

ROYAL ACADEMY OF ENGINEERING

VISITING PROFESSORS IN ENGINEERING DESIGN FOR SUSTAINABLE DEVELOPMENT

VP Workshop 2003

Experiences in Teaching Sustainable Development through Case Studies

Belfast, 17th – 18th June 2003

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.

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Opening session. Wednesday 18th June 09.00

Introduction to the workshop

0905 David Foxley in Housekeeping

0912 Jim McQuaid - Welcome

Room G09 Session 1 09.15-10.30

Room G09 – Manufacturing and process engineering

Chair Richard Dodds

Aston University

George Drahun

Aston University Academic mentor

In Notsa Green on the River Ouse

The case study was in the form an inquiry concerning the proposed expansion of a factory producing PVC window frames. We assumed that the vinyl chloride is made and polymerised on site and the frames made. The students were divided into groups and had to produce a report and conduct a public enquiry, including presentations and discussions. This idea was borrowed from Newcastle's experience that also gave their help in developing it.

The project was multi-disciplinary with both chemical and mechanical engineering students. The groups are formed in alphabetical order ensuring an equal balance of the two disciplines. The students have to collect information in their technical area and one of the rules of the project is that all students have equal access to the same technical information. They are not allowed to seek further information elsewhere.

The groups also have to deal with the social issues and each student has to play a non-technical role – the media, the manufacturer, the unions, the local residents and environmental activists. We assume that the manufacturers are in favour of the expansion and that the environmentalists are against it. The media have an overseeing role and prepare a newspaper. In two groups, the local residents and the trade unionists decided to split into two - one in favour and one against.

The students made use of a homemade software package - The Virtual Learning Environment – comprising a project database of material put there by staff and students, and also a means of communication between students and tutors. The software also allows staff to monitor the use of the VLE, for instance what documents are being loaded up, or not.

A video of one of the public enquiry meetings was shown. The media group ran the meetings and organised the vote at the end.

The student response was very good - it was felt to be better than an exam, and they enjoyed the role playing - even to the extent of printing T-shirts.

The students were final year students most of whom have already been on their industry placement. The Case Study was worth a whole 10 credit module and was compulsory for Chemical Engineering students on the MEng course and Mechanical Engineering on the 3-year BEng. Next year it will also be an optional module for the BEng Chemical Engineering students.

We have twelve 2-hour, weekly contact sessions, beginning with perhaps half an hour lecture. The last one is the presentation.

The chemical engineering students had to do mass-balance calculations and prepare an LCA.

Questions & Discussion

Q Was the case study real or manufactured

It was manufactured, but based on real information. The students effectively had to compare the arguments for and against timber, PVC and aluminium window frames.

Q How portable in the case study?

The Virtual Learning Environment database is essential. We put the information on as we went along on this time, and we plan next time to prepare it all before the project begins. This time we got to a total of 921 documents.

Q What were the deliverables for assessment?

They had to prepare a report in two parts. The first part was a group report presenting the supporting information for their case. The second part was the information that each had collected in their technical area. Together these count for 80% of the marks. The remaining 20% is for the presentation and the discussion that the VP and I assess on the spot. The lowest mark was in the mid-60s, and the highest in the mid 70s.

Loughborough University

Allen Clegg

The VP Secondment at Loughborough is just coming up to the end of year 4 and is linked to the MEng in Product Design and Manufacture. We have developed a specific Module for this course called “Sustainable Product Design” and the case study I am going to discuss concentrates on the Life Cycle Assessment aspects of project design.

The development of this work began within the existing 3rd-year elective course called “Manufacturing for the environment” which comprised two hours per week for a single 15-week semester. The RAEng VP Secondment began in 1999 with the intention of developing further modules. In October 2000 Manufacturing Engineering combined with Mechanical Engineering to form the Wolfson School of Mechanical and Manufacturing Engineering.

In 2001 the School had an IEE Accreditation visit that proposed that the Manufacturing for the Environment elective should be compulsory for all Manufacturing students. The course thus grew from being an option for about 45 students to being compulsory for about 90 students. In October 2001 we also produced a 1-week module in “Engineering Design for Sustainable Development” in the MSc in Mechanical Engineering

In October 2002 we introduced a course in “Sustainable Product Design” for the 4th Year of the MEng degree in Product design and manufacture. This would include LCA and the use of LCA software.

Also in this year a new member of staff became involved in delivering the course with a view to taking it over in the future. From October 2003 there will be 4 academics dealing with this course.

The module is delivered over about 12 teaching weeks with about half devoted to lectures and half to the group project, with tutorials on a number of case studies. In the first year there were 9 students and they were assigned to their project groups at very beginning of the course.

The Life Cycle Assessment project was based on a real example from Nortel and involved the comparison of aluminium and plastic alternatives for a component (a face-plate). The students also used two different LCA software packages - PIRA and BOUSTED. We were able to use the BOUSTED software as the result of getting European funding for a study in LCA software and we have been able to use the research assistant to provide tuition in the use of the software to the MEng Students.

We got good feedback from students on the lecture part of the course, though it was interesting to find that they did not find the course intellectually challenging.

