

# **VISITING PROFESSORS IN ENGINEERING DESIGN FOR SUSTAINABLE DEVELOPMENT**

**Workshop at The Royal Academy of Engineering  
27<sup>th</sup> – 28<sup>th</sup> June 2000**

The key objectives of this workshop were to develop a better understanding of **the case study** and its potential role in the teaching of Engineering Design for Sustainable Development.

Report compiled by Dr Bill Addis: issued 26<sup>th</sup> July 2000

Delegates were welcomed on behalf of the Royal Academy of Engineering by Professor Jim McQuaid, Chairman of the Sustainable Development Education Working Group which has been active since the mid 1990's and also one of the Visiting Professors.

The chairman introduced the meeting of Sustainable Development Visiting Professors, which is an annual event. This was the third time that it had been held as a forum where VPs were able to meet and learn from each others' experience. This year it was decided to change the format by holding it in the Academy's headquarters in London and to aim to produce some useful output on a particular theme of common interest.

In their visits to the Universities the Chairman and David Foxley of the RAEng had been struck by the variety of different ideas of what is a case study and how it is used or integrated into the teaching. The theme of this meeting - in essence 'What is a Case Study?' - was originally Paul Jowitt's suggestion and it was decided that this would provide a focus for the meeting.

Dr David Fisk, Chief Scientist of the DETR, took the chair for the first session and introduced the keynote presentation given by **Professor Nicholas Ashford** Professor of Technology and Policy at MIT. The chairman observed that this title said quite a lot about the approach at MIT, as we have very few such professors in the UK. Professor Ashford teaches courses in Environmental Law and Policy, has been particularly interested in Sustainability, Trade and the Environment, and is founder at MIT of the multidisciplinary course Technology and Policy.

Professor Ashford informed and entertained delegates with a wide range of stories drawn from his background in chemistry, law and economics and his experience gained in helping to solve problems for a large number of people and organisations.

He began by reminding the audience of the fact that there are many ways to solve a problem, and not a single way, as was often originally envisioned by the person who posed the question. To illustrate the possibility of alternative ways of looking at problems he used the tale of a student asked by his physics teacher how he would measure the height of a building with the aid of a barometer. To the increasing frustration of the teacher he suggested:

- using the scale on the barometer to measure the height of a step, and counting the number of steps to the top of the building
- tying the barometer to a string, lowering it from the top of the building and timing the period of swings of the pendulum
- measure the length of shadows cast by the barometer and by the building
- dropping it from the top and measuring the time to impact, and finally
- ask the building superintendent how high the building was and give him the barometer in gratitude.

This illustrates the possibility of using alternative viewpoints to solve problems and, for Prof. Ashford, this was what sustainable development was all about – finding alternative ways of meeting peoples' needs. Unlike many people he found the idea of

sustainable development was not complex - it meant not compromising the life of future generations by our own actions - equity across time, people and nations. It is the solutions that are complex – it is more than making sure we have enough chromium in twenty years from now. It depends ultimately upon three enabling features: a good economic life, good health and environment, and good employment and purchasing power.

As he had become older, Prof. Ashford found that there were only two problems in the world:

- The first is the Balkanisation of the knowledge base in universities, government and industry – the tendency for boundaries to form, separate departments to be created and squabbling to ensue. This came out of the need for specialisation but it has now outlived its usefulness and is now getting in the way and stopping us solving problems.
- The second problem is inequality of access, equal access to political power.

He also found that far too many people spent their time describing problems rather than offering solutions. He cited a recent example of this and Balkanisation from a conference in the USA on environmental sustainability where the scientists and academics were invited. Engineers, who are the people who solve problems, were not present. Prof. Ashford was glad to see that the Royal Academy of Engineering was not falling into this trap and was involving engineers at the very heart of the matter.

The speaker drew on the field of health and safety to illustrate the ‘normal’ approach to decision-making based on the technique of risk assessment, which usually involves looking at the worst-case risk. However, this approach frequently fails, as major accidents such as Three-mile Island demonstrate. He felt it would often be better simply to ask the questions ‘Could you be making your product in a different way?’ and ‘Could you make a different product that serves the same purpose?’

This has a major impact on policy making. There is a fundamental distinction between the policy sciences and what he called policy engineering. Policy sciences emerge from the disciplines such as risk assessment, operations research and meta-analysis, which are fundamentally analytic and useful. Policy engineering is the design of inherently safer production – engineers are basically problem solvers not analysts. He welcomed the efforts of engineers to incorporate sustainability in their methodologies for solving problems.

The speaker warned that the consequence of not breaking down barriers between disciplines was often merely to move the problem. For example, when looking for more benign substances and processes, such as using water-based paints, it was often the case that the problem was moved from the environment to the worker – from environmental toxicity to worker safety. The Swedes have shown that the biocides used in water-based paints are much more dangerous for workers than the production of normal paints. Likewise, while skin cancer resulting from the hole in the ozone layer may be reduced by banning the use of CFCs, the manufacture of their replacement – HCFCs – involves carcinogenic chemicals that lead to cancer among the factory workers producing them.

Sustainable development means embracing more than one discipline – not merely the development of new specialisms at the interface between established fields, such as biochemistry (interdisciplinary work). Nor is it multi-disciplinary, which means being trained in more than one discipline, where you have engineers who know about energy, or cost estimating or production. In his course at MIT he talked of “creating engineers with a difference”.

Trans-disciplinary working means literally transcending the disciplines themselves - thinking differently about problems and approaching them in new ways, and that is a creative process. He thought we could really stimulate this by focusing on sustainable development. As a minimum we are trying to improve the economy and environment, maybe also health and safety, and wouldn't it be nice if employment was thrown in. Wouldn't it be nice if industrial transformations gave us a triple dividend, not just a double dividend? It is interesting that we now realise that we cannot deal with developing new industrial processes and leave the environmental issues until afterwards, as a second thought. This is not the best way to control the environment – “end of pipe” is not effective; it comes too little, too late. How is it then, when it comes to employment, we think it is just ok to let industrial transformations happen and assume the jobs will just take care of themselves.

