

Day 2

Wednesday, 13 September 2006

SESSION 3

ENGINEERING HIGHER EDUCATION

Hugh Norie:

In the first part of this morning, we will have a discussion on the subject of Engineering Higher Education, chaired by Julia King. We will have three speakers and then John Hill, who is chairman of the Joint Board of Moderators, will join the speakers for a panel discussion.

The speakers this morning are Professor Julia King who, as you know, has recently been created Vice Chancellor Designate of Aston University, coming from the Engineering Faculty at Imperial College, where she is well-known. Her field is materials engineering and she has had wide business as well as academic experience in her subject. Before taking up her more recent academic posts, she held positions at director level at Rolls Royce, particularly in the power and marine fields. She also chairs the Defence Science Advisory Council and is a member of the DTI Technology Strategy Board.

Of particular relevance to today, Julia has been chairing the Academy's study on 'Educating Engineers into the 21st Century: an Industry View'. She will no doubt tell us a little about that work.

Professor Chris Pearce will be our next speaker. He is a founding director of the engineering design consultancy, Inbis, and has recently become group technical director of Assystem SA, which acquired Inbis a little time ago. He has had a career as a designer in the aerospace industry, particularly in flying and gas turbine controls, and also in nuclear, rail and marine sectors. He is a visiting professor at Salford and a visiting industrial fellow at Bristol.

Our final speaker is Ken Fulton, who has also had a career in the aircraft industry, specialising in particular in training and human resources. He is currently head of career development for engineering at Rolls Royce, responsible across the company for attracting

and developing the people with the talents it needs for success. This is very relevant to our discussion today. He represents Rolls Royce on various national bodies and is a governor of one of the city technical colleges.

**UPDATE ON THE
“EDUCATING ENGINEERS FOR THE 21ST CENTURY”
STUDY**

**Professor Julia King
Immediate Past Chair, The Academy’s Education Committee**

As Hugh said, I am chairing an Academy working party, which is called ‘Educating Engineers for the 21st Century’. This is focusing on the degree level education of engineers and it is not just about what industry thinks, but the idea is to provide a report for industry, government and universities about what changes are required and recommendations about how we might achieve some of these. The group – most of whom are here, I am glad to say – and I are extremely interested in the outputs of your discussions and thoughts.

I will quickly take you through the survey we did of industry which tends to be called the Henley Study, although I think it should be the Academy Study. The Academy staff and the working group initiated it and have put in an enormous amount of effort into keeping Henley Management College, who were paid to do it for us, on track with what we wanted to get from it. This is just to update you on the conclusions from that.

We are currently gathering responses from academia to a questionnaire which we then sent out, based on what the industry views were. We asked academics to comment on these and how they might respond to them.

If we call the first one the Henley study then, in recognition of the enormous amount of work done by Bob Ditchfield of the Academy, we should call this academic review the Ditchfield Study. I must really say thank you to the Academy team, for all the hard work they have put into this.

This is the industry study and some of you will have seen this before, so I will go through it very quickly. This involved some in-depth interviews with key people in major companies, like BAE Systems and BP. It involved interviews with SMEs and it then involved a questionnaire sent out to a very large number of companies, from which we received 444

responses, just over half of which were from SMEs. I think John Roulston mentioned yesterday that we had had a very good input from the SMEs.

With the university study, we took the conclusions that we had drawn from the industry survey and sent those out to all 240 university engineering departments and also to faculty heads, the accrediting bodies and other people who we thought might have interesting views. So far, we have received 60 replies and they are still coming in, so this is still very much work in progress. They have come from all across the spectrum of types of university and from all but one of the Russell group, although I am not naming any names – but it is not my university, Imperial College.

We have invited them to say what they think about the industry conclusions. Do they agree, or do they disagree? Do they want to comment? We have asked them for examples of best practice, where changes or particular types of teaching or learning were indicated, and we have asked them a range of related questions.

I will just quickly go through these and indicate the alignment between the responses from the universities to the issues industry was raising. I will then direct your attention to some of the issues and questions that are coming out from the study. I hope you might feel that you will want to pick up some of these in your discussions, or in the debate later.

Our first industry conclusion was that industry saw that it would need more high calibre engineering graduates over the next 10 years and that there would be a worsening shortage, as far as it could see. There was a very strong agreement from the universities that that would be the situation.

There was a significant although not huge proportion which saw fewer of their graduates going into industry. There was quite a strong message where they felt that, if industry engaged earlier with the students, and if students had greater visibility of what careers in industry might be like, then the retention of engineers into industry on graduation would be stronger.

The second conclusion from the industry report was that there was a strong message from industry that they wanted graduates to have more experience of applying theory to real, open-ended problems, rather than problems that had precise and exact answers. Universities very strongly said yes, they would like to do that. They try very hard to do that and they would like to do more of it but, to do that, they need greater industry involvement. Universities desperately need more staff who have actually worked in industry and they need generally more engagement with industry over the right range of areas. They need the right sort of facilities for students to do these innovative, hands-on activities. I know that some

universities – such as Liverpool - have made major investments in that sort of facility, but not everybody has had that opportunity. There is a big gap.

Industry highlighted their priorities for what should be included in undergraduate courses. Basically, there was not very strong support for business skills. Industry's strong message was that they wanted business understanding – an empathy with business and an understanding of the types of issues and pressures – but they said that they could teach the business skills, or they could send them on graduate courses to teach them the business skills. The things they could not teach graduates were the theory, and the application of theory – it is much harder to learn that once they have left university. There was thus a strong message, asking for a focus on those.

The third most important point that business or industry highlighted was creativity and innovation – and we will come back to that.

The third [*sic*] conclusion from industry was that industry was reasonably comfortable with UK graduates and that the good ones were certainly competitive with the good ones from Europe. Universities, interestingly, were less sure about this. They put their hands up and said, 'Look, actually, our graduates are weak in maths compared to their European colleagues.' In a related issue as to whether our degrees should comply with Bologna, there was deafening confusion in the university replies. That is quite a worrying point – not necessarily for today's agenda, but an issue for us to sort out in the UK.

We have some interim recommendations from the industry study. Just to give you a feel for the sort of agreement, yes, universities would like to include in their teaching some more open-ended problems. Yes, they felt that their courses needed to be updated to become more appealing and motivating. Yes, they were very strong on teaching needing a higher status and 75 per cent of them commented that they felt the impact of the research assessment exercise on teaching had been a negative one. They were very keen to see more industry engagement but also very strong in saying that they need to recognise the time and cost associated with making changes and also engaging with industry. There was something of the order of 25 to 30 per cent impact on time in terms of actually making some of these things a reality.

One of the interim recommendations was that we needed to address how things like creativity should be learned in university courses. There was a very strong message from universities that they absolutely agreed with that, but they very much wanted advice on how to achieve it.

There were some very humble comments, which were very charming, such as, 'We introduced a course on this, but it has not been a success.' There was a very positive

response in terms of saying, 'Yes, can you help?' At least you are filling the pipeline, which is encouraging youngsters to be interested in engineering.

We also asked a question about whether universities felt that they could be involved in supporting SMEs with graduate training schemes, but we did not hear a very positive response to that – although some 40 per cent or so felt that there might be some opportunities there.

Let me now turn to the subjects on which I would like to spend a little longer. From the academic survey so far, these were the conclusions. There was a strong desire for greater involvement but a concern that industry interacts patchily with the universities. Sometimes it is very keen and, when they cannot recruit graduates, there is a sudden surge of enthusiasm. However, this is not the kind of long-term engagement with a commitment to be engaged over several years, which enables you to integrate some of the industry activities well into courses. This is obviously a general view, which does not apply to every industry and every department.

There have been one or two quite prickly responses, about universities not being there to do industry's training. This was not something that we were suggesting, but that was obviously a slightly sore spot for some people. Bologna – what Bologna?

Industry said very strongly that we would need more systems engineers – much of industry saw a need for that. We asked whether universities felt that systems engineering was a course that could be given at undergraduate level. There was a very strong message that they did not think this was an engineering degree, but most universities talked about how they were trying to integrate systems engineering into their undergraduate courses.