Most illuminating was how the Nortel Case Study brought out the important of the need to compromise in decisions about engineering design and manufacture, and the need to simplify the data available when using the LCA software.

This was also encountered in the group project where we used three car components proposed by Jaguar – a sun visor, a bumper, and a fuel tank. The task was to recommend which material should be used for the manufacture, based on design-for-the-environment principles and they had to undertake an LCA study of a principal material used in the component.

The main feedback from the students was that, while the LCA software was invaluable in providing an objective (numerical) means of comparing alternatives, it was very time-consuming. The software had a limited database, it lacked flow chart guide and the output was poor - the data not transportable. In particular, it did not allow the user to undertake “what if?” inquiries of the analysis.

Our main conclusion is that, although the Nortel case study was valuable, the live projects based on input from a company were preferable in that they provided hands-on learning opportunities. The fact that the LCA software requires specialist tuition will limit the number of students who can take the module, as will the need for a regular supply of projects and the external support they require.

Questions & Discussion

Q What results did the projects yield?

For each of the three separate components they were able to make a recommendation based on the environmental and LCA issues. They were also able to present graphically the relative impact of the different alternatives, for instance, on global warming. At present we cannot release the results as they are of commercial value to Jaguar.

Q Did social issues get included?

Yes. We tried to bring this out in asking Jaguar what their policy on social responsibility was, to try to show, for instance what recycling was assumed and hence the degree to which the demand for exploitation of virgin resources might be reduced. You might think this is perhaps a bit superficial, but at least the questions were raised.

Q Did they assess costs?

Yes, to some extent, especially the manufacturing costs, but the results were only indicative.

Q It seems a bit worrying that the software requires so much tuition and the use of a specialist to do this.

Yes. The whole issue of which software and what data is a large problem in LCA. There are many alternatives and students cannot know about all these. We also found deficiencies and defects in the software – which was a problem for students. We are still in the process of comparing LCA software. It is a fundamental requirement of LCA that the process and the data must be transparent and traceable. Nevertheless, we were lucky in having a group of exceptional students who overcame many of the problems.

Q Did the “Vehicle: end-of-life” issues come into the project?

Yes - this issue was driving the projects from within Jaguar. In fact their main emphasis was on the recyclability of materials - both re-use and remanufacture.

Bournemouth University

George Howarth

The Website and case studies

We decided to use the RAEng VP Secondment as a vehicle to develop a means to communicate with others both within the University and with the outside world at large. We felt that the most effective means for achieving this would be developing a Website.

The Web offers the opportunity of providing access to a huge amount of information and the key issue is devising a suitable means to provide good access to that information. A certain consistency is needed and it must be easy to use. We used the consistent approach to the appearance and the presentation of information to work almost as a brand for the Website. There is, or rather will be, however, the issue of maintaining the Site. This may become a problem if it is not planned.

The Site was carefully structured. It had an introduction to sustainable development, and features case studies on Life Cycle Analysis and designing to minimise waste. The Site also has a number of tools for people to use, including an LCA tool for use on later project work. So too are notes for the lectures I give on Sustainable Product Design and there is a glossary of terminology too. Finally, the Site provides the means for getting feedback from the students.

On the subject of LCA, I would just like to say that I think that academics have ruined the subject of LCA. We try to ensure the students understand the concept of LCA without getting bogged down with the nit-picking detail that many treatments of LCA involve.

In the project the students do, they design a sauce container and include an LCA study of the possible materials as part of the process for selecting the most suitable materials from which to make the container. The most powerful aspect of the simple LCA software we use is that the students can quickly undertake a “What if?” study to see the effect of changing materials on the overall environmental impact and burden of the product.

The students have to report on their study on the nature of the impacts and how they came to their final choice of materials. We include different possible destinations such as Leeds or France to study the effect of transportation on the environmental impact and we also ask them to consider the issue of the disposal of the products.

The latest study topic we have developed is Design to reduce waste – a subject that tends to be overlooked by engineers at the design stages. The Web Site contains a series of chapters explaining

why waste is important, what waste is, why the designer should be concerned, and then detailed information for the designer, where does waste come from, how do you measure it, how do you control and minimise it and how do you prevent, by design. We have a series of on-screen Questions and Answers and in each case these lead into the different chapters. Most important is an indication of the learning outcome of each chapter so that the student knows what they are going to learn and get out of it. Finally it gives the lessons for the designer - how they can design to reduce waste.

We also provide guidance on further information, including SELECTED websites - we have found that the students don't like using the Web because they get too much information and are not at all sure of the quality of what they find.

The Website also gives students access to certain practical exercises such as using the LCA software "Ecopackager" to study the difference between making a component using virgin materials and using recycled materials, including plastics, aluminium and paper.

The other practical exercise we did was to get students to take apart a series of consumer products including an iron and a toaster. The students then have to redesign the product to reduce the amount of waste that its manufacture would generate. The students were assessed based on their presentation of how they would have changed the design.

The final case study work that we have done is on a Masters course we run and its aim is to introduce the social and economic issues of Sustainable Development. Like others we pay tribute to the Case Study developed by Geoff Hulse at Newcastle, and also used at Aston, which takes the form of an inquiry and develops students' understanding using role-playing.