The TNO in Delft did a study to see what effect on employment it would bring if manufacturing were devoted entirely to achieving cleaner production by substituting greener chemicals and processes. They found it would not lead to additional employment – just different employment. This sort of change did not really mean a change in the system such as introducing sustainable agriculture.

Ultimately the difference between a multidisciplinary person and a trans-disciplinary one is that the latter just talks about a problem you have to solve, you can not tell whether he trained as an engineer or a lawyer or an economist, he just talks about a problem.

One of the major stumbling blocks to introducing trans-disciplinary thinking is, of course, the faculties in the universities. They always want to replicate themselves. The speaker recounted how he had been one of four trans-disciplinary professors at MIT who were meant to be followed by many, many more. In fact no more were appointed. The faculties did not know what to do with them and the traditionalists didn't trust them. One thing you can be sure of is that when the trans-disciplinary approach is applied to an old problem it means that previous attempts at finding solutions have not worked, and that the traditionalists in the field are threatened. You therefore need endorsement from the top of the university.

The speaker turned to the problems that can arise from innovative thinking, recommending delegates to read *The innovator's dilemma: when new technologies cause great firms to fail* by Clayton M. Christensen (HarperCollins, 2000, pbk. ISBN: 0066620694, £9.80 from Amazon). He concludes that the most successful firms are those that listen to their customers, and that the most spectacular failures are in firms that also listen to their customers. Dominant technologies are not going to generate their replacements. Innovation challenges and, hence, threatens orthodoxy. This is the reason why there are so many spin-off forms that come from established industries. The author had coined the term ‘geriocracy’ – a system that seeks to

preserve old ideas; we do everything we can to keep old technology in existence as long as possible.

It was important to loosen the creative spirit in ways that are not formulaic. Over two centuries we have learnt how to engineer labour out of production; but how do we engineer labour *into* production? We hear that pollution problems are anthropogenic. So why is it that people strive to find technocentric solutions rather than anthropocentric solutions?

Despite being an environmentalist, Professor Ashford did not believe it would be from the environmental and health and safety issues that the pressure for fundamental changes would come. It will come from the fact that for fifty years now we have been displacing labour by more efficient production; we should not now be surprised that unemployment or underemployment is so high.

If there was ever a case where you need anthropocentric solutions it is in communications technology, when workers are now measured by the number of keystroke operations. We should not be surprised that workers are not truly committed to their enterprises when they see people who perform poorly being sacked. It will be essential for long-term survival for firms to have dialogue between labour and management.

Prof. Ashford reported that he had persuaded three ministries in the Netherlands – economic affairs, social affairs (employment) and the environment - to fund a research programme into achieving the triple bottom line rather than just the a double dividend. At present they are dealing with the problem of high productivity by displacing older workers because they cannot socially deal with large-scale unemployment among the young.

The Technology and Policy programme at MIT, with just 35 students a year among 10,000 in the whole of MIT, was considered by the speaker a ‘huge success’ as the graduates all went off into highly influential positions. There is evidence that only about 15% of engineers had the ability to undertake trans-disciplinary work and of these only about 2% were actually doing so. It should be the aim to raise the 2% to 15%. For the remainder it would be the goal to instil an understanding of and respect for the trans-disciplinary approach.

In the Netherlands the Technical University at Delft and the Erasmus University have decided to address this matter by signing a memorandum of agreement at the highest level to make the purpose of their universities and their cooperation to educate people in sustainable development. Initially, in Delft, this will comprises three elements:

- the design of a first year course on Technology in Sustainable Development for all students of the university with the message that sustainable development is crucial to the engineering profession
- the intertwining of sustainable development in all regular disciplinary courses corresponding to the nature of each specific course
- developing the possibility to graduate in a sustainable development area within the framework of each of the seven faculties which are problem-oriented in their scope, not departmental or by discipline such as civil or mechanical engineering.

With similar aims in mind, MIT, the State Technical University (ETH) in Zurich and the Tokyo University have formed an Alliance for Global Sustainability and committed themselves to undertaking a range of collaborative projects. The projects are not very big, and the cultural differences between the Japanese perspective and those of the USA and Switzerland are very great, but it is a start.

At a recent meeting of the National Academy of Sciences on The Built Environment the Assistant Secretary for Energy Conservation said “energy conservation in office buildings is not important ... labour costs are more than a hundred times more significant than reduced energy costs”. By improving the indoor air quality a little we can reduce absenteeism so much it totally masks any savings we can make from using less energy.

We also need to bear in mind how reluctant people are to change, even when irrefutable facts are at our disposal. A medical example illustrates this point. Despite a new cure for stomach ulcers being discovered and well publicised in technical journals nearly 20 years ago, still only 19% of doctors in the USA were using the cure, the remainder persisting with older, more expensive and more invasive treatments.

To conclude, Prof. Ashford described what he saw as the American solution to solving major problems through the marriage of engineering and economics. It was based on three premises, all of which are wrong, in his view:

- using rational choice theory and cost benefit analysis as the *only* way to establish public policy,
- the Government should play a minimalist role, and
- the industry that causes the problem will be the industry that provides the solution.

Prof. Ashford strongly urged the European Union not to follow the American way of trying to deal with environmental issues and global warming. Nor would he recommend we emulate what they have done at MIT. He would rather suggest we follow what they are doing in the Netherlands where they are taking the environmental issue much more seriously, even though it is difficult. In the USA he saw an entrenchment of the disciplinary stranglehold on public policy. We say that the problems are all global and we no longer ask our PhD students to know more than one language.

