ROYAL ACADEMY OF ENGINEERING

VISITING PROFESSORS IN PRINCIPLES OF ENGINEERING DESIGN

VP Workshop 2002

Best Practice in Engineering Design Teaching: Lessons from the First Twelve Years of the VP Scheme

UMIST, 17th – 18th April 2002

The key objectives of the workshop were:

- to review the collective experience of the VP Scheme
- to present examples of good practice in the VP Scheme
- to discuss how the VP Scheme might be developed in the future.

Opening session. Wednesday 17th April 18.00

Theme - Engineering Design Research

Delegates were welcomed to the opening session of the meeting of Visiting Professors in Principles of Engineering Design on behalf of the Royal Academy of Engineering by Hugh Norie OBE FREng, Chair of Design Matters Group.

The chair introduced the first speaker, **Geoff Kirk**, RDI, Chief Design Engineer – Airline Business, Rolls-Royce, and VP at Queen Mary College, London. At Rolls-Royce he is responsible for design concepts in all countries.

Lecture 1 by Geoff Kirk, Rolls-Royce

Design Research and Industry

Geoff Kirk wanted to talk about the way Rolls-Royce has been doing design research. Industry and Academia have successfully worked together for many years, mainly on technology for the benefit of the product. Industry has also recognised that improvements in people and process are just as important as improvements in products. Design is a key process for business success and there are strong motivations to improve, however, the extent to which design research has been embodied across industry is mixed. Ivan Yates' report of last year reported some experience.

At Rolls-Royce they have built up some success that may be of relevance to smaller companies. The problem is that the person at the coalface has no time to do research – I have a battle to fight, says the King. The King is about to commit a lot of soldiers to battle – but does the King understand what the researcher has to offer? So the researcher feels aggrieved.

There are many obstacles to incorporating research into industrial activity - it may not be relevant because it does not match Industry's needs or there is a lack of understanding between Industry's needs and Academia's capability. Academic recognition and the reward system may not suit relevant research.

Alternatively, the research may be relevant, but not successfully embodied, for many reasons – poor communication, for instance. Geoff reported he had been at an academic conference about design in the previous year and, for the first day, virtually failed to recognise the activity he had been engaged in for the previous thirty years. Many of the researchers seemed to find design and designers merely further subjects for academic study.

Another reason why research might not be taken up in industry was that industry was not being made aware of the research activity; further there can be a lack of commitment (on both sides). IT policy can get in the way, or research may be impossible to incorporate in the current business. There can be a lack of effective training or a lack of follow up; and even if the path is well-prepared, people can suffer from 'initiative fatigue'. Finally it may be judged that the business risk might be unacceptable.

Geoff reminded the audience that Rolls-Royce is a diverse company based mainly on gas turbine technologies for power, civil and defence uses. It employs some 30,000 people in the UK and 8,500 in the USA; it has manufacturing capability in Germany and its marine gas turbine business is based in Scandinavia.

Rolls-Royce wants to develop things once and use them many times, in different areas. Processes in use should, whenever possible, be the same in Indianapolis as they are in the UK. The company has had a great deal of experience of many research schemes over many years. At the end of the 1980s and early 1990s it decided to set up a number of University Technology Centres. These provide a world-class capability in basic science, applied research, staff training, and technology transfer in disciplines critical to Rolls-Royce. They also provide an integrated approach across broad technology disciplines by fostering the collaboration of a number of university departments in partnership to create a number of centres of excellence.

UTCs are funded on a five-year rolling contract and there are now 17 throughout the UK. The majority of Rolls-Royce university funding is now channelled this way.

While the UTCs initially focused mainly on products and process, it became clear there was a need for a Centre of Excellence for the engineering design process itself, based on the UTC model. In deciding how this should be set up, the key issues were:

- which topics should be pursued?
- who were the best people to do them?

After wide consultation within the Company key topics were chosen and a Request for Bids issued. Coincidentally BAE Systems were thinking along the same lines and we came together as a partnership.

In selecting the topics, it was recognised that the major element in the design process is creativity. Improving the design process involves changing working practices, and that inevitably involves people. It was also know that there is already a vast amount of knowledge the Company has accumulated and in the wider world that somehow needs to be captured, managed and reused. In different sectors market demands are multi-dimensional and optimisation of the product becomes a key to success.

A number of universities submitted bids to do the work but no single one was found to encompass the range of work to be undertaken. The solution was to work with a number of non-competing university departments. In 1998, Rolls-Royce and BAE Systems set up three programmes of research into design:

- Human factors and innovation, at Sheffield University
- Design search and optimisation, at Southampton University
- Engineering knowledge management, at Cambridge University

The Design UTP has now been in operation for nearly four years. There are over forty research topics under investigation, and over ten MSc and EPSRC CASE students engaged. Some short term research has already been embodied. The work seems also to have been accepted by the firm - Annual Reviews and the Spring conferences are already oversubscribed; the benefits of this enterprise are acknowledged at senior levels and there is an

appetite for involvement from all sites in Rolls-Royce. A final measure of the inventiveness and success of the scheme is that five patent applications are now pending.

From Rolls-Royce's experience with the design UTC, a number of lessons has been learnt which can be of relevance to smaller companies as well as large ones. It is important to have a shared vision and there must be recognition within the Company that the research is relevant. A work plan including deliverables and agreed levels of support from the Company is needed. In order to achieve effective concurrent working Key Topic Customers need to be appointed within the Company. This gives a pull and a push on the work being undertaken. An implementation plan at the inception of the work is also needed to ensure commitment to embody the research results.

It was also learnt that industry needs to provide free and open access to the universities to facilitate the research. Personal relationships are extremely important and working in complementary disciplines eases University interactions by avoiding unnecessary competition. It must be recognised both that some work will be speculative ('blue sky') and that there are specific academic needs to be fulfilled along side the research (e.g. publications). Finally it is agreed that long term relationships are vital – a one year contract is no use in attracting good researchers!

So, where now? The UTP is fully established and success will only be finally achieved when practising designers feel a beneficial change. A successful start has been made on involving the Rolls-Royce sites throughout the world, though there is still some way to go to ensure that it is not UK-centric and we need to ensure that some topics are owned locally, say in Indianapolis. The firm is exploring how to improve the interchange of personnel between sites to help this process.

In summary, the UTP model is one way of improving the Design Process by using the benefits of academic design research, and it works for Rolls-Royce. Critical factors appear to be that:

- there must be a common purpose but each party must feel that their own needs are being satisfied
- there is a recognition that transfer and implementation can probably be the most difficult part and specific plans are needed very early on to address this issue
- the partnership has to be long term to maximise mutual benefit for both industry and academia.

Lecture 2 by Derek Sheldon

Hugh Norie in the chair then introduced the second speaker, **Derek Sheldon**, Professor of Engineering at Anglia Polytechnic University and Editor of the Journal of Engineering Design.