Our subject is to establish the best site for a new car factory. We chose a car plant because most people already have well-formed views about cars and understand a lot about what they are for - this would not have been true of a medical product, for example. Each student has to approach the challenge first as a designer and then from the point of view of one of the other stakeholders - a local resident, politician, environmental activist, and so on.

Teaching and outcomes

This year we have run two one-week modules on sustainability in the Masters Course, one on Sustainable Product Design and the other on Design for waste. We have used the case studies in both of these modules.

I also do some lectures to the final year students of product design & computer-aided product designer and we have used the case studies with them too.

In the second year I give two hours introducing sustainability and product design.

We have also done some visits - we had a fascinating visit to a local car recycling plant and that was an eye opener. We saw a brand new Mini being stripped to enable just one bit of electronic equipment behind the dashboard to be removed - the rest of the car was crushed. That made a big impression on the students - they saw the commercial reality of recycling.

We have had a lot of good feedback from the students through the Website and we improved the brief for one of the projects as a result of such feedback. Being computer based we can also watch the students at work and see how easily (or not) they used the website. It was also interesting that groups of students would often collaborate spontaneously and talk around a computer screen.

We have had some success in promoting the idea of sustainable development for instance by getting sponsors for an award (from Smith and Nephew). We have also written several papers.

Perhaps the most important lesson we have learnt was how best to create a good website. It is not easy and takes a lot of time - much longer than you think. We achieved it by forming a project team to

create the website. This comprised not only the experts on product design, sustainability and web design, but also someone dealing with the educational and learning aspects. The eight criteria we established are worth repeating - variety, stimulation, action, application, interaction, feedback, scaffolding (building things up) and evaluation.

As to the future, we learned that there is a need for better, and more information about materials, especially including the environmental data appropriate for LCA work, and we will be endeavouring to provide more of this data.

We have agreed that a formal structure within the school to ensure that sustainability is addressed. A Sustainable Development Steering Group has been set up which is attended by the Head of School with representatives from various groups within the school.

We have also formed a design working group and the first thing that has come out of this is that the staff want a sustainable development awareness course to educate all of them about the relevance of sustainable development.

Liverpool University**Richard Dodds VP; (academic partner Bernard Hon)**

Richard found the key to introducing sustainable development was to engage people, and link it to their own lives, for instance the discussing the value of taking newspapers and bottles to the tip - how many people do it? Why? Does it do any good? This gets them looking at their roles as consumer versus citizen. There are analogies with other issues such as mobile phones and GM foods.

It is very much about perceptions of the issues, especially the perception of risk. If you volunteer to do something, you are likely to take more risk. For consumer products the consumer experience of product information influences their perceptions.

Just as important are the instruments that can be used to implement environmental policy. At the top there are information-based strategies; that is where most of the consumer industries are at present. They have lots of information up their sleeves – press releases, in case they are asked, life-cycle analyses in case they are asked. There are also incentive-based instruments to change people's behaviour, for example the Vehicle EOL legislation. Finally there are absolute trade restrictions and bans at the bottom end.

When trying to persuade Heads of Departments of the importance of addressing sustainable development Richard found it useful to use a time-line. The whole story is very recent; Rachel Carson's "Silent spring" was the beginning and that was only in 1962 and Limits to Growth in the late 1960s. We now have the WEE and Vehicle end of life regulations. Sustainability issues are bound to affect all students and young engineers within a decade, at the very latest.

Different approaches to delivering sustainability have different degrees of difficulty and different levels of impact on sustainability. Ultimately we want it all embedded in the systems we use, but that is still very difficult to introduce. At present people are happier with lower level impact of designing for various objectives – reuse, recycling, extended life, green design.

The social and regulatory issues are important as part of changing people's behaviour – if you get people to buy a car with a catalytic converter, have you done your job? Often it is how you use a project that is more important for sustainability. You may be able to engage the consumer with sustainability through marketing and forming an association with a certain product and the way you use it, and you may even be able to brand a product as green or sustainable.

Richard delivered 8 hours of lectures in 2-hour slots to the MSc course.

- scope & historical context; simple LCA methodology
- social and regulatory contexts; a case study on consumer goods
- case study 2; global issues on sustainability (including the "sceptical environmentalist")
- the overall framework; introduction to project tasks

The students were of mixed nationalities and they did both individual projects and a team project. They certainly got interested and put far more into the projects than the reward (marks) they got from it.

At undergraduate level, stealth has again been used, for example by adding some sustainability issues into existing first-year projects such as their analysis of an electric drill and asking them to make

suggestions as to how the design might be revised to improve its sustainability performance. Several lecturers are now wanting to put something substantial into the third year – perhaps another project.

Questions and discussion

Jim McQuaid asked why should students be able to do an EIA when the software exists?

Richard replied that he had learned useful lessons when he had been responsible for introducing LCA into Unilever. Initially everyone was very sceptical; now it is *de rigueur*. It is essential that the impact of each new product is looked at and it is important that people can think this through themselves – it helps them to understand the big picture. The problem is that the different impacts all have different units so all you can say is that one product is better than another on global warming but might be worse on another impact. The question is how you trade them off.