What I thought was a positive message was that 72 per cent of university responses said that they would like to see new engineering courses starting in new areas. We are often accused of sticking very rigidly to our Victorian silos of mechanical, electrical and civil, but universities were asking to be given the chance, because they would actually like to start courses in new areas. More than 70 per cent of them thought that would be good.

They said they would like to be engaged in developing creativity and innovation more effectively in their students, and asked for help.

There was a concern about current assessment and accreditation. As I mentioned before, there was the concern with the RAE about the impact of teaching and the status of teaching. Teaching should be much more visibly celebrated. Once again, the engineering and material subjects tend to have a pretty good press.

An interesting issue was that, at departmental level, most of our respondents had no idea how much it cost to teach a student, per year. Certainly, our estimate at Imperial was of somewhere in the range of £14,000 to £15,000 per year and UCL gave us a similar figure. The places that had some idea were in the range of £10,000 to £15,000 per annum, but of course the HEFCE allocation is somewhere around £8,000 per annum. You can therefore see why universities struggle to run expensive departments like engineering. This is an issue that government has to face up to with the universities and we have to help to bridge that gap if we want any of the good things that we have been talking about to happen.

We have many examples of good practice which, when we have time to go through, to pull them out and get more detail on them, we will publish on the website. We will make sure that they are available for other universities to look at.

My thoughts about some issues to try to provoke some debate is that there is a very positive first headline, which is that universities are strongly in support of the comments that industry made to us, and they would like in general to do all of the things that industry is saying that it would like to see happen.

One of my comments would be that, until I was signing the letters to go out, asking people to fill in this questionnaire for us, I had no idea that there were 240 engineering departments in the UK. That seems to be quite a lot to me. We have been worrying that having 40 physics departments is perhaps not enough, but we have a very large number of engineering departments. We need to address the question as to whether that is one of the reasons why resources are spread so thinly. Do we think that is good, or should we be concerned about that?

There is also the idea that we are all buying into – and I do, too – that we need more engineering graduates. We heard Sir George Cox say that more people should study engineering, whatever they want to do at the end of the day – and I also buy into that. However, we keep being told that China and India graduate about half a million engineers per annum, while in the UK we have around 22,000 to 23,000. That gives us about four times ten to the minus four graduates per head of population and Chindia – as I learned yesterday that we can call it – have half the number of engineering graduates per head of population.

Given the enormous infrastructure and engineering issues that both those countries have, should we feel quite so frightened about them producing half a million engineering graduates per annum? They will actually be very well occupied, dealing with some of their own countries' problem. Viewed like that, the comparison does not look quite as frightening when you look at the density of engineering graduates.

The idea of Bologna is that we should have a three-year first cycle degree, followed by a two-year second cycle. This would mean that we should have a bachelor's degree in three years and a master's degree after a further two years, which would extend our current MEng degrees by a year, making them five years instead of four. Is that of any interest or importance to industry? Or, indeed, should we get onto the question of whether we need to educate different types of engineers at degree level? Do we need a smaller number of elite courses, as Hugh was suggesting yesterday, for our potential engineering leaders, and perhaps shorter degrees for our professional engineers?

I am trying to use words that are not emotive, and hence I have chosen to say 'professional engineers' for the other ones. I am not in any way trying to say that these are substandard qualifications. However, there is then the concern that, if we were to encourage lots of people to follow that route of the professional engineer on a shorter degree, then will those people then discover that, actually, the engineering outposts in India and China are starting to take their jobs, in the way that manufacturing has disappeared from many areas of the UK?

Should we take more risks in introducing new types of courses? Hugh showed a slide at the beginning, indicating that we all thought that energy was one of the most critical issues. Last night at dinner, Andy Hopper said that we should be making more of the fact that energy and global warming is the issue that will be solved by engineers. We should be selling this to children and their parents: 'if you want to save the world, do engineering.' Should we be offering them courses that reinforce that, since it is one of our major problems?

How can we get industry to make longer-term commitments to engagement with education? The Lambert report talked about some of the good things that have happened in university/industry partnerships in research, but is there an opportunity to do more of the same kind of thing in degree level education? John Roulston yesterday flagged up the issues of SMEs, and how could we support them better? Perhaps it could be achieved by involving groups of SMEs in that.

How can we have more interchange of staff between industry and academia? This is an issue that has challenged us for the last 25 years.

Developing creativity and innovation – if you have advice, then the university would like it. Once again, is this an area for some new type of Royal Academy of Engineering visiting fellow, using people from backgrounds that we have not normally seen as Royal Academy of Engineering fellows? I do not know – this might not be the right mechanism but, if you have thoughts about what the right mechanisms are, that would be a really useful input.

Those were some thoughts and issues and I hope some of them were provocative. I will finish at that point. Thank you very much. *[Applause]*

ENGINEERING OUR FUTURE

Professor Chris Pearce
Group Technical Director, Assystem SA

Good morning, everyone. It is very interesting to be here – that is probably the best way to describe it. You will know the old saying, ‘I used to be undecided but now I am not so sure.’ I will try to illustrate that point with my opening slide.

This talk is a derivative of the one that I gave in March at the RSA and it will probably rehearse many of the issues that have already been discussed. When I was wondering what I should talk about and what I should say, it is really about the activities we are undertaking here today, to engineer our future as a profession. Or is it?

Perhaps it is about engineering our future as a nation. Or perhaps it is, Engineering – Is there a Future? We face some fairly profound issues and questions over the next 10 years or so, as we look forward in our profession.

I shall probably speak a little from the perspective of design, because that is the area which I perhaps know best and in which I have been most actively involved.

The historical context

I would like to put engineering into some kind of historical context. Engineering is different from science, and that is one of the issues that sometimes worries me, when I see engineering being lumped into science by government. Science is a very pure discipline while engineering is not. Engineering is a very heavily art-oriented activity. If you look into history, the bias was strongly towards art with some science assisting us along the way.

If you look at the function of design, design is not necessarily about depth but it is more about breadth. Having had a CASE student working on a concurrent engineering project, and finding the difficulties of getting an academic to examine that degree because it did not have apparent sufficient academic depth, from a design perspective, that gives me concern. If you look at engineering historically, it has very much been about how we have the breadth to integrate and develop the products of the future.

Engineering: is it evolutionary or revolutionary? Historically, perhaps there was a good deal of revolution but, over the last 40 or 50 years, it has been mainly evolution.

However, perhaps as we look to the new sciences coming along, perhaps once again there will be the opportunity for revolution in what we are doing.

Is engineering mind or artisan? Effectively, the practical skills of dealing with the material world is a key part of what we do as engineers. We have to have both mind and feeling for the artisan in what we do.

Engineering is about both individual genius and the ability to deliver through team mechanisms. In the historical context, engineering has had these dimensions.

Today's context

What about today? Today, frankly, I do not see very much difference in the environment that we have. We are trying to train our young people in the impossible art of engineering. I picked up one of the large number of papers that David was kind enough to provide us with, and actually read some of it – which just goes to show that, when you are on an aeroplane, you can occasionally find things to do to put you to sleep! [*Laughter*]

Engineers in 2020; Visions of Engineering in the New Century – this is the National Academy of Sciences. Engineering is a profoundly creative process. The most elegant description is that engineering is about design under constraint. That, to me, is a very good and important definition of design.

What do we mean by “Design”?

When I had written down a definition of design, I found that they summed it up perhaps better than I did. Design that we try to take people to understand is about identifying need, and it is about having the vision to conceptualise a solution. One of the fundamental challenges that we have to face as engineering designers is that awesomely difficult starting point where we are faced with a blank screen. I have to say ‘blank screen’ today because, unfortunately, we design on screens. However, as far as I am concerned, the blank piece of paper is where the conceptual ideas start to flow. The ability to visualise is important to us.

Engineering is not a sole activity, but it is a co-operative activity. We therefore have to be able to put the skills in place in order to be able to interpret engineering knowledge and science in putting a practical product together. The engineer's product impacts upon every aspect of our lives. Many of our young people, and many of their parents, really have no appreciation of the impact of engineering on the world around them.