Professor Ashford finished by thanking the Academy for having been invited to speak and he was glad to find that they were addressing the problem. He hoped he had given the audience something that would stimulate some inspiration.

Dr Fisk thanked the speaker for his stimulating presentation and invited questions.

### ***Question 1***

Jim McQuaid (VP Ulster) asked how the speaker would set about dismantling the professional institutions.

The speaker replied giving the example of the medical professions in the USA. Now less than 50% of practitioners belonged to what had been the established professional

body. It was simply not addressing the major issues that concerned the profession. There were now several rival bodies that were attracting members. Another change is that new publications are being launched to rival the established ones set up by the established professional institutions. New fora for discussion need to be established.

Prof. Ashford went on to observe that the system of *peer review* was part of the mechanism by which the established order maintained its influence on professions. A more equitable and less reactionary system would be *professional review*. You don't give a paper on global warming or toxicology to experts in those fields. You give it to anyone who might have a professional opinion on the subject.

### ***Question 2***

Barrie Mould (VP Brighton) asked what we can learn from examples where creativity has broken through the inherent conservatism and blossomed.

The speaker replied that the new technologies always appear before the old ones have died. He referred to Peter Drucker, who had recently written in the October issue (1999?) of the Atlantic Monthly about the next industrial revolution, resulting from innovations during the next twenty years or so, will have little or nothing to do with information or communication technology. That is an astounding thing to say, especially when you look at today's NASDAQ index. The speaker thought that we don't have very much to learn from these emerging technologies, which doesn't mean that those technologies aren't important. We have much more to learn from looking at why dominant technologies prevent innovation and keep new technology back. He illustrated this with an example from the car industry.

A few years ago, the American car industry was being penetrated by Japanese imports and it was complaining at the new environmental regulations imposed by the Carter administration. Prof Ashford found that the foreign firms were using the new regulations as an opportunity - a means by which they could achieve more penetration of the market. And the interesting thing was that the foreign firms used American technology, American inventions to achieve this.

We should also be very careful when the old industries buy up the new industries, they have a vested interest in not nurturing them because they are used to large profits and the new ventures don't give that. What we really need to do is to stop the perverse incentives that encourage old technology to stay in existence as long as it can. We need to start with an even playing field; we need a tax system that rewards innovation; we need to teach engineers that it is safe to innovate; but he did not think that we have anything to learn that we don't already know.

The speaker felt that at Sussex University, where he had recently lectured, they really understand industrial policy. He felt they used to have people like that in the USA, but they don't have them any more.

### ***Question 3***

Paul Jowitt (Heriot-Watt) recalled the speaker's suggestion that cost benefit analysis could fail. There are some areas where sustainable technologies can show economic benefit. But there are others where this is not the case, yet we are stuck with

discounted cash flow analysis which evaporates the future. He asked the speaker to say something about the failure of the market.

Prof Ashford said he made a distinction between market failures and the failure of the market. The trouble is you can never get the right price for global warming. There is always a problem when we need investment now and get the benefits later. Some people say you should perhaps reduce the discount rate by 1%. But what about health – as we get older health becomes more valuable. That is equivalent to a negative discount rate; the economists don't know what to make about that. Brundtland says the whole issue of sustainable development is extra-market. However, not subscribing to cost-benefit reasons for decision making does not mean that you are being irrational, which is what some people assume. Some economists argue that reducing global warming makes no economic sense at all. They are right. That is the next generation's problem. But public policy making is not based only on economic or scientific arguments. It is informed by other decision-making rationales.

#### *Question 4*

Andrew Barry (Edinburgh) observed that environmental problems have a timescale far in excess of the period in power of any government. He wondered, therefore, whether involving the public in decision-making on such matters would get round that problem.

Professor Ashford felt this was a rather Anglo-Saxon viewpoint. In the Netherlands they do it differently. They don't forecast; they back-cast. They decide where they want to be in forty or fifty years from now and work backwards to decide what has to be done now in order to get there and set about engaging the stakeholders to try to get it done.

We are governed by a close relative of NIMBY principle - the NIMTO principle – not in my term of office. But the speaker saw the demonstrations around the WTO meeting in Seattle as a watershed. People are no longer satisfied to have decisions taken in secret; they want to be involved. They no longer lobby the environmental agency, they lobby the trade representative– that's where the real power lies.

[Something very interesting is happening in the USA now. Ralph Nader, a presidential candidate is starting to get more votes in the polls. If he reaches 15% he will have to be invited into the TV debates. He says he has joined the race to smoke Al Gore out, to expose his environmental shallowness. And these 15% are hard-core democrats. This is dangerous politics.]

In the USA we have all but destroyed our judicial system. Were we aware, the speaker asked, that a certain court of appeal had invalidated the ozone and particulate standard? Why? Because the Clean Air Act says you have to protect the public with an adequate margin of safety, giving discretion to the agency. But the judge said no, Congress cannot give discretion, it has to specify. He wants a bright line between ample and non-ample protection of public health, as if you knew what level of ozone was ample and what was not. But these are judgemental issues. Now Congress is not letting the Environmental Protection Agency monitor any industrial emissions from firms. Do you think there is going to be compliance with a regulation when you are not allowed to spend money to comply? This is environmental anarchy. The speaker

could not square industry's commitment to sustainable development and their support of these kinds of efforts.

In conclusion the speaker urged the EU to decouple its policies from those in the USA – in defence, in science and technology, and in the environment and global warming, Britain and the EU should decouple itself from the American leadership, it doesn't deserve to be followed, adding “ and I don't mind being quoted on that”.

### *Question 5*

David Fisk (Chairman) returned to the emerging information and communication technologies and wondered if there were not some ways in which they might help bring about some of the revolutions to which the speaker had referred.