The LCA approach the students do looks at just four stages of a product's life – materials requisition, manufacture, use (very important for consumer goods) and disposal. For a certain product they consider three or four key impacts (such as landfill for cars, phosphate pollution for laundry detergents) and then look at how they could reduce those impacts, perhaps by technical means or through legislation. This gets them used to looking at products in a radically new way – not just as an artefact.

Anon commented that they found it interesting that LCA was useful as a defence, but wondered whether it would not be better if sustainable engineering went the other way – designing a product to be more sustainable.

Richard replied that he was concerned to present to the students the reality of the commercial world. In industry, LCA is often used as a defence. You do your analysis and your press release and you say “laundry tablets result in people using less power than if they used powder out of a box, and we have evidence to prove it”. In real life industry doesn't work by asking how they can get leverage out of sustainable products. They know if they go and ask consumers they will say they are not going to pay a penny more. There are very few products where industry says “we will design it to be more sustainable and we will charge more for it”. The only reason motor car manufacturers are responding in terms of the materials used in the manufacturing of cars is because of the Vehicle end of life legislation.

Adisa Azapagic (Surrey) said she understood the need to talk about the real world but felt it was important for educators to introduce other approaches and ways of looking at things so they may bring about changes in the future. Telling the students that industry uses LCA only as a defence mechanism and not to help produce a better product was not a good message for students.

Richard replied that there was a balance in the course – the students saw enough of both points of view – the visionary and the commercial. He was also concerned for there not to be too much emphasis on LCA, that is only one aspect of sustainability and designing products. Students will not be able to go out into industry and say “we are going to do this because it is good for the environment”.

Anon asked why it had taken three years to get sustainable development introduced as a compulsory part of the course and curriculum?

Richard replied that it is difficult to introduce such a subject into a conventional engineering syllabus such as electrical engineering. It is easier to do if there is already an element of environmental engineering in a department. Talking to other VPs it seems to be most usual for it to be introduced into second and third years. He had wanted to introduce it into the first year, partly to get an influence early on, and partly because he believes there is an interest there in the students that is unsatisfied.

Newcastle University

Peter Norman

(Jeff Hulse was not able to be present)

In addition to himself and Jeff, the team at Newcastle includes Sue Haile who is the University's Sustainability Coordinator, delivers lectures on sustainability in a number of courses and is also responsible for the MSc course in Clean Technology.

The department has developed a website dealing with sustainability which acts as an important resource for students, for instance a glossary of terms.

The first case study that was compiled was the design of a new household detergent. The second was the Byker incinerator that was a hot topic on Tyneside at the time when it was found that the residue from the incinerator, which had some rather undesirable ingredients, was being used to make paths in public parks and allotments. This provided some good public domain material for our case study. We made this into a role-play project where the students were pitched against each other. This has been very successful.

The waste water project looked at the disposal of waste water into the sea from an off-shore rig. This was a multidisciplinary team project with chemical engineers and biologists and was an exercise in decision making in the design process.

In phase 2 of the VP secondment we are continuing to develop the case studies and getting them onto our web site (www.sustainable-engineering.org).

We are also seeking to improve the wider dissemination of our work through outreach, into industry through CPD, into schools and public.

One of our main targets for 2003 is to try to get sustainability into other departments. It is not easy and he would welcome any suggestions!

Birmingham University

Gary Acres VP

School of Engineering, Department of Metallurgy and Materials

The brief had originally been to look at the hydrogen economy and was later widened to include "sustainable materials".

At the beginning of his secondment the engineering school was reorganised and this proved to be useful in getting sustainability into the department.

In the first year an existing second year materials course was modified to include more on recycling and other sustainability issues. The students were also given a questionnaire to establish how much they knew about sustainability, and it became clear that 2nd year students had little idea of SD, just as had been found from the RAEng survey. It was clear that they would need an introduction early on before they could do a more specialist course.

In looking at the case studies there was an opportunity to link in with some funded research that was being undertaken on the role of case studies (in general) in university engineering education (research which has now been completed and will soon be available). This helped a lot in designing the case studies.

For the large case study on the hydrogen economy the teams were not chosen by random selection. Students were categorised using a questionnaire to identify their strengths – leader, gofer, information gatherer, etc. to help ensure the team was well constructed.

Questions and discussion

Anon asked what benefits there had been in the way the project teams had been selected.

Gary replied that the students had found the process interesting and it did seem to work.

Jim McQuaid asked whether LCA had formed part of the Hydrogen Economy case study.

Gary replied that it had not, but that he was reminded that, in their presentations the students had addressed some of the non-technical reasons which certain options might be followed, for instance, to do with the firms image or reputation linked to its responsible attitude to the environment, and some of that was related to life-cycle issues for materials. In some of the min-case studies LCA had been touched on, but not to the extent of making detailed assessments.

Anon asked whether the different group in the major case study came up with different answers and recommendations.

Gary replied that, each group had looked at different aspects of the whole story and so their work was not directly comparable. They had also tended to focus rather towards the technical issues and had given perhaps too little consideration of business aspects.

Surrey University

Adisa Azapagic (Academic partner)

There had been a long tradition of teaching environmental engineering and there were already some environmental modules to build upon.