We, as engineers, must increasingly recognise that we have to be socially and environmentally careful in what we do, whilst producing this commercially viable solution. So engineering for me is exactly what the NAS said. It is a profoundly creative process of

design under constraint, and that is the challenge that we face, to which we have to help our young people to orient themselves.

Design competencies for industry

This reflects much of what has been said about engineering fundamentals. Frankly, without them, we cannot do what we need to do as engineers. However, one of the subsets of that is a recognition of how important attention to detail is in developing a successful engineering solution. It is in the detail that we always fail and therefore we need them to appreciate how important that is. They have to be aware of their environment – social, law, and so on. They have to be able to understand the importance of developing a definition of need, because we can so easily solve the wrong problem.

We have huge volumes of information around the world today, but which of it is good, and how do we separate the information from the data and make it valuable? Once again, that is a key skill.

Critical thinking and effective decision-making – that is a key skill. However, increasingly, it is the ability to work with uncertainty, because uncertainty is a significant element of what we always face.

There will be working in multi-disciplined teams, because we will no longer necessarily achieve as individuals. We achieve through the collectivity of having many working together and therefore our ability to manage processes is important to us. Increasingly, in this context of multidisciplinary teams, the world in which we live is generating the need to be able to operate in multicultural, multi-site, multi-country virtual teams, and that is a skill in its own right. That is different from operating in a monocultural environment. Thus, design for industry is quite a difficult challenge – design for everyone.

Threats and opportunities (1)

We face threats and opportunities. Globalisation is both a threat and an opportunity. We see and have heard about countries aspiring, through their graduate population and through their activities, to move into higher value-added activities. There is very strong pressure on industry in the West to reduce all costs – and design costs are just one of those costs.

In Assystem, we have operations in China doing design for the West, and in India, Morocco, and in Romania and Slovakia, doing design for the West. That is because the unit costs there are lower and the economic pressures are driving us to give serious consideration to resourcing engineering into these environments.

We have already seen much manufacturing going into the low cost economies. One of the by-products of this is that we are removing the mind from the skills of the artisan and our young engineers are having perhaps less opportunity for contact with the real art of cutting, manipulating, forming, solving and all of those other basics that make up part of a good design process.

Because there is pressure to reduce costs, we move the lower skilled engineering tasks abroad. The implications of that are that we are moving the tasks that we have traditionally used to train our younger engineers as they come through their careers. This therefore represents both a significant threat, but also an opportunity for this country if we can develop a cadre of people who can operate in this challenging environment.

Threats and opportunities (2)

We have supply side threats and we have heard a good deal about this today – getting the right people into what is perceived as a tough discipline. It will be perceived as a tough discipline, needing good maths, and we have to make it attractive. We have to find effective mechanisms for sharing that excitement of design and, in the short- to medium-term, sustaining an effective and vibrant industry in Europe, to give them an attractive long-term future.

Threats and opportunities (3)

We have real opportunities, too, when we start looking at the implications of the environment. We are moving into an environment where systems integration is a key skill. It was interesting to see that 70 per cent of academia were not particularly interested in systems engineering as a separate subject. Perhaps 'systems engineering' is the wrong term, because I think the 'ability to integrate' is the key issue here.

There is also the opportunity that we have traditionally been an inventive and innovative nation but where we have failed, sometimes, is in taking that through into manufacturing. There are potentially opportunities in looking at mechanisms for encouraging effective transfer of technology from universities into real product, and making that happen in this country rather than abroad. That is a far broader issue, which takes into account the attitude of our financial institutions too.

In all of this, there is both a threat and an opportunity for our government. How should we advise them to be involved in this process and to take positive action that will make an impact on our industry? The R&D tax credits have been very welcome and it would be most interesting to see how those are sustained and whether they are developed going forward. But what other mechanisms might there be?

Opportunities?

If we are radically to shift the perspective of engineering, then we have to involve existing practitioners in design education and, in particular, help to avoid the generation gap. I have spent much of my career in aerospace. Between 1985 and 1991, I seem to remember having to make redundant over one-third of our workforce, because of the severe downturn in aerospace. The simplest mechanism was to allow some of the more experienced people to take early retirement and we lost many educated and experienced people in that way. We also had to cut back on training and, today, we are seeing an education gap, where we have a paucity of engineers in a particular age category. We have to ensure that we do not make those kinds of mistakes in the future.

Equally, if we are to attract the best into engineering as a subject, then where should our focus be? Yes, it should be on influencing the 16 and 17 year olds, but somewhere we also have to capture the nine to 12 year olds, and their parents and their teachers, if we are to move our activities forward. This is an interesting conundrum.

Teaching design at HE level

Design is experience-based. Once again, we have heard a good deal about this. For me, the key feature about design – and the key feature that the visiting professors have been able to provide – is a context for theory and thought. Context is everything in teaching effective design because much of design is about learning by osmosis. It is a matter of learning about the things that do not work, just as much as learning about things that do. We have to create that environment for them.

The role of industry/profession in teaching design

Industry has to engage - and that is a challenge – by providing context and role models. It has to provide a link to reality, and support curriculum development. Those things are very easy to say and we know that we should do this, but getting industry involved is quite a challenge. There is a separate dimension, which is about how we relate to and develop that industrial input and properly value it, and get it valued in their eyes.

The RAEng VP scheme

The VP scheme does part of this. The practitioners who are represented in this room are very respected in their fields. They are eminent, and they have really strong capabilities. In the *Cox Report*, it was acknowledged that this scheme was a very good model indeed for how we achieve some of these issues by providing direction and influencing curricula. There is also some of the cross-disciplinary thinking, which is a key underlying principle that we

need, and championing sustainable design. All of these issues have been very positive outcomes from where we are today.

The most important role of industry/profession and teachers

It has been part of sharing the experience and the excitement of design – and it *is* exciting. If you were there when the A380 took off from Toulouse on that first flight, that was awe-inspiring. It was amazing but every new project is, in its own way, hugely exciting – to see a concept turned into reality. That excitement is something that we have to capture.

We have also lost the contact somehow, during the education of our engineers. I had the fortune to go through a thin-sandwich degree course. The six-month sandwich has its downside, but the upside was that, very rapidly, I was in a six-month environment of applying what I had learned in industry. That was hugely powerful. We cannot go back and recreate that environment but what can we do to give more of our young people that exposure and the long-term, sustained input that we must have?

So what do we need to do to teach design?

What do we do to teach design? I do not think we teach design, but we create the opportunity to ‘have a go’, and to learn from doing. In providing the theoretical context and the decision-making context, and the critical thinking context, we have the beginnings of the way to do design.

And what next in the UK for the RAEng scheme?

One of the questions we shall be addressing later today is, what next for the UK Royal Academy of Engineering scheme? What should we do? I believe that we should sustain and strengthen it, and it is critical that we do so – but what about the visiting practitioner scheme to complement it?

If you look at small and medium sized enterprises, where much of the innovation and leading-edge thinking is going on in our country, how many of them can afford to release a critical engineer to come into university and to make an input? That is a real problem, and how should we address it?

Since many of our young people have never had to take a Honda 50 to pieces and put it back together again, because that was the only way they could get to their next date, they have lost their contact with the real world. They do not know that, if you put a very heavy cut on, life becomes exciting. They do not know that, if you are soldering, solder can be quite an unpleasant thing to pour over your finger. There is a real dislocation with the hard world of engineering and, somehow, we need to find a way of getting back to that.

How might we look at artefact-based teaching, perhaps, to learn something from it? There are some good examples of that around the country. Should we promote the extension of that thinking?

How do we fund SMEs and encourage them to let people out to have a go at being a contributor to the nation, rather than just to the company? How do we influence schools and how do we influence parents? How do we contact them? What do we do with the Royal Academy double-decker bus that we were discussing the other day?

Final thoughts

Engineering is the lifeblood of the UK in my opinion – but then, I am an engineer and I would think that, would I not? I am not an economist.