A review of design research and its impact on industrial practice

The results that Derek Sheldon presented were the outcome of a three month study funded by the RAEng. This was a follow-up from a previous study of the role of design in engineering departments in UK universities that seemed to reveal a rather pessimistic situation.

A number of prior perceptions were assumed to exist:

- there is a disconnect between industry and academia
- academic research does not match industry's needs
- there is a lack of mutual understanding
- there are barriers to industry adopting academic design research.

A review was undertaken of activities at nine universities, chosen for their established track record in the field of design research. These were: Bath, Cambridge, Coventry, Hull, Imperial College, Liverpool, Newcastle, Strathclyde and the University of Wales Institute in Cardiff. Senior staff responded to 14-15 questions and the universities' facilities were visited. Following the visits, a number of follow-on discussions were made with industry.

The university interviews found design research being undertaken on a wide range of new products and methods, such as a materials selector, pavilion designs, electronic publishing, medical equipment, life support systems, etc. They also revealed design business process research into virtual design teams, performance analysis and product development communications. There was also research being undertaken on design software tools including DFM, DFA, DFS, TCE, and SCONES. The departments generally had well-equipped facilities for use in industrial collaboration.

The discussions with industry revealed a very positive response towards design research and collaboration. The outcome of collaboration often yielded improved competitiveness and productivity. Contrary to some preconceptions about universities, good reports were received of their ability to deliver to time, within budget and with high quality. In some cases the costs of a product had been were improved by up to 60%. It was also reported that research involvement by a firm could help and encourage "joined-up thinking" in the company.

The main conclusions from the study were that:

- examples of vigorous and exciting academic–industry design research were found
- there were several examples of good collaboration with SMEs and OEMs
- the EPSRC were not the only funders
- there were real value-adding product and process deliverables to industry
- research staff are meeting industry needs while also able to achieve 4+ Research Assessment Exercise (RAE) ratings.

It was felt that new research funds and 'visiting designers' are essential to build on existing practice. It was observed in a number of cases that a University's VC could often be an important influence on achieving success – evidence they are not only interested in RAE ratings. They often felt that industry / academia collaboration was a positive influence on the university's standing.

Finally, Derek Sheldon reported he had discovered some support for the idea of funding someone to take a regional look at industry / academia collaboration in order to spread the best practice in this type of experience.

Discussion

Hugh Norie in the chair found it fascinating to see the design process is starting to become a science in itself.

John Coplin (VP, Imperial College) wanted to know from Geoff Kirk more about "maintaining the patience of the investor" while spending money developing the product in advance of earning money. Rolls-Royce had experience of this in 1971 in a big way (the year it went bankrupt). How will we be able to address this issue more effectively? What are the milestones that will register with the investors that will tie into the research programme?

Geoff Kirk said he had not presented the full list of possible research topics considered - it would be very long. Rolls-Royce looked only at the top four themes, and chose the four thought to give the best return

John Coplin (VP, Imperial College) felt that it is vital to how you prioritise what you do, especially for SMEs. Geoff felt this was more of a commercial or business school issue but John Coplin disagreed with this. Geoff also felt it was rather beyond what can be dealt with in a university environment.

Hugh Norie reminded the audience that they were not dealing with research into the product, but research into the design process.

Tom Hyde (Nottingham) had been involved with one of the UTCs for some time. You do a lot of research and there is then a big problem getting it back into the company. Ultimately that must be up to the company, not the university, otherwise all the work is wasted.

Chris Rodwell (VP, Leicester) wondered about patents. How did the research into design lead to patents?

Geoff Kirk replied that Rolls-Royce have taken out three software patents and two process patents, but he did not have details of them. He asked Ken Wallace who was involved in two of these.

Ken Wallace (Cambridge) said he had been amazed at what you can patent! It was not the case that something had to be a material thing to be patented.

Derek Sheldon observed that design research and patents are not incompatible. IBM gets a large income from licensing its patents – over a billion pounds.

Peter Foyer (VP, Coventry) said he operates between design research and turning it into tangible products. He found the work has to go all the way down to the making of an actual product in the market place. The problem is to decide who takes the risk – how it is to be shared. We need our engineering management and business school colleagues to help us here. Often the customers need help too. Other parts of the university can help too. He felt it was essential that universities had some business help in these activities.

Derek Sheldon had found that often many faculties and disciplines collaborated.

Dick Harris (Surrey) wanted to know how the UTCs develop consensus and commonality of design processes between different countries, market sectors and so on.

Geoff Kirk said they had to bring people together, physically. This was also embedded in the higher level quality system. It took about six months to set this up. Concerning people, we look carefully at how we plan to progress good people through the firm. For technology we always identify a process owner and this becomes embedded in the quality system. Was it coercion or persuasion? A bit of both.

Bill Oliver (VP, Newcastle) noted that Derek Sheldon had talked about difficulties in understanding between academia and industry. He wanted to know what some of them are, and how can we get around them?

Derek Sheldon preferred to look at it from a positive point of view. It is important to have a good idea of each other's position and to write it down. And don't rush it - trust and confidence take time to build up. It can all depend on charisma. It is important to agree on the deliverables – product or process, and to define what they both want out of it. If you turn all that round, you can see the negatives. It is also important not to hang the whole collaboration on one person – people move on.

Peter Hills (VP, Royal Military College of Science, Cranfield) thanked both the speakers for giving a new picture of design research. However, he did not have the same faith as St Paul. Manufacturing industry is not doing well at present, yet, from what he had heard, the speakers seem to be saying that everything is OK. He did not think it is …

Geoff Kirk said that Rolls-Royce finds the 5 year funding term helps to deal with the problem of lack of continuity of funding. It does not have to be re-justified every year and does not come under threat.

David Foxley (RAEng) made an observation that Rolls-Royce knows what it wants and is doing very well at getting it, and is doing OK. He pointed out that Derek Sheldon had done his research as a follow up to the earlier research study that had had pessimistic conclusions. He had then been asked to go out and find examples of where design research did seem to work. The idea was to try to learn from the successes.

Derek Sheldon said he had often been delighted with what he found. The pioneering spirit of a few people in a university. He also thought that things had, in fact, moved on since his previous work.

David Foxley commented that it was also significant the much of the research work that Derek had discovered did not have any EPSRC research funding – good entrepreneurial skills were often needed for finding funding for design research.

Steve Culley (Bath) was glad to hear Geoff Kirk mention speculative research work. What did he find was the role for speculative research work and fundamental understanding in the broader picture?

Geoff Kirk said what he meant by speculative research was being able to go down a route where you cannot see the outcome. An example had been product data management – the Sheffield research team had shown Rolls-Royce a new way of looking at it. Its role can be as a provocative stimulus to people in industry to do things differently. He added that was talking about process development, not product development.

Derek Sheldon's initial gut reaction had been that speculative work would have been mainly done by the large companies. But in 2 of the 9 cases he found that this was not the case. It was simply an entrepreneurial attitude that led to small firms putting their own money in.