There is a set of dedicated lectures that are backed up by a number of case studies. There are two compulsory modules for chemical engineers in years 1 and 2. The first is an introduction to sustainable development; the second is about corporate sustainability preparing students for the secondments to industry in Year 3.

Two case studies have been developed on water quality and on air quality. Apart from the general lectures, there are specific lectures to introduce the case studies.

The questions are of a specific technical nature such as “Choose the most sustainable technology for water treatment” or “Design a sustainable system for the control of nitrous oxides emissions from the manufacture of nitric acid”. In resolving these problems the students need to address all aspects of sustainable development – the social and economic issues as well as the environmental. Under the social side of sustainability we also look at the ethical issues.

The learning outcomes of the case studies have been developed using the guidance produced by the Institution of Chemical Engineers. They include a need to understand the wider issue of engineering and its social context. They need also an appreciation of technical issues, and economic, social, economic aspects & their relevance to engineering. The students also learn how to apply various tools and approaches and methods and tools to help the problem-solving and decision-making, including the use of LCA. The students come to appreciate the role of society in corporate and public decision-making and how this influences the engineer’s work. Together these form a body of skills that enable engineers to promote the ideas and practice of sustainable development.

To help assess the success of the modules and case studies, the students complete the questionnaire about sustainable development both before and after the modules have been taken, and results show that they seem to have been quite successful. The students' reaction seems to be that they are interested in sustainable development and they feel it is definitely going to be important for them as engineers, and will be more important in the future. Often the students seem to prefer the case studies to lectures and, of course, some students seem to remain unmoved by the subject altogether.

Adisa is taking a three-tier approach to the integration of sustainability teaching into the engineering curriculum. First a series of dedicated lectures on SD and its concepts; second, a number of specific case studies giving some solutions. Finally the third tier is to integrate this into other modules such as using CHP as a case study in the thermodynamics module.

In developing the lectures she had used the paper on the teaching of SD to engineering students produced by Forum for the Future a few years ago (with the RAEng).

Next year Adisa is introducing a new module on Sustainable Design in year 3 in which students have to design a chemical plant and include an assessment of sustainability issues and criteria as part of the design project.

There have, of course, been some difficulties.

The first thing we all hear is the problem of "curriculum squeeze" – there is no room. She has largely overcome this by ensuring the subject is integrated into existing courses. And the RAEng and IChemE have helped considerably by being seen to be promoting the integration of SD into undergraduate degree courses.

As for student interest, this can be generated as long as can be done carefully. They do not like it if they are told they must do it. They must understand things by themselves.

Another problem is that they tend to be more interested in the hard science than soft issues and they need to be reminded regularly to keep their attention on all the issues. There is also difficulty in mixing different types of engineering students (in the first year) when civil engineering students, for example, do not think they should be getting lectures from a chemical engineer. In the first year the students also have had little relevant background understanding and are rather immature and so are often not interested. This barrier can only really be overcome by having enthusiastic lecturing staff.

Adisa concluded that, at Surrey, they had succeeded in developing and using the case studies to help integrate sustainable development into all levels of the course. The feedback from chemical engineering students has been especially positive.

Questions and discussion

In response to a question about the difficulties in the mixed first-year teaching of civil, mechanical and chemical engineers, Adisa said the problems had been noticed in other subjects' areas too. The feelings were sometimes strong – when the students were asked to calculate the quantity of carbon dioxide released from a certain chemical reaction, one civil engineering student wrote "I am not going to answer this question *on principle because* I am not a chemical engineer". It was partly a problem with first year students who are a bit immature and are not good at generalising, but she did not want to postpone the introduction until later in the course.

It has to be said that there are some similar problem with staff in other departments who seem not to be so interested in SD, and she does not really know why. In fact only about five of the seventy or so academics in the whole engineering school have shown much interest in sustainability development and that is not very many.

Room G10 Session 1

09.15-10.30

Peter Guthrie (Cambridge) was in the chair

Oxford University

Roger Booth, VP

Roger explained that his VP secondment had begun five years ago and was now officially at an end. As his background had been 36 years in the oil and petrochemical business, he had chosen the theme of 'sustainable energy'. From the outset he and Richard Darton, the academic partner, had two important constraints – whatever was done had to fit in with the particular teaching practices at Oxford and to find suitable slots for delivery in what was already a very crowded curriculum. By the end of the secondment, they had developed four different slots in the course. The first introduction is in Year 2 in the Engineering in Society lectures and a one-week coursework module. Two elements have been built into the year 3 design project, and there also lectures in the Chemical Processes option in Year 4.

Roger and Richard believed at the beginning of the secondment, and believe it still at the end, that, at least initially, that the material developed by the VP should also be delivered by the VP. This gives the VP the opportunity to get to know students – what turned them on and, more importantly, what turns them off. As a result there are very significant differences between the materials that were presented in year 1 and those presented in year 5 of Roger's secondment. They all learned a lot in that five-year period.

The material that was developed was mainly not in the form of classical 'Harvard-type' case studies, and this was a bone of contention with the RAEng. Nevertheless, the material prepared for the tutorials (which are given by tutors in each of the colleges, not by the teaching staff of the Department) were, in effect, small case studies and they served to disseminate sustainability more widely throughout the University.