There are very real threats from the emerging economies. In spite of the relative density of engineering activity, I know that we are now transferring the skills to India, China and other places, that we used to use to train our young people on. I know that the economic pressures to drive down design costs are reinforcing that, and this therefore represents a threat, because we are training the potential competitors of the future. How do we deal with that problem to make sure that we maintain the high ground?

How do we inspire our young people to come into engineering? How do we get the real excitement across? At the end of the day, engineering is *exciting* – that is why I did it, rather than going to one of the colleges in the environs here, to read pure maths. Frankly, three years of that would have driven me crazy,

The Royal Academy VP scheme is a model which we know works. How should we now promote it and take it forward? I leave that question with you.

One final thought, once again from my homework on the aeroplane. The National Academy of Science report concludes:

“This study suggests that, if the engineering profession is to take the initiative in defining its own future it must:

1. Agree on an exciting vision for the future;
2. Transform engineering education, to help achieve the vision;
3. Build a clear image of the new roles for engineers, including as broad-based technology leaders in the minds of the public, the prospective students who can replenish and improve the talent base of an ageing engineering workforce;
4. Accommodate innovative developments from non-engineering fields, and

5. Find ways to focus the energies of the different disciplines of engineering, towards common goals.”

I have to say that those words resonate with me and with some of the things that I have been saying.

I hope you enjoy the rest of the conference. Let's look forward to some interesting workshop sessions. Thank you. [*Applause*]

THE EMPLOYER'S VIEW

Ken Fulton
Rolls-Royce

Good morning, everybody, and thank you for this opportunity to give a perspective on industry's view on matters concerning the higher education of engineers. I am particularly grateful that my brief this morning is based on giving some comments and observations from our experience at Rolls-Royce. I have not been asked to provide any answers to any of the points and observations that I made, so that will be food for thought for some of the syndicate work and perhaps questions for the panel.

I will just give you a few thoughts on these four broad areas. I will do a little exploration of whether industry knows what it really wants anyway, in terms of engineering talents. I will make some comments from an international perspective, and take a specific look at industry/university links. Then I will take a slight step back to look at higher education as part of the total picture.

My job within Rolls-Royce gives me a perspective on some of these things. It concerns some of our engineering talent throughout the world. I look across the whole company and check that we have in place the talent that we need both for our senior engineering leadership positions – those people who will lead and direct our engineering activity in various parts of the world – but also to make sure that we have the key technical specialists that we need in the disciplines that are important to us.

I take a full, global look across all our sectors. Our main business sectors are in civil aerospace, defence aerospace, energy and marine, and it is across all our locations. It is also looking, in a way, at the whole pipeline. Some of my day-to-day work is about senior level succession issues but, equally, you have to look back at that pipeline, and the talent that we are bringing in through our graduate programmes. A fair of my work is back into the

educational sector. Having said all of that, I am absolutely not an educationalist and I am not expert in the theories and principles of education itself. However, I am clearly a consumer of the output.

Just to give a brief feel, we have about 8,000 engineers across the world and, in our terminology, we are talking about the overwhelming majority of those people being graduate calibre or above graduate – masters or PhD level. We have a few hundred people who you would recognise, in old language, as technician level engineers, but the overwhelming majority of our engineering activity is through a graduate population.

We are mainly in the UK – but only just mainly in the UK. The history of Rolls-Royce is definitely that of a British company with all of our engineers in UK locations but today, just more than half are in the UK. Many of the rest are in North America, in Indianapolis, and there are quite a few in Canada. We have a major engineering activity that continues to grow in Germany and we have engineers throughout the Nordic countries. We partner with other companies in different countries but, in terms of our own employees, that is the main spread.

Does industry really know what it needs? Industry talks a good deal – to itself and to the media. It conducts many surveys – hardly a month goes by without me or one of my colleagues responding to a survey from the CBI or from the Engineering Employers' Federation, or from the ETB or, in our case, from the aerospace parts of our business, from SBAC (Society of British Aerospace Companies). There is some regional stuff that goes on, where we are asked all sorts of questions about our skills needs and future requirements in terms of skill types, numbers and so on. We do a great deal of work to try to get that picture of what we need.

I have to say – and I am sure that it is an obvious point in a way – that we clearly cannot see into the future. We need to be very careful in assuming that industry can correctly predict its needs. This is partly because different parts of industry have different requirements and, even within a sector, different companies suffer different fortunes. If you look at the automotive sector, the needs of Rover are very different from those of Toyota at the moment, so we need to be aware of those subtleties.

However much we talk about our needs, quite often our behaviour does not match what we are saying. We can talk about skill shortages and needing more engineers in the UK at the same time as, for business reasons, we are deliberately putting work into India. We can talk about the urgent requirement for more engineers at the same time as making people redundant because of the vagaries of the business cycle. It is quite difficult to translate that message into a reliable signal to education.

Having said that, my experience has been that when we have given a clear message to higher education, the higher education system has responded. Probably the best example I can think of on that is of a few years ago when we and other companies were saying that engineering graduates were OK technically but they were a bit 'spoddy', to use a Derby word. What people were meaning by that is that they were a bit techy, a bit geeky – they could do the sums, but they could not work with others and they did not have the problem solving skills and so on.

Higher education took that message on board pretty proactively and we have noticed a difference. However, it turns out that we did not really mean it, for some of the reasons that the earlier speakers referred to. It turns out that we really wanted engineers who were very good at maths and physics. We can select on personal qualities, problem solving, communication skills, leadership and all the rest of it – we put that into our assessment centres – so we are back-tracking on that message a little. To a certain extent, however, it is too late and we have started to develop people in a certain way. We therefore need to be careful in the way that we put those messages in, and we need to be very careful before we ask for something because we just might get it! *[Laughter]*

I will just skip through a few thoughts on the international perspective. We recruit about 20 per cent of our graduate trainees in the UK from universities outside the UK. We do that on purpose but it is important to understand why. This is not to support overseas operations directly – and that is true for some companies, because they are truly multinational and have operations everywhere and they need to recruit everywhere. However, that is not the case with us. Neither is it because we could not find what we were looking for at home.

We deliberately set out to recruit graduates who were born and educated outside the UK, to try to better reflect our growing international customer base. It dawned on us in the late 1990s that we were doing all of our engineering work for a global customer base, but with teams of engineers sitting in Derby and Bristol, who were born and educated in the UK. We therefore deliberately set out to spice up the mix of our engineering team. When we set out, we did not know what the quality of the graduates we recruited would be but the conclusion there at that bullet point is that our experience has been that the graduates we recruit from outside the UK are very high quality.

There are a number of different reasons for that and I have given a few pointers up there. They definitely have a broader educational base – they know more stuff before they start to study engineering. Having said that, they then study engineering in some great

depth. They tend to have had more structured work experience than UK students. By definition, they are mobile and committed and they bring cultural awareness.

Another point, which I have not included on this slide, is that they tend to know what they want to do. If we have a graduate from Italy, Spain or Germany, who is telling us that they want to work in the field of gas turbine performance, then they are usually right about that. That is what they want to do, and they come and do it. Sometimes we can recruit very talented students in the UK and, largely because they are so much younger – and, just to pick up on another point, I am not saying that we have to adopt Bologna but this is just an observation as a consumer – quite a number of talented graduates who join us say that they want to do something, when actually they do not. We, as a company, can absorb that, because we have so many other opportunities both within and outside engineering. However, this is a clear difference between the European graduate and the UK graduate.

The next bullet point there refers to the fact that our experience has been that professors in European universities appear to believe that their job is to help their students to become engineers, whereas there is an inclination in some UK universities for engineering professors to believe that their job is to teach their students about engineering. That might seem like a slightly unfair distinction but, after seven or eight years of working with universities across Europe, that appears to be the different perspective. This is probably driven by the fact that there is no such thing as a career service in many European universities, so that the professors almost have to start to dabble in careers issues. However, that is a distinction, and it is one that works in our favour when we can have those kinds of relationships with the universities.