Tom Smith (RAEng) wondered about the interchange of personnel. There is nothing healthier than getting different people together. In his experience of multicultural work he had found large problems with interchange – different salaries, working conditions and so on. How can an average sized firm deal with international interchange? He had found it difficult.

Geoff Kirk said he had been talking about interchange between universities and the company. He agreed that it was not easy, and the company did not do it lightly. They try to identify people who have senior management potential or particular expertise potential and introduce them to working on different sites in different organisations - sometimes 2-3 years, sometimes a 3 months attachment. It is expensive – but has been worth it.

Sami Ahmed (VP, De Montfort) noted that there was always a problem in joint research about the joint ownership of Intellectual Property Rights. Had others found this so? How did they solve it?

Bill Oliver (VP, Newcastle) said he had seen attempts to side step the problem by creating an industrial club with many members – if one partner develops things further, they eventually get the IPR. It can, indeed, be a constant thorn in the side.

Ken Holliday (VP, Sheffield) said it was clear from the examples that there had been important benefits to firms and universities. But he reminded the audience that this discussion was meant to be about the teaching of engineering design. What do the students get out of it? How does it lead to improving the teaching.

Hugh Norie agreed this was an important issue and should be addressed later in the workshop.

James Armstrong (RAEng) wanted to know about leadership. He had gathered that there had been multidisciplinary teams on most of these projects. Each partner has their own ideas and what they each want out of it. The problem is to integrate individual and the team aims. How do you keep hold of the leaders of the teams?

Derek Sheldon had found that the selection of the right people is the most important issue – both the academics and the industrialists. Some universities are very careful to select who is most suitable, and to make sure they are going into industry for the right reasons.

Hugh Norie in the chair concluded the discussion and thanked the speakers for their excellent contributions.

Second session. Thursday 18th April 8.30

Review of the 1999 workshop at Churchill College, Cambridge

Hugh Norie in the chair began the session with a review of what the VP scheme had achieved in the last 12 years and of the sort of advice that may help the RAEng on its way forward. He appealed to the assembled VPs as best able to give this advice, for it is their scheme.

He began with the confident assertion that, using any criteria, the VP scheme has been a success. It is particularly important to review this success and broadcast it widely, not least to those who will carry on funding the scheme.

The scheme has placed 126 VPs in 46 universities in "Principles of Engineering Design" and a further 21 VPs in "Engineering Design for Sustainable Development" in 21 universities.

The scheme has strongly reinforced links between university and industry and brought industry's requirements more into focus. It has also displayed to a large number of undergraduates the personal qualities, the enthusiasm, the capabilities and the plain saneness of practising engineers. The scheme has also brought into focus the value of design in engineering, how design is to be taught, and has brought back some of the pleasures of engineering. It has also highlighted what has been called the essence of engineering – the reasons why engineering is not a pure science.

In the 1999 conference we focused on the principles of engineering design and had keynote lectures on the teaching of engineering design, the challenge of system integration and on sustainable development. Since then the sustainable development scheme has gone ahead strongly and become a key part of the Academy's VP Support.

The conference recognised that design should be fundamental to the academic training of all engineers and that this could be done successfully through the VP process. This VP involvement also led naturally to improved collaboration between industry and universities. The scheme also showed how VP involvement could act as a catalyst to improving teaching processes and syllabuses and clarify the true requirements of industry, in respect of the training of engineering students.

During the two and a half years since the previous conference it must be said that not all of the recommendations have been adopted as fully as they might. In some areas the scheme has not succeeded as well as others. One recommendation in 1999 was that the syllabuses in engineering courses needed to be revised to bring in design throughout the courses. We are not there yet. A number of recommendations could still be more effectively implemented:

- the need to focus on soft skills
- the extension of design into first year courses
- the need for better VP coordination
- the need for the RAEng itself to lobby government, universities etc.

Nevertheless there have been great successes. Some of these will be presented later in the workshop as case studies – a showcase of the work of the VPs in Principles of Engineering Design. (Sustainable Development will be the subject of a separate conference in June).

Following this conference the RAEng will publish the proceedings with these and other case studies. We can use these as evidence of what has been done to help publicise the scheme's achievements. They will help us define the way forward –and in bidding for more funding. Decisions about the future need to be made soon. We need to identify what improvements will make the VP Scheme even more effective.

Keynote presentation by Chris Pearce, INBIS Group

Hugh Norie introduced Chris Pearce FREng, the Technical Director of the INBIS group, formerly a VP at Salford University.

Implications of Technology Transfer in the Teaching of Engineering Design: "Competing in a knowledge-based world – the challenge of idea sourcing"

Chris Pearce had worked across a number of different engineering sectors, and noticed that the basic principles are similar in many industrial sectors. It is the jargon and the mystery that is different. He had found it interesting that good ideas seldom seem to pass from one field to another.

Ultimately, it is the relative merit of your product that brings the success. So where does technology strategy fit in? It is vital to the success of a business – and it is important to think what merits might be important tomorrow.

A series of questions need to be asked – How do we succeed? What is actually happening? What does it mean? and What do we do? How, then, do we manage technology as a strategic resource?

Today we are increasingly working in multidisciplinary teams. The density of information is increasing and this makes it much more difficult for the designer. The design process is now much more difficult to manage; the serial process is no longer sufficient.

Also, the technology environment has changed. There are many islands of technical information and methods and it will become more important to manage the interfaces.

INBIS is in the process of teaching people how to become team leaders. For this they have to understand the constraints, be able to coach and counsel people, and resolve conflicts, while understanding that conflict is good for creativity. Team leaders need to be forceful and goal oriented - caring Genghis Khans, so to speak. We have a responsibility to create the right environment in which design can occur. After all, design is the value-added part of engineering upon which UK engineering depends.

The multi-disciplinary team's knowledge is used to benefit the project, but what do other people know that we do not? True innovation occurs when ideas pass from one sector to another. But how do we make this happen?

Chris Pearce then introduced the audience to the Sequoia tree analogy. Sequoias can live for between 2 and 5 thousand years. Their roots merge underground and store water that is shared in times of drought.

He compared this with the "Bonsai tree model" of business – where constraint of the roots leads to stunted growth.

The crucial question is: How can we create an organism similar to the Sequoia Tree in engineering? How can we share knowledge from other sectors?

INBIS looked for ways to bring in ideas from other industries. One example was in bringing new ideas into the nuclear industry, illustrated by remote manipulators used during the decommissioning stage of nuclear installations.

The need was for a high power reconfigurable manipulator with up to 7 degrees of freedom. Several new ideas were needed. Some were found in the aerospace sector, some in the waste management sector and some from the nuclear industry itself.

They had little experience of using titanium and so explored different materials, for instance ceramic bearings instead of steel. The design team took ideas from the design of gas turbine shafts in order to get the confidence to analyse stresses satisfactorily.

The design of the gripper was something they knew as they had been doing it for 40 years. But they were not able to optimise the many variables. So they developed skill in using constraint modelling, adding in economic constraints and others. This allowed the weight of the gripper arm to be reduced by 30 %.