Most importantly Roger felt he could say that the teaching of sustainable development is now fully embedded in the undergraduate teaching at Oxford.

The college structure of the University at Oxford differs from most universities, with students being members of both a College and a Department. While the main teaching goes on within the Department, tutorials are organised and run through the Colleges. The curricula are tightly regulated by Departments and Faculties, and any changes to the curriculum need to be approved by both an Academic Committee and a Sub-faculty board. It was thus essential to get widespread buy-in and commitment in order that the changes to the courses could be introduced.

[Roger then went through his PowerPoint presentation almost verbatim].

Roger's conclusions were as follows:

- Teaching SD is now fully embedded at Oxford
- The teaching is being taken over by academic staff – and this will continue
- New material in the curriculum must be consistent with (local) teaching practices
- Initial delivery of the material by VP is essential to understand students (this led to significant changes from years 1 to 5 of the secondment).
- Close co-operation and support of mentor and Head of Department is essential
- The students responded positively

- Outside world moved on in 5 years
 - ⇒ New entrants now have greater awareness of SD than they did 5 years ago
 - ⇒ This rate of change has required responses far higher than typical of u/g course material
 - ⇒ There is still a demand – content must be well planned and up to date.

Ulster University

Alan Strong (Academic Partner)

School of the Built Environment.

Alan began by saying that one of his particular passions as a University academic was inculcating in the hearts and minds of students the importance of radical thinking, a logical approach, and conceptual ideas. And he felt that sustainable development was an excellent vehicle for all of these.

Alan introduced Leslie Hempel, who had been assisting him as a researcher in SD, and Jim McQuaid who had recently ended his three-year secondment as VP in the Department. Alan's presentation focused principally on the Case Studies they had developed.

The first introduction the students had was an IT project, where they learned all their IT skills while focusing on a sustainable development theme. A number of lectures by visitors were used to help inform and inspire the students. The second element of the work involved the development of the case studies, and the third strand was instructing SD into the design work, especially with civil engineers. Finally, there were opportunities for integrating sustainability development issues into final-year dissertations.

The main case study they had developed had as its theme a mill, developed in the late 18th / early 19th century, which was crumbling and in need of attention to ensure its preservation. The title of the case study was "Mossley Mill – Regenerated to last".

Developing the case study involved both very informal input by staff to more formal engagement for instance from the local authority who were supporting the project and a minister. A report on the project they had recently produced had led to some good media coverage.

The local authority had, for some time, been seeking a new site for the council offices and when Mossley Mill was assessed using their appraisal methodology, it scored much higher than the previous favourite option. The project to restore the mill for use as their headquarters lasted three years and involved a wide range of issues that touched upon sustainable development, and thus made an ideal theme for a case study.

Alan used the ROAMEF statement for developing the case study, dealing with the various sustainability issues under the key headings:

- **Rationale** - Triple Bottom Line, LA21, Pedagogy, multi-use
- **Objectives** - Account of: Before & After, SD appraisal, pedagogy, future development
- **Appraisal** - Data capture, synthesis & analysis leading to delivery of each Objective (?)
- **Monitoring** - Engage Staff, SPAT + Stakeholders (students, staff and external)
- **Evaluation** - Stakeholders + the "Sustainability Visiting Panel"
- **Feedback** - Inform future CS work; see below

It was especially important to engage the various stakeholders, and to do so sensitively. For example, sustainability had not been part of the architect's way of thinking at all, and they had to careful not to appear to judge his performance as poor using sustainability criteria when they had not been part of the brief, nor his approach. The success in creating the case study was largely dependent on establishing good relationships with people, both in the project team and within the Department.

They also got involved with the local community many of whom were passionate about the mill, and felt they would be losing it when it became the council headquarters. Many of their grandparents had worked there and had strong memories of the strong influence the mill had had on building their community – the nineteenth century mill-owners had provided the housing, schools, hospitals and leisure facilities that had formed the community.

A particularly difficult issue for the engineers involved in developing the case study was the need to deal with qualitative or soft data. This was something they were not familiar with handling.

[Otherwise, Alan followed closely his PowerPoint presentation].

De Montfort University

Greig Mill

Institute of Energy and Sustainable Development, Leicester.

Greig reported that they had produced three case studies and they took the form of CD ROMs. One of the main reasons for this was that some two thirds of their students were distance learners. They also hoped that this would make the case studies available to others involved in the VP scheme and, indeed, further afield.

They had decided at de Montfort to run a separate module on Sustainable Development, which is compulsory for all the MSc students at the start of their course. Among the usual topics, Greig mentioned one of his favourites in the field of economic sustainability which had originated in 1977 in the work of John Hartwick and which was also taken up by Nobel Prize winner Robert Solo. They demonstrated using mathematical models of the economy that economic sustainability was possible, but only with a certain investment plan that maintained the stock of capital. In essence this represents the commonsense position that to be sustainable in the long term you must maintain the level of capital and live only off the interest. And this is true of other types of capital too, especially man-made capital. The relevance of this to engineers is that they, more than most, are directly concerned with the capital in our built environment.