The speaker replied that the technologies are neutral and it all depends on how you use them. He gave the example of the automated repair of televisions when it consists merely in replacing each module to see if the fault is cured – what satisfaction does this give the TV repair man? Compare this with how a new way of thinking can lead to benefits for all stakeholders in a system. Some photocopier manufacturers were now preferring not to sell the machines but to charge their customers for the copying service – the customer gets the service they want without large capital expense, the firm is better able to maintain the quality of the technology and the repair staff gain a higher status as their role is seen to be essential to the business – a far cry from small firms who make their living from repairing TV sets with little or no interest in the customer's long term satisfaction.

The speaker observed that the same information technology led to both situations, but one enriched the work, the other diminished it. It is possible to use technology to rely on specialists who have rewarding jobs; it is also important to recognise that the workers might also have good ideas about how the work should be done in ways that are rewarding – some things should be automated, some things should not be automated. Why not have workers participate in management? It is important to broaden the base of decision-making. Ultimately social inclusion in the decision making process is the only way that people may come to accept new technologies such as biotechnology. At present people participate in public participation when local or national government has failed to carry the electorate with it and people feel the need to institute their own checks. But it would be terrible to end up with government acting as the referee between rival public factions competing by shouting louder. This would not be a good way for establishing public policy.

The Chairman thanked the speaker on behalf of the Academy for his stimulating talk.

The presentation was followed by dinner in the Academy.

## **WORKSHOP THEME: WHAT IS A CASE STUDY?**

### **KEYNOTE PRESENTATION**

The workshop began with a keynote presentation by Ken Roberts from the European Case Clearing House (ECCH), based at Cranfield University. Ken was formerly the head of management at the University of Staffordshire and, during his career, he was a manager in many engineering companies including GKN and BTR Industries.

Ken entitled his talk: “The use of case studies in business management education and their role in learning - some implications for Visiting Professors in Engineering Design for Sustainable Development.” The following is a summary of the main points he made. The full set of slides for the presentation is attached in Appendix 1.

The ECCS collects case study material from throughout the world (except the USA) and these are used by most of the major business schools. This is the organisation you approach if you want pre-prepared case study material. Although they are prepared and collected with management and business education in mind, there is no reason why some of them could not be used in engineering education, and some already are being so used.

Case studies were first used in management education in the UK about 30 years ago, but spread to all business schools only during the last 10-20 years. They are used in different ways and to different degrees – the MBA course at Harvard comprises three case studies a day on business management, every day of term over two years – a total of about one thousand (Harvard first started using case studies in 1908). The case study method accepts that there is no single, all-encompassing theory of the firm – many partial theories are used for different purposes.

In the process of education it is important to consider what both teacher and student bring to the classroom and, in particular, what the student takes away. When devising a case study you have to think very carefully about how it relates to these inputs and output, and how the teaching strategy using the case study will influence the learning process

A case study requires the presentation of a number of issues and real, specific problems to be solved. It is effectively a distinct form of narrative, but unless it has issues or problems to be resolved it is not a case study, it is a case history. And fundamental to all this, of course, is the willing suspension of disbelief, for the student must become the decision maker or manager in the case study. Students need to have received the case material before the teaching session and will have needed about two hours to prepare each case study. One problem is that students tend to believe in the idea of a single correct answer, and it is often disarming for them to realise there can be many responses. They also have a disproportionate interest in what you (the teacher) think or what actually happened in the real case. Neither of these is relevant to the use of a case study in a class.

The successful use of a case study can develop in students the ability to analyse situations, make decisions, or form opinions, but often they are often reluctant to do so!

The role of the instructor is manifold. The main role is to run the show. But you also have to stimulate the students and provide additional, specialist information when needed. You need to keep the discussion on track in order to achieve the educational aim, without over-asserting your influence on the proceedings. You need to keep a record of the discussion, which may last for two hours, to enable you to sum up at the end and, of course, you also need to ensure the class reaches the end of the case within the time available.

The change from lecturing to teaching by case study can be very daunting. Running a case study is not a soft option. The instructor needs to know each case study extremely well and they need a lot of preparation. In a lecture, the instructor is in total control; in case-study teaching, the students are in control.

Finally, in the preparation of a case study, it is important to be aware of the so-called “case study iceberg”. Apart from the information in the public domain it is important to delve beneath the surface and to research the culture of a firm and establish what is *actually* happening.

In summary it is best perhaps to look at what a case is *not*. It is not

- a well-defined problem
- a specific problem, with one answer only
- an example of how things should be done
- an example of best practice.

A case study is an actual story. Alternative outcomes are possible and it requires the student to exercise the same skills as the decision maker:

- be clear about the objective
- study the performance
- identify what could be done
- select the best solution – what *you* would do.

In conclusion Ken Roberts expressed his feeling that case studies could be an excellent capstone to a whole course, serving to pull it all together.

## **SYNDICATE GROUP DISCUSSION (1)**

Following the keynote presentation, Professor Paul Jowitt introduced delegates to the themes for discussion in the syndicate groups. A full set of his presentation slides is attached in Appendix 2.

Syndicate Groups A, B, and C would respectively discuss the Attitudes, Skills and Knowledge that students needed to develop in engineering design for sustainable development. Group D would address the attitudes, skills and knowledge needed by the educators involved in this education process.

The conclusions of the syndicate group discussions were as follows:

### **Group A – Student Attitude**

Presented by Kevin Lomas (de Montfort)

*How can the appropriate Attitude be developed effectively in the student?*

- The right attitudes among the staff
- The engineering part of Political, economic social and technological education ‘PESTE’
- The titles of degree courses
- Case studies and case histories
- Involvement
- Breadth - a wide conception of the context for engineering
- Link to CEng / IEng
- Change and progress in PEIs
- Make sustainable engineering exciting and sexy

*Innovative learning solutions which overcome the barriers*

- a competition for Engineering design for Sustainable Development
- the sustainable business challenge (via www)
- exposure to economic and political realities (politicians, economists, sociologists)
- reach out to schools
- site visits

It was important to emphasise that engineering is a part of, not apart from society - humanising technology and, hence, engineering.