So what had been the human influence on technology transfer? First of all, corporate encouragement and a cross-market sector chief engineer's group. And of course, some key individuals.

Several links with academia were formed – at Bath, Bristol and Salford. There were partnerships with others and supplier integration. There was also a lot of training.

So what were the keys to successful technology sourcing and transfer?
- developing an awareness of the wider world through technology watchers
- developing internal data and knowledge capture systems
- understanding how to use information sources
- be open to new approaches (kill off the Not Invented Here syndrome)

And what do we need to teach? We don't. We need to give the opportunity to gain experience and awareness in multi-disciplined team environments and let the confidence of youth loose on a prepared world.

What can we give students in a university environment? Experience of working in multi-disciplinary teams working on realistic projects.

The VP's role in this is to develop appreciation of the power of ideas and the value that transferring knowledge can have. He can encourage excellence in data mining and the ability to argue for engineering innovation from a sound commercial standpoint. A VP can offer a good grounding in engineering reality and help open minds – in fact, all that the RAEng VPs aim to do.

What gets in the way? Mainly timetables. Until we can take control of the teaching timetable and make it possible for electricals, mechanicals, business studies, etc to work together on a common project, we will never achieve our goal.

Where do we go now? Development times are reducing. It is increasingly important to deal with downstream problems upstream. There is an increased aversion to risk. We need to understand the impact of network technologies and develop techniques for knowledge capture and recycling. In virtual worlds, we have a mixture of games technology and process modelling – and we must not forget that only about 5% of graduates can read a 2D drawing and see it in 3D.

In future we may face many threats:
- a shortage of multi-skilled team leaders
- a loss of the social dimension in teams
- a loss of "engineering feel"

The Sequoia Tree has developed its own mechanisms for dealing with disasters. After a drought the sequoia pine cones lie dormant until they are activated by forest fires.

The companies that will survive are those like the sequoia.

Third session. Thursday 18th April 10.45

Case Study Presentations

Case Study 1: Brighton University

John Downie

Brighton has had a long tradition of putting design firmly in focus in its engineering courses since the 1970s, when still a polytechnic. After Finiston it had offered one of the first BEng degrees. The university was in at the beginning of the VP scheme and had been a catalyst for its development. It now had some 10 years experience in hosting visiting professors. All this made it difficult to separate out just what contribution the VPs had made, since developments in engineering teaching were already firmly established.

The university's strategy had been to integrate civil, electrical and mechanical engineering and this was helped by the VP scheme. Now the departments have merged. In the MEng programme they have multidisciplinary teams of students – here the VPs helped again, both with project ideas and running them.

Brighton did not use the VPs as occasional lecturers. It was considered more important that they were involved in the curriculum and timetabling. There were 5 VPs with considerable experience of real design. All the VPs joined the industrial advisory boards and a Design Forum was started to help encourage collaboration.

Outcome of this work is that engineering design is now integrated in the faculty and a low-bureaucracy design approach has been introduced successfully for undergraduate design teams

The curriculum too has changed with all courses now involving more design-related activities, and the syllabus content has been enhanced by the VPs.

A further outcome has been that the students are now involved in more realistic, open-ended design projects. All courses now include group design work concentrated in "design weeks". Also, many final year projects contain a significant design element and the use of CAD is routine.

Unlike traditional engineering courses, the students maintain a record of their design activity in the form of a portfolio. There are also display periods, and "crits" which enable objective and professional criticism by the VPs.

Brighton has now developed a series of design courses, mainly in the area of product design, and the VPs contribute to all these. It has also made the most of the Teaching Company Scheme to develop students in a professional environment. There are also now plans to develop a University Design Centre with the University of Sussex.

Some VPs have retained their involvement with the university after their formal contracts had ended. We are also now benefiting from the VP in Engineering Design for Sustainable Development who has agreed to make a faculty-wide contribution to the courses.

Case Study 2: Bristol University

Jon Sims-Williams

Bristol's activity was summarised by the headline title "*VPs motivate a new degree programme in engineering design*".

The faculty has had seven VPs involved in the development of the new MEng in Engineering Design. The current VP programme has included:
- a series of lectures on the nature of design in the VP's own industry
- visits from recent graduates working in the VPs' firms
- design seminars with multi-disciplinary design teams
- a group multi-disciplinary design project in year 3
- an annual public lecture on design

While this programme had been successful, a new idea gradually formed that an Elite Course in engineering design could be developed which would produce graduates who even more closely matched the VPs' idea of what the best engineering education could provide. This would include:
- leadership
- multidisciplinary engineering skills
- a strong theoretical understanding
- well-developed modelling skills
- a specialisation
- a degree of economics, business, environmental and political understanding

The question was, how do you put all these into an engineering course? It was agreed that the course would need to attract the best students and it would lead to a general engineering degree with a prominent specialist skill area. It was also agreed that it should be run without the need to develop and deliver any new course units. This posed problems as it would be difficult, after the first year, to provide course units that would equally suit a student on a specialist degree and one following a general course. Nevertheless, a programme has been developed, and is now part way through.

The course is sponsored by 13 different companies and in the students' 4^{th} and 5^{th} years groups of students work on projects developed with the sponsor firms. In year 4 they prepare and in year 5 they undertake the project. The teams are made up from students with different specialisations to form a multi-disciplinary team

The success of the scheme will be judged by the residual value that lies at the heart of any educational process:
- a set of concepts
- a set of ways of thinking
- some personal skills for communicating
- some manual skills, and
- a set of personal values.

One common problem with the modular system in universities is that students can drop a subject after that module has finished. In the Elite Course this is not possible. For instance, the Research and Communication Unit runs through all years and students can be examined on all subjects at any time.

One particularly important theme is the "understandings" element of this course that focuses on the key concepts of a subject area, and where students can develop their knowledge and understanding further. The other key component is the "back of envelope modelling" – answering questions such as How long would it take to boil a kettle using human muscle power, and What is the power of a given electric motor?

[Jon put out a plea for help in finding good questions for students to tackle in these two key areas – they are difficult to devise!]

A key issue was the recruitment of students to the Elite Course. Twenty applicants a day take a maths test and have a 45 minutes interview with the industrial partners who seek leadership potential, engineering motivation, technical competence and physical understanding. The industrial partners host the students during summer placements and the third year placement. So far the results look good and the companies are thrilled with the students. It already seems likely that there will be a much lower dropout from engineering after the Elite Course has ended.

Case Study 3: Loughborough

Mike Holmes (VP) and Dennis Loveday

Across the whole engineering faculty there are 8 VPs contributing to six departments. Mike is a Building Service Engineer from Arup Consulting Engineers and is VP in the Department of Civil and Building Engineering. His interaction with the university is focused on the research side of building services but includes some involvement with the teaching:
- Lectures for elements of a vocational MSc Course
- Specialist lectures, beyond the normal curriculum
- General guidance and collaboration on EPSRC funded research
- Collaborative research
- Raising the International profile of the Department.