The challenge for the case studies is to bring such ideas into the context of engineering and, as the VP David Bartholomew likes to put it, to introduce “real-world complexity”. One of his favourite ideas for London, for example, is generating energy from waste, but there are significant barriers such as legal problems in the EU Waste Directive and both political and public acceptability of the idea.

Greig mentioned that two new case studies were in preparation to add to the three already completed. Sustainable Development was now well-integrated throughout the curriculum at de Montfort and the case studies were already being used in many different ways with different groups and for many different purposes. He hoped their use would continue to spread even more widely.

Workshop discussion

Peter Guthrie (Cambridge) was in the chair

Anon asked if the de Montfort case studies were available via the web [they are not] and suggested it would be useful if there was a page or so on the Web describing the case studies and giving a flavour of them so that others could take things further if they wanted.

David Fisk (Imperial College VP) said that they were still a year or two behind the people who had just presented their work and he was keen to learn from them. He had some worries, however. He found engineering students were now very streetwise (unlike architects, he suggested) and wondered how he was going to be able to introduce the origins of Sustainable Development (Rio and all that) now that many now perceived that the United Nations was “a busted flush”. He wondered how others had tackled this issue.

David raised a second problem he had encountered when looking for case study material in buildings that had actually been built. He had found that much of what had been promised by architects had survived only until the client found out how much it was going to cost; thereafter, the buildings became just like any other. (This had been an issue revealed in the Probe Studies, too). He had found that the big intervener was the quantity surveyor who had the job of managing the capital budget for projects. While he (David) had found a wealth of inspiring material in the design stages of building construction, he had found very little evidence of this being carried through into later stages. He felt there was a gap that needed filling in.

Peter Guthrie (Chair) agreed and wondered whether there was a danger that we might all be overselling to undergraduates who go out into the world and get disillusioned by what they find.

Anon said she had got some students making a study of what Universities are actually doing about sustainability in their buildings, and had found that budgetary constraints meant very little was being done.

Peter Guthrie (Chair) said that the new Maths building at Cambridge was a case in point – it was not performing as it should be – in fact it is using twice the energy it was designed to use.

Paul Jowitt (Heriot-Watt) said that it could be useful in education to study the lessons from failures. There were many international examples of where things had gone wrong. They can be far more potent as a learning example than things that have gone right.

Anon (a new VP) noted that de Montfort had focused their efforts on the MSc and a few other avenues but not on undergraduate course. At his University they were obliged to focus on the undergraduate courses and wondered if this was also an obligation at de Montfort. On a more practical note, he noted that the CD format was not suitable for providing access over the Web, and wondered if they had looked at using “Info-for-Education” (?) and other databases which were able to handle very large .pdf files.

Greig replied to the first question that the Institute is not involved in any undergraduate teaching though they do sometimes try to make links with undergraduate courses elsewhere in the faculty. On the second question, he said they were indeed exploring different ways of presenting information.

Greig also mentioned that the first Case Study that David Bartholomew had produced (on the Queens Building at de Montfort) had very much tried to address the issue of quantity surveyors and pressures on costs and so on, rather than the technical design side. David was very keen on what he calls the “human factors” side of things.

Peter Guthrie (Chair) asked if others were using the study of failures. Gordon Baker replied that they were looking at public transport, but Peter felt that was too easy – a “soft touch” (much laughter).

Roger Venables (QUB) said that they had begun some comparative studies of how some completed projects would be done if they were begun now. These would bring out the progress there had been in policy, planning, legislation, technology and design skill. On the subject of failures, the civil engineering course at QUB had a course on disasters and one of the challenges they had set was to embed sustainability thinking into that. It was planned (in January 2005) to get students to look at how a project was actually done, then to propose how it might have been done if sustainability had been brought into the project and to assess whether this might have prevented the disaster from occurring. Roger agreed that it was important in education to look at both successes and failures.

Peter Guthrie (Chair) said that one of the problems he faced was selecting projects that were intended to be exemplars of sustainable development and finding, on closer scrutiny that they were flawed, and sometimes very deeply flawed indeed as exemplars. He wondered if, indeed, there might be no projects that would stand up to the sort of scrutiny that we would want to give them.

Roger Booth agreed and said they used failures in their course, for example the Brent Spar oil rig and the Newbury Bypass, and of course Jeff Hulse's Byker incinerator study is a classic example of how not to involve your stakeholders and how things can go disastrously wrong. In that last example it looks as if they are now actually beginning to get it right (after 5 years or so) and look as if they may be on the way to finding a solution to a very difficult problem.

Lorna Walker (VP, Sheffield) agreed with two things. She thought it was important not to send students out thinking they could solve all the problems by Tuesday. We (at Arup) get your graduates who are saying you can do this or that and we have to explain that its not quite like that. We have to take the continuous improvement approach to sustainability. On the subject of failures, she said she would be very suspicious of a case study that claimed that everything was perfect. It was really important to point out the short-comings and to instil the idea that, on this occasion, this was all that was possible, but don't give up.

Harry Eccles (Edinburgh) felt that undergraduate level might already be too late to introduce the ideas of sustainable development. Something they are exploring at Edinburgh is to take it into schools. At least that way they will be arriving at university understanding some of the issues and the complexity of sustainable development. There were, however, difficulties in presenting the subject at that level in a holistic way.