... but don't bring complexity too soon - it may put students off.

*Assessment*

- book reviews / oral presentations
- course assignments
- group design projects
- exam questions

## **Group B – Student Skills**

Presented by Dr Richard Darton (Oxford)

*How can the appropriate Skills be developed effectively in the student?*

Three key skills – creativity; communication; handling complexity.

### **Creativity**

*Methods*- open-ended problems, case studies, design work

*Barriers* - the education system itself

*Innovative learning solutions that overcome the barriers* - learning how to learn, making time for creative activity; encourage thinking outside the box

### **Communication skills**

*Methods* - written and oral reporting

*Barriers* ‘tick-box’ mentality; lack of practice; superficiality; not good at defending opinions; poor writing skills; sound-bite mentality (PowerPoint presentations)

*Innovative learning solutions which overcome the barriers* role-play, video, reporting with feedback; probing by teachers; mentoring by older students; peer group presentation with challenge

### **Handling complexity**

(NB complex is rich in structure; complicated is rich in detail)

Not best achieved by doing 1000 case studies!

*Methods* brainstorming; group work; mentor & small groups

*Barriers* - lack of confidence; lack of initiative; dominant students; time management

*Innovative learning solutions which overcome the barriers* - contact with real-world problems and professionals; see real projects in progress; big-scale problems; holistic approach; multidisciplinary groups; team self-assessment; critical path techniques for planning; work logs – getting them to write things down.

## **Group C – Student Knowledge**

Presented by Charles Duff (VP Surrey)

*How can the appropriate Knowledge be developed effectively in the student?*

*Methods* - knowledge / awareness; ‘catch-up’ course on sustainable development in first year (NB it must be done in the Engineering School - not by a service department); a mixture of lectures, case studies and design projects; need to convey complexity and interactions among many stakeholders.

*Barriers* - the timetable; staff skills and engagement; involvement with the subject and student pre-knowledge; communication skills of students; means of assessment; lack of awareness about which employment markets the engineering students will be

offering their skills in; international, political, social, community contexts. How to develop multi-disciplinarity?

Short-term thinking is now the norm: sustainable development is all about long-term thinking. We are used to a 2-D appraisal of our projects; it must now be multi-dimensional, including sustainability issues. Students should also be reminded (told) that the public is not stupid. Gone are the days when the expert view was king. Public opinion is equally important.

*Innovative learning solutions which overcome the barriers*

Enhancement - student / employer interchange; career opportunities; use of role models – young engineers demonstrating how they have used knowledge gained in their undergraduate studies. It would be worth doing some market research about what criteria of selection potential employers may have in this area. The Sustainable Challenge (World Business Council Exam via Internet);

**Group D – Educators’ Attitude, Skills and Knowledge**

Jeremy Purseglove (VP Hertfordshire)

We need to consider how the work we do, as RAEng VPs will survive after our tenure has ended. Will it just evaporate?

To teach sustainability to students you must first change the staff and the universities. We often find the students when they come in are greener than the staff.

Problem 1 - Staff attitudes and background

Solutions

- induction courses
- dialogue between staff and VP
- outreach ‘retreat’ for staff and students (as run by CRAC for PhD students many years ago)
- threat that staff will lose their jobs as engineering applications drop
- a system of “accredited teachers”
- change the courses and maybe the staff will feel different

Problem 2 - Courses which reflect the structure of ‘faculties’

Solutions

- make sustainability compulsory with credits
- credit accumulation (everything is boxed) vs. the aim of holistic learning
- raised expectations from professional engineering institutions
- qualification on sustainability

Problem 3 - Lack of text books and teaching material on sustainable engineering

Solutions

- write / produce them
- use the Internet

Problem 4 - Sustainability is woollier than engineering

Problem 5 - Internal politics in faculties and departments

## PLENARY DISCUSSION (1)

Richard Darton asked what would happen to the work achieved by VPs at the end of their periods of tenure, and wondered if, perhaps, the RAEng should act to ensure it would take hold in universities.

Jim McQuaid (VP Ulster) identified the need to develop new measures of success in education. The very idea of a 'right' answer was simply not appropriate to problems in sustainable engineering

Roger Booth (VP Oxford) observed that while this Seminar was looking at undergraduate teaching the latest EPSRC Awards indicated that there were a great many projects in the field of sustainability.

Barry Mould (VP Brighton) reminded delegates that the world was changing very rapidly indeed and that the government commissions some 40% of UK construction and has the potential to influence the addressing of sustainability issues. Already government contracts are starting to ask for environmental issues to be taken into account. We are going to have to deliver students who are able to handle these issues.

Paul Jowitt (Heriot Watt) asked how the RAEng VP Scheme would endure after those currently in post. It was arguable that previous VPs in Design Principles had not left a permanent change in their universities.

Jim McQuaid (VP Ulster and Chairman of the Academy's Sustainable Development Education Working Group) replied that the Academy was aware of its duty to draw together the various outputs from the individual universities (with VPs) and make it available through a medium that was accessible to all Universities in a generic form. It was recognised that this would require some considerable effort and the Academy was going to address the matter of funding it as a separate exercise later in the year.

The Academy was also trying to get the message across to the funding councils, though so far with little response, and making it clear to them that the role of the Academy's work was pump-priming. It might be hoped that there might be a means of influencing the core funding of Universities in the long term and introducing sustainable development that way. The Committee of Vice Chancellors and Principals did write earlier this year to all vice chancellors impressing on them the need to include sustainable development for all undergraduates.

We are also working on Government Departments, who are the customers, especially the DETR. We are proposing to get some ministers to visit one or two of our VPs in situ so they can see the success of the scheme and there are not yet very many success stories in sustainable development for the Government to point to.