The aim of the collaboration is to develop and enhance the design process and the teaching and development of new building services engineers

Mike Holmes described some of the uses of software in building services, for instance modelling air flow in buildings and lighting levels from both artificial and daylight. An important function of these models is to communicate with architects (and others) who do not understanding the engineering basis of the results.

Currently Mike and the university are collaborating with others on a project to develop an analysis software package with a purely graphical input of data.

Discussion

Commenting on the Bristol course one contributor said he was not surprised that the students are very good, But he was not sure what they would be good at?

Jon Sims-Williams (Bristol) relied that they do all have about a year of specialist skills, and they will develop skills in certain specific areas during the summer and third year industrial placements.

Roy Crookes (Queen Mary College, London) wanted to know if the course would be accredited by institutions

Jon Sims-Williams (Bristol) replied that they all seem to be positive so far.

John Watton (Cardiff) commented that they had been doing this sort of course for 10 years. The original target was 15 students a year; now they have 40 a year. And all the students do seem to find jobs.

Chris McMahon (Bristol) commented that it had taken a lot of effort to persuade the university to allow some 26 to go against the grain. They had used the sponsoring companies a lot to help persuade the University to do it – they virtually said "We will sponsor them; we want these students!".

Case Study 4: Leeds University

Richard Taylor OBE (VP)

Richard Taylor (VP) presented Leeds endeavours in developing the "*Global Engineering Design Team*". The partners were Arizona State University and the Boeing Company from the USA, and Rolls-Royce and the university of Leeds in Britain.

Participation in and leadership of global product teams requires individuals who possess a global attitude and are aware of business practice and success factors in the global workplace. They must be technically excellent, and have strong character and the highest integrity.

The quality of the one-year course was assured by means of accreditation – through SARTOR in Britain and ABET, the Accreditation Board for Engineering and Technology, which accredits all engineering degrees in the USA.

The aim of the project was to optimise a generic helicopter engine exhaust system.

The students applied, were interviewed and selected – 4 students from each university. They began with two weeks at Leeds followed by a summer industrial placement. The project itself ran from autumn to the following summer.

Project deliverables were defined precisely – a full project proposal and contract (project) performance plan. Proposals had to be submitted to an interim review and after refining the scheme from concept design to detail design a final report was prepared prior to a final project review.

The project brought out a number of important non-technical issues – dealing with the students' expectations and with the shocks they encountered between the two national cultures and the two working environments – industry and university.

The learning outcomes were impressive. The students learnt to deal with open-ended problems and how to communicate. Their planning and management skills developed and they learnt about teamwork, especially the importance of trust.

They also had to overcome their initial reliance on what they knew rather than deal with what they needed to know. They had to learn how to use their time and tools more effectively and improve their effort effectiveness. They had to deal with their lack of industrial experience and learn how to motivate and engage people. And of course they learned the importance of detail in design.

Case Study 5: Strathclyde University

Department of Design, Manufacture and Engineering Management
Neil Juster, Head of Department, with **Bill Ion**, Director of Teaching and Learning

Strathclyde has the largest engineering faculty in Scotland – over 2300 undergraduates and 500 postgraduates. Its degrees are centred on the MEng. The Department of Design, Manufacture and Engineering Management (DMEM) is one of nine disciplines in the Engineering Faculty with the aim or *realising engineering products from design through manufacture to operation within a business and environmental context*. In other words "Create, make and manage".

The VPs are used principally in the Product Development Partnership (PDP).

Multi-disciplinary teams of four or five students in their 4^{th} and 5^{th} years work on a project with an industrial client from November through to April. Most of the projects are with SMEs,

and students learn to work with the client company – to ensure that the interaction works. This year some 20 projects are running. These are managed by the students and they meet the clients when appropriate and present their final output to them. They are expected to produce a prototype and it must be costed.

Current projects include roof anchors for building maintenance, a salmon storage station, a household data logger and a synthetic bagpipe reed.

For the roof anchor project, not only did the students deal with the design and manufacture, they also helped the company to develop the new service with marketing literature and a multimedia CD ROM.

The Department currently has two VPs who come to the department every Wednesday. They assist with individual projects and provide guidance in project / team management. They are members of the Industry Advisory Panel and also do a lot of networking and advertising for the department outside the academic environment.

The students consider the VPs to be external resources and value their input. They also learn, with the VPs help, how to manage the interface with the client company and deal with the "reality" of the project beyond the technical issues.

The Department has found that the VPs are most effective when they have had a lot of experience and are still engaged in design-related activities. They should also live near the university and have a good network of local contacts. They also need to devote regular time and be able to engage with the students.

On the other hand, the Department too has responsibilities. It must allow the VP time to integrate – this may take up to a year. It must also make the VPs an integral part of the teaching team.

Case Study 6: University of Manchester

Glen Birchby, VP

An external assessment of the role of design in aeronautical, civil, mechanical and electrical engineering courses was undertaken at the Manchester School of Engineering in 1994. They were found wanting in several ways and a number of key areas were identified for improvements in the teaching of design. These included the need for interdisciplinary activities involving teams of students and a recommendation to incorporate a systems approach to design in the courses. One key outcome was the decision to apply to the RAEng for funding for two VPs. One took up duties in the civil and mechanical fields in 1995, followed by another in aerospace and electrical engineering in 1996.

Each VP reviewed teaching their disciplines and found the following general issues needed addressing:

- There was little integration across modules
- analysis and design were not integrated
- design often meant little more than sizing components and detailing
- students often had too much of the problem defined for them
- too little was taught about materials' properties and behaviour
- design teaching varied considerably across the School, from non-existent to enthusiastic, although it was generally hidden from view in lectures and projects.

In the 3-year courses design had been squeezed out for many reasons – modularisation, increasing computer analysis and the introduction of commercial and professional matters.

There were also doubts about the role of design in a university course – how could it be taught until there was a good grounding in engineering science? Is design an academically acceptable subject? Is it a sufficiently rigorous and prestigious activity for the university?

Nevertheless, it was decided to raise the status of, and the commitment to, design as a fundamental part of engineering education. An opportunity was seen to develop design teaching in the 4-year courses.

The VPs were invited to help the School effect viable and durable changes in design teaching. They would achieve this by providing input into project work and providing case studies from industry, by participating in curriculum development and in establishing design as a central theme common to all modules and disciplines. The changes needed to be revolutionary, not evolutionary.

With the introduction of SARTOR, and a number of staff changes in the School, the opportunity, the environment and the will existed to define a new direction.

A new course structure was defined and the feasibility of introducing Problem-Based Learning (PBL) from Year 1 across all course programmes was investigated, and found to be workable. PBL was found to be widely used by other professional disciplines such as medics and dentists. It is a team-based practical approach to solving problems where one of the main tasks is to identify gaps in the knowledge needed to solve a problem. This stimulates further research and learning.

The VPs became actively involved in the PBL activities and a cross-school Industrial Liaison Group was established to enlist further comment, input and support from industry.