The next point is a UK/USA comparison. I have said on the slide that engineers in the USA are more focused on further development but probably what I really meant was that they are focused on further learning. When we recruit an engineer in the US, it seems as though it only takes two days for them to be knocking on the door and saying, 'I have heard that on a Thursday after work there is a three hour lecture on gas turbine performance every week for the next 16 weeks. Where do I sign up? I really want to learn more.' Whereas, in the UK, we offer opportunities for our young engineers to sign up for further study but only about half of them in an average year will take up that opportunity. The others seem to feel that 'A degree from a good university is the pinnacle of the education system in the UK. I have a 2:1 – what more could I need to do?' That is slightly unfair, but there is that difference between the UK and the US.

Then there is the point about globalisation being real. We have seen this from all kinds of angles. In Rolls-Royce, the point I made was that 10 years ago all our engineers

were in the UK, but now they are not. The research that we do with the universities – 10 years ago, 98 per cent of it was with universities in the UK, whereas now it is 48 per cent. We have not reduced what we do in the UK but it is just that all the growth has been elsewhere.

So it is real, but I do not think that we have fully adapted to it yet. There are 400,000 engineering graduates in China – that is true, but what does it mean? Will we put loads of work into China? Will we recruit loads of Chinese graduates into the UK? Will we work through an intermediary somehow? We have not quite figured out how we will translate that into practical actions.

Even in our attempts to recruit and move people around globally, there are restrictions and restraints. We have recruited a French graduate recently, who we would like to work in Indianapolis, but that is just not on because France is not in NATO. There are all kinds of restrictions here and there. Although we want to behave in a global way, therefore, there are still some restrictions related to that.

I am just galloping through all of this, and I hope some of the points make connections with what we have heard from other speakers and discussions later. Both Chris and Julia talked about industry/university links, and I will not say anything about that. We believe it is important for effective research and it is important for quality teaching.

The UTC (University Technology Centre) model relates specifically to how we have set ourselves up to do research with universities. We provide a five-year visibility, a research programme, with a given university on a very specific topic. We have a range of universities with which we work. We work with Loughborough on combustion and with Southampton on noise. There is a whole pattern on them, but these are quite tightly constrained research programmes. However, because we provide the forward funding, it allows the universities to get high quality researchers in and it is just a really good model. It has many strengths, but it is limited to research. There is almost no cross-over into the teaching side of things. Seven or eight years ago, when I started to try to raise the profile of Rolls-Royce as a graduate recruiter in UK universities, I thought we should use the UTCs because they were a good model, a very powerful tool which would definitely help. However, I was surprised to find that many undergraduates in the universities did not even know of the existence of our UTC operation, because that was a research thing that was somehow separate.

In itself, the research and teaching debate is an important one, but even saying that the research with the UTCs – that does not help with the transfer of people between industry and academia. We are Rolls-Royce and we are funding research, and that is going on over here, and there is not much transfer of people between industry and academia. It appears

that academics in the UK are hugely driven in their own career to need to publish stuff in order to achieve advancement. The idea of going to work in industry for two or three years is potentially a two or three year hole in what they are able to publish. Equally, we have not had much success with younger people, as part of their career development, moving from industry to spend time in university. We need to try to find another model of getting a better understanding and some cross-over there, because moves between the two do not happen very naturally in the UK.

Of course, we have one or two high profile examples of where that has worked. You heard earlier that Julia, with a very strong academic background, also worked successfully at a high level within industry. However, this tends to be the people who have already achieved a very significant standing in academia, who then make the transfer, and we do not seem to have that happening naturally lower down. The observation is that that does happen in some of the countries in which we have engineering activity. Germany would be the strongest example, where we have a good handful of people who started with Rolls-Royce, went to university and came back into Rolls-Royce, or they started in the university, came to work in Rolls-Royce and they have now gone back to university. This also happens quite naturally in the Nordic countries. In the USA, the transfer does not happen quite so much but they seem to have a better set of arrangements for sabbaticals and people spending short periods of time on the other side of that divide, but without their employer.

I should have said earlier that a good deal of what I am saying is definitely true and I have plenty of evidence for it in terms of data and experience. Some of what I am about to say, however, is just a personal opinion and I will try to differentiate. The point that has reminded me of that is this one about student choice in secondary education. This is not a point on behalf of Rolls-Royce but this is just me as a parent, a governor and all the rest of it. I do not know why we have let young students have so much choice about what they study – we should just teach them what is good for them because we know best. *[Laughter]* That is not meant to be a frivolous point but it is a serious point of view that I have reached. I saw in the press that Cambridge University is starting to offer students advice on what subjects might be well regarded when it comes to admissions decisions and I broadly applaud that move. We need to think very carefully about the concept of consumerism at secondary education level.

Better research into careers advice in secondary schools – there have been quite a number of surveys. We have done a fair amount of structured work with careers services and we know that some people who are given the job of advising young people do not have sufficient understanding of careers and industry to be able to give the advice that is needed. In particular, there is the point that studying science and engineering subjects is a good

platform for almost any career choice and therefore, to be advising students to stick with those scientific and mathematical subjects is good – wherever they might happen to end up is something that we need to address.

'Higher education teaches only the teachable'. The remark in inverted commas on this slide is a quote that I read, attributed to Aldous Huxley. I am not completely sure what was meant by the original quote but I thought it suits quite well a couple of thoughts around higher education here. There is one interpretation of that which says that higher education can only teach people who are capable of being taught, and that relates back to whether they have the basic skills required to do what is a demanding subject at higher education level. However, it also points to the fact that in between studying something at school and becoming an engineer, there is an experience piece in all of this, which it is not possible to teach in purist terms. Therefore, industry needs to be careful about what it expects of higher education. In my view, the idea that higher education can teach the fundamentals, and industry can help with the experience, is clear enough.

Rather than get into the detail on that, I would like to finish by taking quite a big step back to explain that last bullet point. This is just to put it into context. We recruit, say, 100 to 120 graduates every year. I nearly tripped myself up then, because I nearly said *engineering* graduates, but what we recruit is about 100 to 120 technical graduates, to come onto our engineering graduate training scheme. Typically, there will be a mix of some mechanical engineers, some aeronautical engineers, some manufacturing engineers. Equally, however, in any year, there will be quite a few mathematicians, a good handful of physicists, some material scientists, a couple of chemists, and they will all come and join us from university. They will do some structured training and move around a little in their early career – find something that they quite like. Four or five years in, they will be doing engineering jobs in Rolls-Royce, and we will not be able to tell which one of them has a degree in physics, or who has a degree in engineering, or who has a degree in maths. The question is never asked again.

Any kind of argument that is about real subtleties in the curriculum, and the curriculum of this university versus that of another, it then becomes a little meaningless to us – as long as the fundamentals are there in terms of understanding the principles of maths and physics. The key point on which we select, however, is the proven ability and desire to continue learning. Our leading technical experts, to whom I referred at the beginning, are technical experts who are practising stuff now which is quite often a very long way removed from what they learned in university. They have learned to become world-leading engineers because they have the fundamentals and because they have the drive to continue to learn – not because of the detail of the curriculum they were taught.

Thank you for bearing with me on one or two of my prejudices and opinions. There is some information in there that is fact-based, which we can discuss later. Some of it is opinion-based and I hope I have been clear about which was which. Thank you. [Applause]

PANEL DISCUSSION

Julia King: We now have about 50 minutes for questions for this panel. We are being joined by John Hill, who is chairman of the Joint Board of Moderators, representing the professional institutions. We are open to questions.

Tony Stevens (Loughborough): In my view, we have a Catch 22 situation in this country. We are still the most creative nation in the world – and please, hands off creativity by the academics, because you cannot teach it. You can teach innovation, but do not be arrogant enough to think that you will teach creativity.

The problem is that we have this enormous production line of new ideas and then there is a big gap. It is beautifully funded all through the university system and the research system, and then there is a gap. The City does not want to know, and the Government does not want to know. The Rolls-Royces of this world are brilliant and they are earning their keep in the country, but we need to generate more Rolls-Royces. That means generating SMEs from the ideas. The Rolls-Royces are fantastic, but we need more than five per cent of the FTSE 100 being positive in earnings for this country.