We are also in touch with the Round Table on Sustainable Development (soon to be replaced by the Sustainable Development Commission). The chairman of the Round Table was very impressed with what we have been doing.

Jim felt that these are evidence of many activities which are in place to ensure that current good work will have a lasting effect, and not fade when the Academy moves on to some other issue.

Commenting on the discussions so far, Peter Guthrie (VP Cambridge) made three observations:

- the phrase sustainable development is very widely used and being used so much that its meaning is tending to be abused and thereby devalued.
- our government is much less clear about its approach to sustainable development than the Netherlands, for example. Our Government's first priority is 'sustained and high levels of economic growth' (not activity). It is difficult to reconcile this with sustainable development. The government is also not wont to look at long term views. It has even dropped its 20-year plan for housing.
- Finally there is the matter of measuring sustainable development in the construction industry. The indicators being proposed by various bodies (e.g. CIRIA) are silly or unmeasurable or meaningless – not because the people are stupid, but because it is extremely difficult to come up with indicators that are simple enough to be measured yet robust enough to be meaningful.

Roger Booth (VP Oxford) observed that the work on sustainable development being promoted by the RAEng was being looked at with interest by a great many people, and he knew of no similar scheme elsewhere in the world. He doubted however whether sustainable development would soon be widely adopted. It was, in practice, difficult to find more than about 30% of engineering academics prepared to commit themselves to changing what they did.

## SYNDICATE GROUP DISCUSSION (2)

Barrie Mould (Brighton) took the chair after lunch and introduced the second series of syndicate discussion groups building upon the work of the earlier discussions. The general theme was:

*How do we prepare and use case studies to meet our students' needs?*

This theme was broken down into two subsidiary issues:

*What attributes of case studies are appropriate for different stages of the learning process?*

- length and complexity of case studies
- interaction with other teaching methods
- subject matter (& state of development)
  - o real projects completed
  - o real projects in progress
  - o real potential projects
  - o conceptual / hypothetical projects

*How do we use some of the techniques mentioned earlier to enhance learning through the use of case studies?*

- peer group presentations
- role play
- site visits
- brain-storming
- mentors
- group working
- work logs
- design work

The emphasis for the Syndicate groups should be to deliver some useful output in the form of *practical advice to VPs* on what they might implement in their own university situations and how they might best achieve this.

The four Syndicate Groups were invited to address different stages of the undergraduate programme:

- A – Initial awareness to level the playing field at the start of a degree
- B – 1<sup>st</sup> and 2<sup>nd</sup> year ongoing development of awareness, skills and knowledge
- C – Optional or compulsory full module at 3<sup>rd</sup> year level
- D – Input into MEng project (design or otherwise)

What is the role of case studies at each of these stages?

## **FEEDBACK FROM SYNDICATE GROUPS**

### **Group A – Initial awareness to level the playing field at the start of a degree**

Feedback by Peter Guthrie (VP Cambridge)

An awareness-raising course would need to incorporate the following:

- Introduce Sustainable Development on a broad front – as an inclusive matter
- Introduce the key issues
- Use accessible (local), real case studies
- Use visible (national / international), real case studies
- Develop a consistent approach and methodology for addressing and analysing the issues of sustainable development
- Demonstrate the incorporation of
  - o social dimension
  - o economic dimension
  - o environmental dimension
  - o social inclusion
- Sustainable development is not a synonym for a concern for the environment.

Case study suggestions:

- Accessible case studies used at the University of Ulster include
  - o the university campus itself
  - o a local hospital
- Visible case studies might include
  - o M3 Twyford Down
  - o West Coast mainline
  - o Channel Tunnel Rail Link
  - o Locally notorious schemes
- Examples of unsustainable development
  - o A hotel development near a coral reef
- Technology-led success stories
  - o Fuel-efficient vehicles
  - o The Clean Air Act

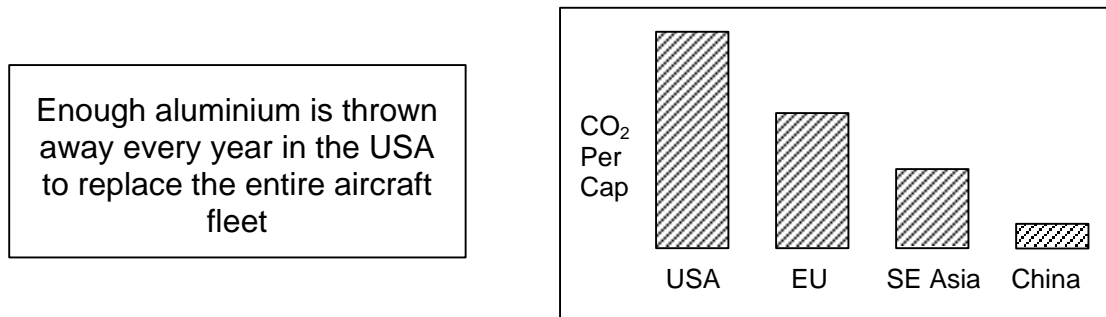
Peter cited the example of the route of the M3 as particularly instructive because he used it as a case study example of a poor choice on sustainable grounds, whereas he thought Jeremy Purseglove used it as a case study demonstrating a good choice. And for Peter this was entirely defensible. It should be possible for people to come to different conclusions about projects, given the potential for different weightings given to different issues and so on. (Jeremy did not quite agree that there was clear water between their two positions, but agreed with the conclusion about coming to different views about a project)

In all case studies it was important that:

- students should be presented with open-ended problems
- students should define their own boundaries, because this is a fundamental part of understanding sustainable development
- engineers should not be demonised
- students should feel that engineers could actually make a beneficial difference.

When using case studies the tutor should be employed as an enabler. Students should be encouraged to think for themselves and to develop their own attitudes (any attitudes!). Any technique should be used which releases energy, encourage attitudes and engage students in the process, e.g. role play, site visits, brainstorming, video, photography, CAD and felt tip pens. Presentations by students are important and prizes are good incentives.