In the new course structure PBL occupies some 50% of the common course to all Year 1 students and recurs in later years as the studies become more specialised. Design has now been placed firmly at the centre of all the engineering courses and the VPs have especially contributed to raising the profile of design and establishing its importance as fundamental to engineering.

Glen reviewed the achievements at Manchester against the recommendations from the 1999 VP Workshop at Cambridge – including focus on design, new teaching technologies, project based activities, and a systems approach to design. He believed they had met most of them and PBL had been at the centre of this achievement. They had found a workable balance between engineering science and design in the course and had dealt with the familiar constraints of timetable issues and the shortage of time available from both academics and VPs.

The presentation ended with a short video showing students testing prototypes made in the hovercraft design project

Discussion

Bob Lark (Cardiff) said the last three presentations had been very impressive, but was concerned that they seem to be very resource intensive – indicating a considerable commitment by the Universities. He wondered about assessment. At Leeds, how are students assessed, especially if some students do different projects?

Richard Taylor (VP, Leeds) replied that it had needed a sea change in the culture – a different attitude to the entire process. The younger academics are putting in a lot of effort.

Sami Ahmed (VP, De Montfort) was worried about the amount of time that seemed to be put in by the VPs.

Neil Juster (Strathclyde) said that the VPs do, indeed, put the time in, every week.

Geoff Kirk said Rolls-Royce gave its VP staff a half a day a week to devote to university activities.

John Bull (Newcastle) said their VPs came in at Friday lunchtime. There were four projects and all 11 teams presented to the VPs, not just the best projects.

Fourth Session. Thursday 18th April 14.00

Syndicate reports

David Foxley began the afternoon by introducing the new area of the RAEng web site reminding people first to check their personal information and update if necessary.

The electronic library would provide access to various papers, including the proceedings of this and previous VP Workshops. There is also now a "Forum" to allow continuing, on-line discussion about the topics addressed at this conference.

Hugh Norie took the chair again to introduce the reports from the Syndicate Groups on the five questions that were discussed.

Question 1: What are the main lessons of the VP scheme?

a) What are examples of good VP input?
b) What characterises those examples?

Ken Wallace reported for Syndicate Groups 1, 4 and 7.

- There is a difference between VP and academic viewpoints – and the cultures
- The VP introduces a "real world" feel to the students
- There is no single successful approach – one size does not fit all.
- Continuity can be a problem – there can be a need for a "product champion", such as the Dean of Faculty
- While retired people offer flexibility as VPs, it is preferable that the VP is still working
- It is important to get the university to understand "design" needs
- The role of design in courses is changing – so too must the role of VPs. They should be the catalyst for change
- It can be a challenge to find sufficient meaningful projects
- The VP can help to unify across disciplines
- There are many good examples of how the VP scheme can work well
- VPs can bring some understanding of practical technology to students (which they need)
- A clarity of objectives is needed
- VPs need to attend regularly
- Although the funding of the VP Scheme has almost stopped, it is still surviving – this speaks for itself.

Bill Oliver reported for Syndicate Groups 2, 5 and 8.

- VPs are effective as catalysts for change and bringing different disciplines together
- It is important that VPs are supported at both Departmental and Faculty level at the top
- VPs need time to adjust to the university environment (it takes about a year)
- VPs can have different roles – teaching, research, course content, projects: all are valid. Ideally a balance across the whole range is desirable

- A VP can provide a "real-world" credibility that a full-time academic may not
- There is benefit in VPs joining forces to create a critical mass in a university, in order to have greater influence.
- VPs need to attend regularly and frequently
- VPs can help bring different academic disciplines together

Chris McMahon reported for Syndicate Groups 3 and 6.

- Everyone (and each situation) is different
- It is important to agree mutual expectations
- The VPs network of contacts are very helpful
- VPs can take a step back with both academics and students, giving a fresh view, a broader picture
- It is very important that there is a champion for the VP in the host university
- A VP does not have to be local, but does need to schedule attendance at the university
- Important to emphasise "maintaining patience of the investor"
- VPs should be active in design
- A VP's experience complements that of the academic
- Student proctoring is good
- The VP's contribution is variable; the VP needs to be asked to do things, and needs to be selected carefully
- The VP's industrial experience is most valuable
- University timetables (and changes) inhibit the contribution of VPs.

In summary, the main strengths of the VP scheme have been:
- expertise and networks
- complementary / fresh view
- importance of process

Discussion about Question 1

Jon Sims Williams (Bristol) felt that VPs could perhaps help more with raising industry funding for research projects in their universities, drawing, perhaps, on their links in the wider community.

Graham Oates (VP, Birmingham) addressed the issue of critical mass. At Birmingham there are 3 VPs and they have worked together from the start. There are also a further 25 honorary / visiting professors in the university from many other sources. These other people, unlike RAEng VPs, did not have a framework in which to work. While they felt honoured in their position, they didn't really know what they were meant to be doing or how best to achieve anything. There could be an opportunity for the RAEng to take the lead here and help bring more resource on board, especially if, as he suspected, Birmingham is not unique in this respect.

Dick Harris (VP, Surrey) said he had heard much about the environment, politics, business etc. this morning. To what extent should the real world and management be brought into departments? (agreed to deal with this in later discussion of Question 2)

Ken Wallace (Cambridge) reminded the delegates that there was not much time for an undergraduate. The most important thing we can do is to try to cover those things that the student will not get after university, e.g. thermodynamics.

Hugh Norie agreed it was difficult to know how much to bring in – there is the Jack-of-all-trades-problem. In the commercial world it is often not what you know that is most important; it is who you know who knows.

Sami Ahmed (VP, De Montfort) wanted particularly to emphasise the issue of expectations, on both sides. This is especially important at the beginning of a VP's tenure in view of the limited time available to the VPs and the staff.

Jim McQuaid (VP, Sheffield) wondered whether the VPs met often enough. His syndicate group had felt there should be more frequent meetings – once every three years was not often enough.

Ken Wallace (Cambridge) replied that several people had mentioned the opportunities that are now available for communicating, via the web, for instance.

Question 2: What are the future directions for the VP scheme?

a) What are the future requirements of the professions (vis a vis design capabilities)?
b) What are the opportunities / constraints facing the universities?
c) Should universities be encouraged to share more teaching materials?
d) Are there any alliances that should be sought with other organisations or schemes?

Ken Wallace reported for Syndicate Groups 1, 4 and 7.

- Best practice could be better propagated through meetings, and the web, but this would need specific funding to ensure it is kept up to date and really active.
- VPs could encourage Universities to talk to each other
- Efforts should be made to encourage the sharing of teaching materials
- It will be important to tackle the resource issue for project work – for instance by more funding of VP scheme
- It could be worth producing different VP profiles – research orientated, focusing on the teaching staff, focusing on teaching students, etc.
- New ways of interacting might be developed (VPs are busy and may be distant from their university) – e.g. on-line discussions, mentoring
- A common first year for all engineers should be encouraged
- It is important to encourage students to learn how to solve problems
- There is a need to encourage a rethink on teaching of engineering science
- In Design – make – manage projects, the last of these needs more emphasis

- There is a need to influence the Engineering Institutions regarding accreditation – this should involve the VPs
- The RAEng should make more of a contribution to courses for incorporated engineers

Bill Oliver reported for Syndicate Groups 2, 5 and 8.