At the moment, I think we are producing enough engineers for what we have. We are sending them overseas. What we need to do is to create the jobs and the new business, and then the engineers can work there. If you want to start from the ground up, then perhaps a practical suggestion would be to turn half our universities back into technical colleges.

Chris Pearce: In many respects, it is difficult to respond to that comment. There is no doubt that the gap between concept and turning that into jobs is a significant funding problem and I am afraid that I do not have an answer to that. I have bumped up against just such problems. You begin to see some indications that there is the occasional recognition in government that there is a need for additional support to make that transition but I have never succeeded in obtaining any funding to do it.

DEFRA have an advanced food manufacturing link programme and have now developed something they call the Development Link. This basically recognises that to take an idea from the end of research to first implementation as a practical product, there is a need for continued government support. That is quite an interesting model.

Up until the point at which I left the AFM panel, there had been quite a few projects to go through that process, but this is a model that might be well worth exploring elsewhere, subject to the funding being available from the appropriate government funding source. The other issue, clearly, is how do we involve a different kind of business angel in this process of investing? The European Union has probably had slightly more success in this with the LIFT programme, Linking Innovation Finance and Technology which, over a four-year period, raised about €40 to 50 million into this particular niche funding line. However, it is hard going and I do not have an answer.

Richard Darton (University of Oxford): I would like to make a comment on that, and also ask a question. I agree about Rolls-Royce being brilliant. We have a good deal of contact with Rolls-Royce, and I thought that was a brilliant talk. Rolls-Royce is of course a large manufacturing company.

I take issue with the last questioner that the City is not interested. In the last year, I have spent a good deal of time talking to venture capitalists and people who are interested in investing in university IP. The problem is that the City, or certain parts of it, are interested, but they just do not know how to get to grips with the university. From their point of view, it is almost impossible to get to grips with a university because it is an amorphous organisation populated by people who do not understand the needs, by and large, and how to go about developing IP. That is something that we should consider and try to do something about.

Too many of the schemes that I have seen put forward for Royal Academy involvement involve people from industry coming to universities and telling us what to do. I do not think that is a very good model, although it has its place. One of the schemes that the Royal Academy has run, which has been very successful, is the Visiting Professors in Sustainable Development. One of the reasons for that is that, at the same time as people have been coming from industry and helping to develop that subject, there has been a real engagement from the university side in developing the subject at the same time. That is to say that there has been a meeting in the middle of the people coming in and the people on the inside really trying to develop the subject.

Now, to get to the point, that is something that we could also do in the creativity and innovation area, but not in the way of having someone come from industry and tell us how to

go about creativity or innovation, but helping academics themselves to become more innovative, creative and, in particular, to go about developing and commercialising their own IP. My observation is that, once the academics start to get involved in that, it involves the students as well. That is a hugely motivating activity to have in a university. When students start to see their own lecturers and professors starting companies, developing IP at the lab bench and taking it out, and the students get involved in that, then that is a fantastic way to involve them in the creativity and innovation. They can then see how it really works.

My suggestion for another Royal Academy scheme – and I do not have it fully worked out in my head yet – is something along the lines of having visiting capitalists, if you like, who come in, partly sponsored and paid for by the Academy or somebody, who will have as a remit helping engineering departments to develop their own commercial activity. How about that?

Julia King: Thank you very much for that. Is there anyone on the panel who would like to comment on that, before we take any further questions? I think Andy Hopper at dinner last night gave us some thoughts about bringing back your successful alumni who have developed IP and started companies, getting them to be present in the tea room – to be there to chat to the students and the staff. That is the same sort of feel of integrating them into the community and getting that enthusiasm.

John Sims-Williams (University of Bristol): My excuse for standing up is that the Royal Academy scheme professors at Bristol encouraged us to start a degree that is addressing most of the suggestions that have been made today. We have 12 sponsoring companies who come in and some of them give lectures to us. They provide projects to us and they interview our candidates. They are quite strongly involved. The side effect of that is that we get 75 per cent of our students going into industry at the end – half of them go into the sponsoring companies, which is of course why the companies are involved. Rolls-Royce is one of them, as I hope you know.

I would like to say that everything is wonderful but, actually, it is not. It is an absolute nightmare. *[Laughter]* This is because of the Research Assessment Exercise that compels the University of Bristol, and every other university, to have departments whose sole focus in life is to try to make money through writing papers. They want to appoint staff members who are narrow and who can write papers – lots and lots of papers – on some really narrow topic.

Then you come in and say that you have this marvellous project from industry. And they say – ‘But it is huge! It is about so many different things. How can we possibly help you with a project like that? We do not know about half of it. There is probably nobody in the

university who knows about lots of the things in there. And anyhow – that is cross-departmental – how will we ever run it?’

It can be done, but we really need to get rid of the Royal Academy. [*Laughter*] Sorry, no, if we could get the Royal Academy to help us to get rid of the Research Assessment Exercise, then that would be very useful.

Chris Pearce: With that Freudian slip, people might think that RAE (Research Assessment Exercise) and RAEng (Royal Academy of Engineering) might in some way be connected to one another.

Julia King: I know that there are various people here who are panel members for the current Research Assessment Exercise. I certainly recognise some of the concerns that you have. We are trying very hard in the Engineering RAE, in all the panels, this time around, to change the emphasis and put much more value into the industry-related research. Indeed, we are trying very hard, as panels, to encourage departments to submit as outputs things other than papers. However, you can be confident whether a paper is of very high quality, but it is much harder to know how a panel will respond to some other kind of output. Thus the security comes in, still driving towards the best papers. We are trying to ensure that, whatever follows the RAE, it does not lose the fact that, for engineering, we need to drive towards the industry engagement of things as well as simple measures of research excellence. Many of us will empathise with what you have said, but let me give the other members of the panel a chance to comment. Is this Bristol course one with which you are familiar, Ken?

Ken Fulton: One of the issues of trying to get industry and universities to work together is structural, because they are separate. I know that this might sound like a simple point but, wherever we put people to work with another organisation, you create an interface. You almost make it worse by giving somebody the job in this company to face up to this other organisation – which might be a university, or another company with which we are working in partnership. Somehow, when we have these kinds of things within our own company, the only way that we ever really solve them is by putting someone in the middle, to deliberately make them feel the heat of working between two departments. The external equivalent of that is perhaps where we have set up a joint venture - and we have a few high profile examples – where you almost create a different employer in the middle of something that is trying to make two things work together.

Building on from some of the points that have been made about this, I just wonder whether we need to find a model somehow that is not about sending someone from industry into a university, or taking someone out of an academic environment and putting them

industry, but rather putting something in place in the middle. This is not a very well-formed thought but it is an observation based on how we have made separate organisations work together in other environments. It is almost having someone employed by Bristol University and Rolls-Royce, and somehow creating a joint approach to it.

John Hill: From the perspective of the Joint Board of Moderators, which is really the construction sector with civil structures, highways and so on, there is a real concern at the moment that the pressure of the Research Assessment Exercise is really damaging teaching. It is making it virtually impossible for people to move from the private sector into universities, and becoming teachers with experience – bringing their experience of practice or whatever into the university. This then feeds this negative impression that we have about the difficulty of project-based learning and so on. This seems to be a key way of turning out really good MEng people who have some experience then of putting their theoretical knowledge to practical effect, and understanding that design is not an exact science and that there are many solutions to fit any particular constraints that are presented.

The way of doing that is to have lecturers who have actually had practical experience, but we are not seeing that. In fact, this is diminishing and it is very serious.

Chris Pearce: I am familiar with the Bristol MEng course. The principles and the basis of that are excellent in concept and, from what I have seen, it is attracting a very high calibre of individual onto the course. As far as I understand, it is not having any difficulty in finding its output being employed by industry. It is a good model, and it is one that was picked up in the Royal Academy Review last year as one of the examples of good outputs from the VPs, who had an input into the conceptualisation of that course.