It is also useful to develop / collect a series of Sustainable Development “Flashcards” such as



### Group B – 1<sup>st</sup> and 2<sup>nd</sup> year ongoing development of awareness, skills and knowledge

Feedback by Ken Snowdon (VP Loughborough)

A number of general points need to be addressed:

- students’ initial anxiety – seeing lots and lots of environmental problems but no solutions on the horizon
- as engineers you are part of the solution, not the problem “you can make a difference”
- Sustainability is only an extension of ‘normal’ engineering
- lack of knowledge about legislation (EU, Kyoto)
- first lecture (at least) must be delivered by an enthusiast
- Important to identify the universal problem (e.g. global warming) and to deliver specific examples in civil, mechanical, chemical, etc.
- Need to relate SD to course content in years 2, 3 and 4.

The following points were especially relevant to year 1:

- a need to define the basics – sustainable development, LCA, Eco-efficiency. Deliver in six 30-minute lectures (say).
- There should be input by industrialists from different disciplines talking from their own personal experience
- Student background varies from university to university (no single best way).

Year 2 courses should embrace the following:

- more detail, especially in the legislative framework
- case studies - energy, waste and water audits applied, for example, to the university campus
- link between theory and practice
- key books e.g. Factor Four

- assessment of case studies by project work rather than examination
- preparation of students from sandwich year or vacation work

### **Group C – Optional or compulsory full module at 3<sup>rd</sup> year level**

Feedback by Charles Duff (VP Surrey)

A third year module would need preparation in earlier years including basic concepts such as waste hierarchy, the second law of thermodynamics and introduced by means of a number of short case studies (a half a day or so) rather than larger, open-ended ones.

In year 3 a module could be a single case study comprising 40 – 80 hours of a student's time. As well as requiring students to apply knowledge already learnt it should also encourage the development of transferable skills such as researching new knowledge, problem solving, and communication.

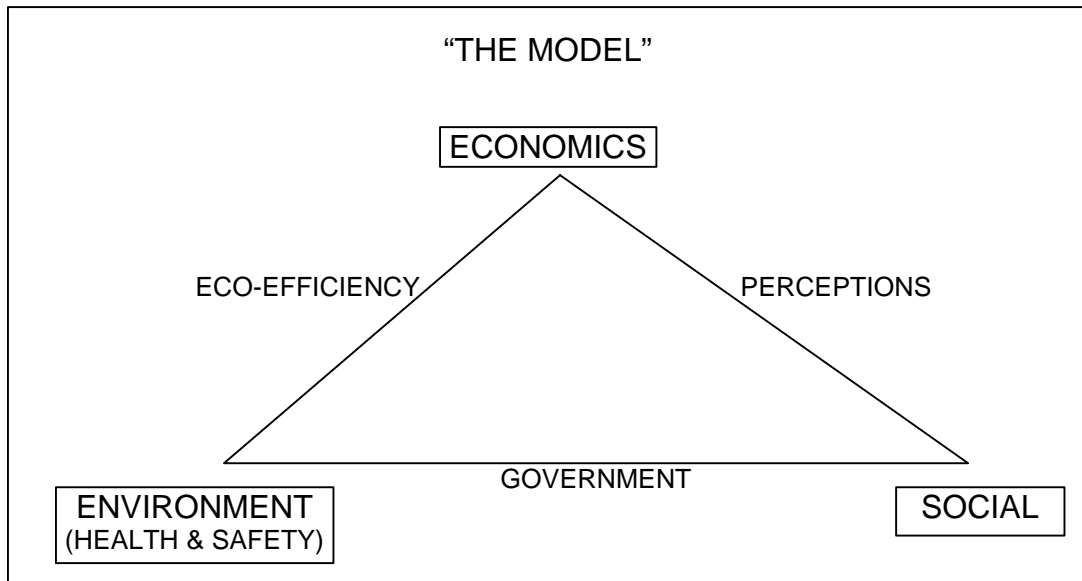
In order to become 'live', a case study should be real (not realistic) and include:

- confronting the client
- involvement of (or visit by) project manager
- opportunities for group work and brainstorming
- full range of issues:
  - o health & safety
  - o law and regulations
  - o social and ethical
  - o full 'environmental' costing

It would be important to relate or link a 3<sup>rd</sup> year module to the 4<sup>th</sup> year project, especially if, as our Group believed, sustainable development is embodied in 4<sup>th</sup> year project assessment criteria, should 3<sup>rd</sup> year module be compulsory?

The Group felt it is vital to address the issues of regulation and legislation and, the social and ethical issues as well as 'full costing' of projects and their impact (green taxes and so on). The importance of good, competent and 'aware' teachers can not be overemphasised.

**Group D – Input into MEng design project**  
Feedback by Jeff Hulse (VP Newcastle)



In a fourth-year (MEng) design project there is a need for the following:

- define the objectives and drivers
- select structure (single or group)
- assessment criteria, including credit
- define the added value – educational and challenging the traditional view
- scope for imagination
- pre-requisites and additional requirements (tools and techniques, EMS, LCA)
- embrace concepts of product stewardship – closed-loop thinking, cradle to grave responsibility
- at Newcastle we let them carry on their project ‘as normal’ and we gradually start to criticise their work according to sustainable development criteria (as in the model above). While the better students do embrace environmental and economic issues, very few initially consider the social issues – which is mainly a matter of perception by the public and others.

## PLENARY DISCUSSION (2)

Jim McQuaid (VP Ulster) began by offering the group some of the benefits of his experience at Ulster in planning their first-year awareness-raising input on sustainable development.