The development of the VP scheme needs to contend with important constraints:
- The Research Assessment Exercise (which is "blind to design" and "drives academics to ignore design")
- Funding
- IPR (Intellectual Property Rights)
- Course accreditation by the Engineering Institutions

Ideas for the future include:
- VPs can facilitate a better understanding of the design process by academics (who sometimes need this)
- Important to establish clarity of purpose and *modus operandi*.
- VPs could be used to facilitate 3rd strand or outreach funding
- It could be beneficial for VPs to report back their achievements, as is done by the "Sustainability VPs"
- It is important to consider both chartered and incorporated engineers
- Important to recognise the challenge for SMEs in providing VPs
- There is a need to identify all stakeholders' needs and create a clear way forward
- There could be more VP meetings – regionally, internationally, through the web
- It is important to maintain the good work on team-working and multidisciplinary projects

Chris McMahon reported for Syndicate Groups 3 and 6.

- It is important to publicise more of the success stories of the VP Scheme
- There is a need to share teaching material
- There are opportunities to make better use of the VPs' networks
- Local collaboration on resource-intensive activities should be encouraged
- The RAEng and VP Scheme could act as national integrating force – trading success stories
- Together they can also act as a political force, including accreditation issues with the Engineering Institutions
- There could be value in broadening VPs beyond engineering, e.g. getting architects or product designers into engineering departments, or vice versa.
- There is a need to resolve the confusion between innovation, design and project management
- VPs have an important role to play in ensuring students achieve a professional level of practice, engineering science and design (as is the case with medics, for example)
- It is important to demonstrate the value of the VP scheme to industry (not just to Universities)
- There is a need for a major study to understand how engineering students learn – is Project- or Problem-Based Learning (PBL) good for all?

- There should be continued funding for the VP scheme

In summary there are opportunities for more effective sharing:
- within institutions
- locally and
- nationally.

Discussion about Question 2

Ernest Irwin (VP, Birmingham) felt that the universities already get a huge contribution from the VPs and did not agree that they should get involved in the process of trying to get research funding - this would distract them from their real job.

Bill Oliver (VP, Newcastle) replied that his group had not meant it like that, as an additional function of their job. Rather that the VP could help bring the university into contact with sources of potential projects and funding by using their network of contacts in industry. It was a matter of facilitating more than anything.

Ernest Irwin (VP, Birmingham) also commented on the suggestion that there should be more sharing of teaching material. University lecturers are usually very reluctant to do this - each lecturer wants to use his own material. There has been a very poor take up of the considerable shared material (for instance in civil engineering) that is already available. Perhaps the RAEng could campaign in this area. He felt that there needs to be a culture change in relation to the efficiency of transferring information.

Chris McMahon (Bristol) mentioned SEED (Shared Experience in Engineering Design) and the many engineering design projects and guides it had produced. He agreed there would be a great saving of time in sharing teaching material. SEED was now looking at making such material available in electronic form.

Steve Culley (Bath) reminded everyone that VPs had now looked at the Principles of Engineering Design, and a good job has been done. The RAEng could, perhaps, move on now. The next theme it is addressing is (already) Design for Sustainable Development, and that is eminently worthwhile and going well. A new theme could be engineering management. Universities could benefit a lot from some help here – the elements of engineering management.

Colin McChesney (VP, Nottingham) did not agree. He felt there should be more VPs, maybe younger ones to replace the older ones. The RAEng should not change horses, but should build on the success of its current scheme.

Hugh Norie wondered if the whole situation is not changing. Younger people now want different things when they leave school.

Steve Culley (Bath) commented that courses are already required to address management issues, but that it is generally being done by people in management departments. The problem is that such people do not understand engineering.

Tony Stevens (VP, Loughborough) reminded the audience that Universities are not only places where knowledge is being transferred, they are a breeding ground for new ideas – we are the most creative country in the world , although we are probably the worst nation in the world for making money out of being creative. While our VPs bring a considerable engineering experience into the universities, they do not necessarily bring the best creative business and commercial skills for exploiting creativity. Maybe this is an area the RAEng could become involved in.

Bill Oliver (VP, Newcastle) said the RAEng was careful to select good engineers as VPs. He made the observation that this might not be so easy or successful if they were trying to select good project or engineering managers.

Chris McMahon (Bristol) told the audience that, at Bristol, they had used their VPs to give a different focus in different years. In the first year it had been "The challenge of design", in the second year "Tools and methods for the design process" and in the third year "The management of international projects". In this way they had succeeded in bringing some management into the courses, after they had had their input on design matters. It had worked very well.

Roger Johnson (Warwick) turned to the suggestion that VPs should campaign for a common first year course. However, there is a very wide spread of ability coming in, and different universities also seek to create a unique product – finding a niche in the market. He felt it would be a mistake to aim for a common first year course across all universities, and there would be endless argument about what it should contain. If one is seeking greater efficiency in the whole process, it would be much more valuable to focus on A-levels and getting a core syllabus at that level in maths and physics. That would avoid the terrible waste at universities in having to deal with some students who have no statistics and others who have no mechanics.

A further speaker thought we are now not really getting the right people from schools with the right qualifications and interests. We need to get better understanding of engineering in schools and getting the right teachers in schools.

Hugh Norie thought that no-one is really able to influence schools and teachers. The universities may have to adapt to deal with the different intake.

Bill Oliver (VP, Newcastle) was concerned that one consequence of SARTOR was that people now need to choose their GCSEs and A-levels earlier. As engineers we have a job to explain what we believe engineers need.

Tom Smith (RAEng) thought we should return to looking at the future. We need also to learn from the failures of the past. During the last 12 years the RAEng had focused on multi-disciplinary design – there had been some favourable experiences while others have said it is

impossible. No one has raised this at this meeting. Does this mean it is now not a problem to do it, or are people ignoring it? Is it now an acceptable principle that multi-disciplinary projects are included in courses?

Ken Wallace (Cambridge) wondered what degree of inter-disciplinary work he meant.

Graham Oates (VP, Birmingham) thought the whole idea of a discipline inhibits multi-disciplinary work. At Birmingham the VPs had been instrumental in trying to remove these barriers by bring some business principles into the university. There is now a single Executive Head across all engineering, not five heads of disciplines as there used to be, who would resist any change that threatened their autonomy. There is also a single Director for Learning and Teaching Programmes across the whole department.

Bill Addis (RAEng) mentioned the multi-disciplinary Student Engineering Design Projects he had helped to set up for the RSA five or six years ago. These had never attracted large numbers of entrants. There are probably many reasons, but the main ones were perhaps logistical, such as the many different deadlines for projects in different universities and the difficulty of co-ordinating projects across different departments. These awards have now been withdrawn, at least for a period while their format may be reassessed.