Julia King: I would also like to comment on something that Ken said about the different attitudes of academics towards supporting students in terms of career advice in Europe. We have just had a joint management development seminar with KTH from Stockholm and Imperial College, with the senior staff from the two engineering faculties. They are Sweden's leading technological university. Their staff talked almost entirely about teaching, while our staff talked almost entirely about research – and the difference was very stark. Ken's point rang a real bell with me, because I could see those staff individually counselling their students and discussing with them where they might go and work. Clearly, Sweden has a much smaller population than the UK and it is much easier to have that personal contact with all of the major engineering employers. However, it was just such a stark contrast between what was in their minds, and where most of their funding came from, too. Most of their funding came in for teaching, and it is almost an embarrassment to say that in a UK university if you think you are near the top of the league. I personally feel very

strongly that we need to rebalance that, and I am encouraged to hear the strength of support for that here. This is something that we will say in our report, if you consistently give us that message.

David Foxley: Could I just add something, to pick up on Ken's point? One of the examples in the booklet about *Educating Engineers in Design* was a case study from Strathclyde University. They have had two visiting professors there for the best part of 10 years, whose role is purely to act as the interface between the university and companies in putting together student projects. They describe their primary role as being the management of expectations between the three constituents - the companies, the students and the academics – to ensure that the projects are both structured and managed in a way that all three parties feel that they have achieved something out of it. It is not an easy task, but it is a vitally important one.

Su Taylor (Queen's University, Belfast): This question leads on from the discussions that we have already been having. I run the MEng in structural engineering with architecture at Queen's, and John has some involvement with the course.

The industrial secondment at the Royal Academy does fantastically but, personally speaking, if I have a six-month sabbatical I am not going to take an industrial secondment, I am going to go into research because that is what I enjoy.

This question is really for Ken. You said that in Germany the lecturers go into industry much more, but I wonder why that is. Is it a cultural difference?

Ken Fulton: I have not researched this in detail but I have observed it and there are probably a couple of reasons. Once again, this is not the Bologna point in itself but the fact that the German engineer, once qualified and practising in industry is probably 28 or 29 years old, and has been at university for a long time, means that he himself – and I say 'he' because, as in the UK, there is an issue with the number of women we have studying engineering – has probably developed quite a strong network with that university. They often go back to the university in which they were educated, and that is one point.

Another point concerns the general respect, if that is the right word, for the engineers in Germany, and the respect for their qualification. They are titled 'Herr Doktor', for example, and so there is that kind of academic respect. A number of our senior engineers in Germany are very proud of their title, Doktor. In the UK, we have a number of people who are PhD qualified who just do not bother using it. There is that strong industry/academic link that works through in the culture in Germany. This is something that will hold us in good stead if

we look at this in greater detail, because we have noted it as an observation and a trend, but we have not studied it so as to be able to give you any more detailed answer than that.

Su Taylor: There is no doubt, as John pointed out, that it will affect the teaching. If I went into industry for six months, then I think I could go into architectural design with a little more creativity and perhaps a little more contact with current technology, but that is not what I am going to do. I am going to take a sabbatical in research.

I was quite interested to hear Julia say that this is something that the RAE is addressing and I think that the Royal Academy should be helping us to push this point.

Mike Wood (University of Nottingham): You showed on your slide something about 240 engineering departments, and there was a question about whether that number should be reviewed. Considering that industry consistently says that we are not producing sufficient engineering graduates, I think that number should at least be maintained, if not actually increased.

As to engineering graduates in general, we probably produce the most attractive skills and knowledge, by way of graduates. It also makes them very attractive to other parts of UK industry with the consequence that the cream – by which, I mean the really good innovators or potential innovators in engineering – are actually creamed off by, for example, the financial sector, because they can offer salaries that engineering just cannot match. If industry is really serious about the problem of innovation, then to keep good graduates within the industry they have to throw money at them.

Ken Fulton: I have a couple of thoughts on that. I did not say that in my presentation, but Julia hinted that we talk about a shortage and, if there were really a shortage, then salaries would be higher and there would be a market premium. The fact of the matter is that you take a global view and there is not a shortage of engineers. The fact that they are not all in the place where we would want them to be is an issue, but it is not a problem to employers because, at the end of the day, engineering is a truly global profession. The laws of physics are the same in Dahlewitz, with our factory in Germany, as they are in Montreal and so, as a company, we have a global market. However, we do not have a global market for lawyers and accountants and HR people, because there are actually significant differences in HR practices in Germany or in America and you therefore recruit locally for those skills. Accounting regulations are different, as are legal practices.

There is a problem here, in that there clearly is not a shortage, or else the salaries would be higher. There is a concern that some good engineers are creamed off to go to

work in consultancies and banking but, equally, so do some good classicists and good economists and good law students. We just have to make sure – and I can only speak for Rolls-Royce – that the ones we are recruiting are of the calibre that we need, and not that there is a good one that goes somewhere else.

I have not fully thought through where that will go but there is some strong evidence in the fact that the market forces would drive the salaries up if there were a genuine global shortage. From a company point of view, having the capacity to recruit from elsewhere, I am not sure that it is a desperate problem. From the UK's point of view – and going back to some of the comments about the extent to which the Government ought to be concerned about wealth generation in the UK – there is a problem, because there is a local shortage.

Chris Pearce: I would echo some of those comments. The thing that we, as employers, cannot do, is to get into a spiral of attempting to poach from Rolls, who then poach back from BAE, who then poach from us. That, frankly, is a total economic nonsense, because we just could not compete. It is a national competition for the pool to dominate. If I look at our Bristol office today, when I last looked I think we had 14 different nationalities of engineers working there. Probably 70 per cent are from the UK but, increasingly, I have engineers from India, from Slovakia, from Romania and from France. This is an international recruitment market.

The worries about the UK are an issue for me, and making sure that we protect our key engineering competences in this country is a genuine issue that the Government should be taking very seriously.

Julia King: You have both given us the views of companies that are able to recruit internationally and you understand the international job market in engineers. Of course, we are looking for SMEs to develop and become the next Rolls-Royces, Microsofts and whatever, and they are more constrained. I just wondered whether John Roulston might have any comments about whether there are real concerns for SMEs in terms of UK engineers.

John Roulston: Generally, I have felt that most of the comments made up to this point about SMEs are not recognising just how terribly constrained they are. SMEs really do not have the resources to pay very much attention to anything other than survival. The chances of getting an SME, for example, to locate a productive engineer in a university department for a *day* would be pretty remote. You must understand that the essence of capitalism is survival, and growth comes after that. The SMEs are very much in the survival arena.

Government has to recognise that, by whatever means – and, of course, subsidy is such a dirty word – but, by whatever means, it has to do something to assist the survival of SMEs first of all, and then things will take care of themselves. However, you should not look to great co-operation from the SMEs because they simply will not hear you.

Question (University of Bath): I teach in the Department of Civil Engineering and Architecture and I would like to say something about creativity. I think we should look at other teaching establishments, to see how they do creativity. In painting and in architecture, creativity is treated in a very special way. The people who do it think they know what they are doing. I say they *think* they know what they are doing, but certainly what they are doing is very extreme. Engineering could just simply look out at those other fields of teaching and see what we could get out of that.

Julia King: Thank you. I wonder whether Sir George Cox would like to add to that. You made some comments along those lines in your report, about bringing the art colleges together with engineering and business schools.

Sir George Cox: Yes, that is a serious point. If you speak to people at the RCA, for example, they take the point that you are not going to turn everybody into being a creative, original and lateral thinker but, if you look at what they do there, they have a discipline to it. One should look to places like that and, indeed, a few of us are doing that, and bring people together.

One of the programmes that the Design Council has done is to have joint placements for people from engineering and people from design colleges. It is extremely interesting, because you are not just trying to teach an engineer to be more creative, but to understand – as was pointed out earlier – where other skills come into play, particularly in product design. So more interplay between the colleges of art and design and engineering is basically a very good thing and it is to be encouraged.

