructure, Transport and Tourism)
Figure 11: Scroby Sands Wind Farm, Great Yarmouth (Courtesy of Mike Page)
Figure 12: iLIMB Hand (Courtesy of Touch Bionics)
Figure 13: Baku-Tblisi-Ceyhan Pipeline (Courtesy of BP p.l.c.)
Figure 14: Constructionarium: Scale Swiss Re Tower (Courtesy of Imperial College London)
Figure 15: Local workers, BTC Pipeline (Courtesy of BP p.l.c.)

The Royal Academy of Engineering

As the UK's national academy for engineering, we bring together the most successful and talented engineers from across the engineering sectors for a shared purpose: to advance and promote excellence in engineering. We provide analysis and policy support to promote the UK's role as a great place from which to do business. We take a lead on engineering education and we invest in the UK's world class research base to underpin innovation. We work to improve public awareness and understanding of engineering. We are a national academy with a global outlook and use our international partnerships to ensure that the UK benefits from international networks, expertise and investment.

The Academy's work programmes are driven by four strategic challenges, each of which provides a key contribution to a strong and vibrant engineering sector and to the health and wealth of society.

Drive faster and more balanced economic growth

The strategic challenge is to improve the capacity of UK entrepreneurs and enterprises to create innovative products and services, increase wealth and employment and rebalance the economy in favour of productive industry.

Lead the profession

The strategic challenge is to harness the collective expertise, energy and capacity of the engineering profession to enhance the UK's economic and social development.

Foster better education and skills

The strategic challenge is to create a system of engineering education and training that satisfies the aspirations of young people while delivering the high calibre engineers and technicians that businesses need.

Promote engineering at the heart of society

The strategic challenge is to improve public understanding of engineering, increase awareness of how engineering impacts on lives and increase public recognition for our most talented engineers.

The Royal Academy of Engineering promotes excellence in the science, art and practice of engineering.

Registered charity number 293074

The Royal Academy of Engineering
3 Carlton House Terrace, London SW1Y 5DG

Tel: 020 7766 0600 Fax: 020 7930 1549
www.raeng.org.uk