Svend Trinder (VP, Durham) wondered about the ladies? There are no women VPs. If we are aiming to create role models, we should get more women as VPs.

James Armstrong (RAEng) reported that there are two or three, who unfortunately had not been able to attend this workshop. There are, in fact, very few senior engineers who are women. He agreed we must clearly emphasise that we are not where we are because we are men!

Hugh Norie felt that this might be changing because there are now many more good women engineers coming up through the industry.

Tom Smith (RAEng) added that only the previous week the RAEng interviewing panel had had to turn down a lady applicant, not because she was felt to be unsuitably qualified, but because the university involved had completely misdefined her role.

Question 3: How should (do) we make engineering courses more interesting

a) How early should design teaching begin?
b) What is the best way to introduce design to undergraduates?
c) Should the “heritage of engineering” be included in the syllabus?
d) Is it really necessary to teach so much mathematics and engineering science?

Ken Wallace reported for Syndicate Groups 1, 4 and 7.

- First it is important to note that dropout rates from engineering are not all that high.
- Students should start design the day they arrive (many already do design at school)

- It is important to have some projects of real depth – it is vital to introduce the "technology" somewhere (students lack a basic knowledge of technology & manufacturing processes)
- Introduce "artefact studies" – reverse engineering. This could include heritage issues such as the history of the steam engine or the laser.
- We should readdress the balance between fundamentals (engineering science), projects and maths. There could be better web-based support systems for design projects, including interactive learning methods
- Better (interactive?) methods for teaching engineering science are needed
- Design - build - test projects and competitions are popular
- There is need to change perception of engineering with public, parents, school children and schools.

Question 4: The culture of learning

a) What are the problems of teaching across disciplines?
b) Is there a culture divide between disciplines?
c) How can we best learn the "nuts and bolts" of engineering?
d) Should Problem-Based Learning be more widely adopted?
e) Is there scope for a more qualitative approach to teaching engineering?

Bill Oliver reported for Syndicate Groups 2, 5 and 8.

- Cross-disciplinary projects are good news – they are especially good at encouraging students to be proactive
- There could be possible links to the LTSN (Learning and Teaching Support Network)
- Team-based approach is vital for industry
- PBL achieves good results and puts some fun into learning, but is resource inefficient .
- does PBL actually teach design in the best way?

Question 5: Form as well as function

a) Should more emphasis be given to aesthetic and artistic aspects of design?
b) Should we put more emphasis on ergonomics and the user interface?
c) Can CAD completely replace traditional sketching and drawing?

Chris McMahon reported for Syndicate Groups 3 and 6.

- Sketching and CAD do not serve the same purpose, so students need both - sketching to help create and develop design ideas; CAD to transmit information.
- There is a need to include something on aesthetics (form), function and ergonomics – perhaps a module in the 1st year.
- The usability of artefacts is increasingly important – there is need for understanding ergonomics to help achieve more intuitive operation

- Function is important as well as form – students are often les good at the function; the details are especially important
- It is important not to separate form from function; it is important to understand their relationship and demonstrate traceability
- It was especially important to understand the underlying basis on which any computer modelling of artefacts was done.

Discussion about supplementary questions

The first speaker returned to the matter that Chris McMahon reported about the user interface. This really should be the basis of all specifications and requirements. Yet no-one really owns it at present. The marketing people are incompetent at it and the engineers think it is someone else's job to do it. In his view this is one of the most important things we can do to improve the quality of engineering design.

Peter Hills (VP Cranfield) wanted to support the idea of conveying something about beauty and aesthetics and some of the softer issues to engineers. He recently had the opportunity to take a modern pneumatic cylinder to pieces in front of the students and to compare it with a Martonair pneumatic cylinder of 40 years ago. And there is no doubt that the new one does differentiate itself from the competition by its looks. It is really important that we awaken students to these matters. As regards ergonomics, he believed this was a much maligned and misused word. He gave the example of a car whose instrument panel was significantly obscured by the steering wheel. He felt that one of the jobs of the VP was to remind students that not everything is about science and mathematics and differential equations. A lot of it is about common sense. He gave the example of a new rifle that could not be shot around a right hand corner for fear of the spent cartridges hitting the user in the eye, and it also had a habit of going off if you dropped it.

Fred Maillardet (Brighton) reminded everyone that in the early days VPs were appointed to faculties not departments or disciplines. There is a need for ownership at the faculty level and that brings us back to the "product champion" argument which is needed at a senior level. Secondly, he said he gets incensed by governments that still talk about academic OR vocational activities. As engineers we are right in the middle. As VPs we need to devote some of our effort to educating governments that there is a large area in between these two extremes and we, as engineers, are the people who live there.

Tony Stevens (VP Loughborough) was quite appalled that we are actually asking whether aesthetics was important. One thing he tries to drum into students as a VP is that, in business, things are made for customers and that is what matters. It doesn't matter whether it is a beautiful or clever piece of engineering, it either does what the customer wants, or isn't any good.

Ernest Irwin (VP, Birmingham) came back to the question as to whether it is really necessary to teach students so much mathematics, and the groups have not really dealt with that. We are faced with a very serious situation nationally. He understood that the number of students doing maths at A-level is dropping precipitately. If we continue to require the same level of mathematics that we require now, we are going to be faced with a serous shortfall of

applicants soon. Calculators have done away with the need to do arithmetic: are computers doing away with the need to do analysis. It is not a question as to whether we need to teach so much mathematics; rather it is a matter of what kind of mathematics is needed for the engineers of the future? Perhaps the RAEng should fund a study. From a recent Engineering Council study it would seem that about 25% of chartered engineers need maths at a high level, leaving some 75% who don't. They are different types of engineers. Maybe there is a case for streaming courses with one strand highly mathematical, the other not. But not that one would be easier than the other; they would be different.

John Watton (Cardiff) said they now have a Design, Make and Test project in Years 1 and 2. In Years 3 and 4 they have more projects. He wondered whether they have now got rid of too much engineering science?

Ivan Yates (VP, Cambridge) felt that there is still a lot to discuss. We are not yet reaching very many firms that do engineering design. There are over 110, 000 SMEs and of these some 10-20,000 are doing design and product development. We are only reaching a few of these. We have a big communication problem. Could we perhaps use the new web site to develop this? This is something that the Academy should really look at.

Dick Harris (VP, Surrey) wondered how we would be carrying out engineering design in 10 or 20 years time. It may be that when we put into practice today's ideas it will already be too late.

Finally, Peter Hills (VP, Cranfield) reminded everyone of the Institution of Engineering Designers, details of which could be found at their web site www.ied.org.uk

At 15.45 Hugh Norie, in the chair, drew the discussion to a close and formally closed the workshop. He thanked the keynote speakers, and those who had presented the case studies as well as the syndicate reporters for their various contributions to the event.