Julia King: I do not know whether it is significant, but the only two names of role models as engineers that we heard yesterday were Jonathan Ive and James Dyson, both of whom actually trained at art school.

Ian Carnell (SEMATA): I would like to return to the point about SMEs. There are approximately 75,000 engineering companies in this country, 95 per cent of which are SMEs. It is absolutely critical, as we have been discussing, that graduates get integrated and study in companies, but how will we engage those SMEs? The 240 faculties that we

currently have cannot all use large employers and there has to be a level of capacity amongst our SMEs to pick up the slack. It seems to me that that is one of the critical issues about how we can improve our university graduate training.

Julia King: There is a scheme in the West Midlands – Advantage West Midlands works with the West Midlands universities, on a scheme which I understand links SMEs with the university engineering departments. I do not know whether there is anyone here from any of the West Midlands universities who can talk about that.

Jane Wernick: I would just like to respond to the point about miniscule firms not being able to work with universities. With six or seven people, we regularly have a student from a university, either from Britain, France or Denmark. That works very well and it helps us to have one young person. We can only take one at a time but it is very useful.

I am also a VP and I do a good deal of teaching, and I find that it is very beneficial to our business that I go out and put in a word about creativity and how to design effectively – I am a structural engineer. I am rather puzzled by these comments.

Jonathan Seville (University of Birmingham): In the 1960s a number of universities, and I am thinking of Bath, Aston, Surrey and Loughborough, nailed their colours to the mast and said that all of their students – not just the engineers – will do a year out or, in the case of Bradford, of course, a curious sort of split system. They basically said that all of their students would do a year out in industry. My first academic job in one of those university involved running a scheme like that, and it was a wonderful experience. It seemed to me that it did a huge amount for the students, and particularly those who were in the bottom half of the class. It also did a huge amount for the academic staff, because they were obliged to go out and visit the students.

It seems to me that, since those days, we have actually retreated from that position, which was a very healthy one. I do not know what the numbers are, but I know that those universities have retreated from that position and they no longer oblige all students to go out for a year in industry. Of course, the Russell Group never fully embraced that system, for various reasons. One reason is the fee structure, which makes it economically unattractive for the student to go out, and possibly makes it unattractive for the universities to run such a scheme any longer, but that can be fixed.

The other point that has been quoted to me is that there simply are not sufficient places to go round and industry is not actually able to supply enough sandwich places to meet the need. However, it seems to be a very positive thing that we could do, to improve

the engagement between universities, if we were to reinstate that sort of scheme. A key feature of it was that it was compulsory. I would be interested in your comments on that.

Chris Pearce: As a product of said scheme, I spent a very enjoyable four and a half years at the University of Bath between 1970 and 1974, going through exactly such a scheme. In my view, it probably saved me two years of career development time at least.

At that point, it is probably fair to say that there was a significant compulsion element in that we had the Engineering Training Board (ETB), to which there was huge opposition from employers in general because of the fact that there was in effect a training levy. Thus, you either spent money on training or you paid a tax to the Government. That is exactly the situation that currently exists in France. In effect, there is a one per cent of salary which is the amount that has to be spent by an organisation on training in a year. So in France there continues to be a compulsion to train, but this is no longer the case in the UK. It is extremely difficult to see a mechanism for returning to those days, much as I have to say that I would love to see them come back personally, because I know from my own experience how beneficial they are.

John Hill: We certainly see quite a number of departments with what might be called 'short placements'. These seem to be highly effective in their two-way trade between the companies taking the students, and the students themselves, and of course the department.

There is also an element in this which is probably also worth thinking about. If this is managed in such a way that it actually leads to some kind of an assessment of the result of the placement – be it a report or whatever – and if this can achieve credit, that may be a partial solution at any rate towards the additional requirement for Bologna at masters level. However, where we have seen it, it appears to be highly appreciated and it is also very successful.

Julia King: Some of the replies that we had to the questionnaires echoed some of Jonathan Seville's comments. We asked universities specifically about whether they had compulsory placements and whether they were assessed. Indeed, only a very small proportion had compulsory assessed placements but the main reason for not having them was the administrative task in arranging them, and the lack of opportunity – such that you could not make it compulsory because you could not guarantee to arrange them for every student. That is very disappointing and we should look at whether we could move back to some of these stronger relations with industry, giving more opportunities for that kind of thing to happen.

We have time for one last question.

Alan Topalian (Design Leadership Forum): There are two things that I do not think I have heard at these sessions. One is the term ‘creating and managing experiences’, and the second is ‘leading business through design’. I was just wondering whether you could comment on introducing analysis of experiences – customer and user experiences – in engineering education, and also whether it would have a material difference if the seed was planted in engineering students that they would be the future leaders of business, rather than just of engineering. Therefore, they would have a certain aspiration and certain responsibilities that go with that. That might actually encourage faculty members to change the way they teach engineering.

Chris Pearce: It is an interesting idea, to encourage everyone to see themselves as future leaders. The reality is that not all of them will be, and we have to be very careful about managing expectations. Not everyone is cut out to be a business leader, even if they are heavily involved in the design process, but the sentiment of what you are saying is exactly correct. We progressively have to make sure that we have the right balance in our leadership in our businesses, although not all of the graduates who are going through today will reach that sort of position – indeed, many of them would not want to.

I do not know how you manage the aspirations of young people in that regard but, certainly, we have to set them a vision of why and how they can contribute through design because design, for me, is one of the key facets of all activities. Ultimately, drawing a very narrow description of what the boundaries of design are is one of the problems that we have today. Effectively, design is the satisfying of a need in the market place and that, by definition, brings in all of the other aspects of business.

I become very confused when I see design being used to mean, on the one hand, the artistic representation of a product through to, on the other hand, what I see, which is satisfying the customer need. I do not know the answer to your question, but in my view it is going somewhere in the right direction.

Ken Fulton: Something I did not have time to explain during my presentation was that, when we talk about our structured arrangements for recruiting graduates in the UK, that is only one route by which we get people who are going to do engineering jobs. In the main, our graduate recruitment stuff is aimed at people who we expect to end up in senior positions in the company.

If you remember, I talked about two things: engineering leaders who will lead a big number of people, but also the key engineering specialists. Within our company, we have many people in very senior business leadership positions who we only recruited because

they came to Rolls-Royce to be an engineer. So the guy who runs our civil business is running a business with 4,000 to 5,000 people, with hundreds and hundreds of millions of pounds worth of business – but he is an engineer by training and he came up via that route. So many of them do go into those business roles but, equally, the technical leadership stuff is extremely important to our company. The guys who are working on some issues around fan blade design or whatever – the decisions that they make and the technology that they lead – have a profound impact on our business success, for decades and decades.

That overall context of business, and the excitement of doing stuff that is really important to the business, is something that it is good to have people aware of right from the start. They should not be too 'spoddy', to use the word I used earlier.

John Hill: I just have a thought about the accreditation, of which some people – according to David Foxley – have a very negative impression. I have a personal crusade, when I am involved with accreditation visits. In the thing that we are expecting to see, we have all the different technical areas that students are being exposed to, but something that runs right through from year one is what we refer to as the 'design thread'. This helps to pull together all these technical subjects and especially then in the final year of an MEng, when we generally see a major multidisciplinary project.

This gives an opportunity for leadership to emerge, leading a small technical team on a project. It satisfies what my crusade is, which is to see that we are actually challenging and stretching the very best students in departments. It is not about looking at whether the department is satisfactory or not, but it is actually seeing how it is challenging the best. These are really very talented students that it is going through and it is a privilege for the universities to have them. It actually sows the seeds of what has just been said about leadership and that kind of challenge. We are hoping to see – and we do see – that that is being achieved.

Julia King: Thank you. I have to draw things to a close here, because I have been warned that you will not have any coffee if we do not stop now. Thank you all very much for your contributions, and apologies to those of you we did not get to. You have made some very useful inputs, and I am sure that some of those thoughts will come through in the discussions that we will be having for the Academy report. Some will also come up again in our discussions later on today.

Hugh Norie: Could I finally say thank you very much indeed to our speakers and our panel. [*Applause*]