- They had developed an existing 'IT and Communication' module which was content-neutral and added the aim of developing an awareness of sustainable development. It is due to start in the next academic year (2000-01)
- Six lectures will be given by external lecturers including basic concepts and statistics.
- Local cases studies will be used – the university, a hospital, and a leisure centre – to provide students with a familiar example for which to answer the question 'how sustainable is it?'
- They will be using multidisciplinary teams (civil engineers, architects, quantity surveyors)
- The current staff are very much behind the project and will take part, partly because it provides a much-needed focus to the IT Module.
- Prizes will be awarded based on final presentations.

Peter Guthrie (VP Cambridge) suggested the group should follow the conclusion of last year's VP conference and agree to share material and ideas among all VPs. He was keen to explore the possibility of sharing such material and find a means of doing so. He wondered whether the web site being devised at Hertfordshire (by Jeremy Purseglove and Richard Fenner) might be a vehicle for this.

David Foxley (RAEng) replied that this was already agreed, in principle, and a meeting to this end was in planning. However, the initiative needed to be taken by someone with some material to share. It would only work when appropriate material is offered.

Jeremy Purseglove (VP Hertfordshire) felt that the moment was just right for such an information exchange. He was in his second year and wanted to consolidate their developments during his final year. One problem is the need to get copyright clearance for all the images used. He felt there would be something for people to look out by the end of the summer. He echoed the idea of an 'informal day' later in the year (autumn) to discuss suitable material and the content of such a website, especially to avoid the duplication of effort.

David Foxley proposed that some material should be made available to discuss at such a meeting and offered the RAEng as a venue.

Barrie Mould (VP Brighton) raised the issue of intellectual property rights and copyrights, for example for using OS Maps.

[There are two copyright issues – use of images and use of maps. In fact, most universities have access to OS maps through an annual subscription]

Jeff Hulse (VP Newcastle) felt there was already duplication happening and we are already not very efficient. The chemical engineers group of VPs (Surrey, Oxford, Newcastle) was already meeting at the IChemE headquarters proposing to share

information and sources they had collected and found useful, and preparing case studies for common use.

Although there was some concern at the prospect of disciplinary sub-groups forming, it was felt that they could achieve quicker progress and this would benefit other VPs learning from what was achievable. Jeremy Purseglove (VP Hertfordshire) felt that the timing of general group meetings needed to be judged carefully – neither too early when there would be insufficient material to discuss and share, nor too late when the duplication of effort would already have occurred.

Paul Jowitt (Heriot Watt) thought it would be useful to share a list of useful books and other references, including Web sites. These could be maintained by one or more universities and accessed (hot-linked) through the RAEng Website.

Jim McQuaid (VP Ulster) reminded delegates the RAEng had already published the proceedings of two conferences on sustainability in the mid-1990s.

Roger Booth (VP Oxford) reported that after two years they were still constrained by the course structure to offer sustainable development only as optional modules, not compulsory. He had found that the most important thing was to give a really good introduction to all engineering students in year one, and it is in that area that there has already been some duplication. It needs to be a very particular type of course material that can be delivered to one or even two hundred students. For this the main methodology is going to be lecturing. The case study material used later is inevitably going to be more subject specific and there will be less likelihood of duplication. Even so, there will be benefit of VPs in similar disciplines collaborating together.

It will be in the first year courses that there will be most benefit for shared lecture material, booklists and so on – and not just positive recommendations; at the risk of being libellous there can be much benefit from knowing what texts to avoid.

Jim McQuaid (VP Ulster) informed the group that Forum for the Future was already preparing generic Year 1 material for use by undergraduates of all disciplines. Ten or so universities had already signed up to this development programme. However, several people felt the RAEng should not wait for others. There was already much under way and it should be completed as soon as possible.

Roger Booth (VP Oxford) felt there needed to be some agreement as to the precise objectives of the VP Scheme and what it is that we want the students to have achieved at the end of their various courses. At some stage in the VP programme it might be a good idea to have a debate about what we want to get out of it. He was conscious of the fact that, at Oxford, they were not quite following the case study methodology and he did find it difficult to imagine what would be a really good case study. From what he had heard of what was going on in some other universities, it seemed they were describing as case studies things that seemed to him to be little more than tutorial exercises.

Jim McQuaid reminded the group that there had been an attempt to define the objectives for the scheme in the ROAMEF statement. It was up to each university to interpret these in their own ways.

Richard Darton felt that the ROAMEF objectives were very good but were very ambitious – they look rather like the objectives for an MSc in Environmental Technology. They went much further than we would reasonably have time to do in an undergraduate course. In setting out objectives you have to be realistic in taking account of the amount of time you have available. The ROAMEF objectives were strong on the ‘awareness of’ various matters and problems, whereas we need to concentrate on tools and having the engineer’s slant – knowing how to tackle the problems.

Jim McQuaid said he would revisit the ROAMEF statement, because it had certainly not been the aim to focus mainly on awareness.

Andrew Barry (Edinburgh), who was just looking at the ROAMEF objectives thought there was really no conflict with the RAEng VP scheme. It was mainly a matter of turning the principles into practice. He doubted whether there would be much value in revisiting them again: they seemed to be good enough.

Peter Guthrie returned to the question as to what would happen when this VP scheme came to an end. He felt there was a need for the experience and achievements of all the VPs to be made easily available to all the others. He felt there would be a role for a VP equivalent to rove all the Universities and collect their various experiences. It was more than could be expected from the RAEng staff.

Jim McQuaid reported that the RAEng had appointed a co-ordinator who visited the various Universities with VPs with the aim of collecting different experiences.

James Armstrong (RAEng) felt that the short summaries (some of which were included in the delegates’ information pack) were useful as an overview but there was a need for much more detailed information about the aims and methods in each university.

Jim McQuaid brought the proceedings to a close observing that he now had a much better idea of what was going on in different universities and with a reminder that several delegates had agreed to arrange to meet in the Autumn for the purpose of sharing their experience and knowledge gained from the VP scheme.