Peter Guthrie said they had had a student at Cambridge (who was going to become a teacher) who had made a comparative study of sustainable development in secondary education and the National Curriculum in England and Wales, and in the engineering course at Cambridge. Her finding was that a 13 year-old in Oldham was far more likely to have some understanding of SD than a student at Cambridge! She found that the teachers were still a bit at sea, but the curriculum itself provided an excellent framework.

David Foxley reported that Charles Duff and Jeff Hulse had just got a Wellcome Trust grant for a project to take SD into schools. David also reported, however that the RAEng had been involved in a similar project (via the Campaign to Promote Engineering) to try to introduce more engineering into the secondary curriculum but this had been fraught with difficulties, mainly of a political nature. The trouble was that all the buzz words were there in the curricula but very little was actually being done, except by a few dedicated individuals.

Peter Guthrie then brought the discussion to an end.

Room G10 Session 2 10.55-12.30

Peter Guthrie (Cambridge) was in the chair

Cambridge University

Peter Guthrie (Academic Partner)

See PowerPoint presentation.

In response to a question about what sort of students were doing the ‘sustainable’ courses and research projects, Peter replied that it was across the board, not just civil engineering. He also said the students were, of course, self selecting and the ones he (and the other “sustainable” lecturers) saw were already highly motivated and converted to thinking it was an important issue.

Heriot-Watt University

Gordon Baker (VP)

Civil Engineering / School of the Built Environment

Gordon recalled that, at the first VP workshop he attended five years ago, someone in the audience had said that he thought transport would be quite a difficult aspect of sustainability development to deliver – how right he was. And, recalling Roger Booth’s comment that things had moved on in the outside world in the five years of his VP secondment, in transport things had, if anything, gone backwards in that time.

See PowerPoint presentation.

Gordon used his traffic modelling software to demonstrate the latest case study they are working on – a live case study which was the Green Travel Planning for the Heriot-Watt campus itself and the adjacent business park. The master plan for the site has now been given on condition that the University produces a Green Travel Plan and strategy to ensure that congestion on the site and the approaches to it is avoided, for instance by charging for parking permits and targeting certain commuters to switch from car travel to public transport.

Gordon felt this would be especially good as a case study because it was live and could be revisited annually (for the foreseeable future).

Questions and discussion

A question was asked about why the engineering department had rejected the proposed module on sustainability development.

Paul Jowitt responded that they produced the module and got it passed by the Faculty of Science, and the Faculty of Environmental Studies and the Faculty of Economic and Social Studies. When we took it to the Faculty of Engineering, at just the time that the University was reorganising itself from 15 departments to 5 schools, it was rejected. Three reasons were given, but you have to listen carefully because they were not entirely consistent!

- First it was rejected because the university already offered too many modules for small numbers of students – even though there would be 60 students doing the module, which is not a small number.
- The next objection was that, if we are going to do it, we should be offering it to everybody (across the University – 1200 students in the first year)
- Finally, it was said it would cost too much – running it for 60 students would cost 5 FTEs across the whole university (i.e. one module out of 12, for 60 students). It all got swept in with the new schools worrying about their funding.

Paul felt it might well be worth another attempt, now that the new Schools were firmly established.

Edinburgh University

Harry Eccles (VP) and Martin Crapper (academic Partner)

Harry began with an introduction to the theme of land remediation that formed the core of the first main case study that was developed. The whole issue is still relatively new in Britain and often still sensitive or contentious. This, in fact, made it rather difficult getting good data for the case study. The authorities, contractors, consultants and even the owners of the land are all reluctant to part with information about sites. For instance they were refused permission to use a photo of a contaminated site on the Website. They had to resort, indeed, to going to the USA to get good information to build up a case study.

When they began planning the work to be done at Edinburgh it was clear that it would be necessary to manage a number of expectations – those of the RAEng, the Department and its staff as well as those of Harry himself. Each had different priorities and that had to be managed. Looking around the University it was clear that there were a number of existing modules within the civil and environmental engineering department that were, in all but name, virtually dealing with sustainable development already. It was clear that minor changes and some “badge engineering” could transform them into modules that would meet the aspirations of the RAEng.

As a team of two Harry and Martin found it easy to develop and agree the plans, but they would not be able to undertake all the delivery. From the start, then, Harry’s lectures were augmented by lectures from other members of staff and visitors out with the University. They made a ten-year plan in recognition of the fact that it was going to be very difficult to persuade others to change their courses and syllabuses to incorporate a new concept. What would be in it for them?

It soon became apparent that one of the benefits would be a few more students and that would mean more income for the university and department.

Martin took over the presentation to describe how the subject of sustainable development has been incorporated into the curriculum. In the first year a number of single lectures on sustainability themes have been introduced and in the third year several modules include environmental and broader sustainability issues, some of which are compulsory for all students. In the honours (4th) year the emphasis is mainly on engineering design and it was here that the case studies were mainly used. The key aspect of the programme was to try to replicate the experience of design in an engineering practice, even down to the matter of charging for time for the design work and meetings and the costs associated with using analysis tools and getting borehole and site investigation data.

For each case study information is available about soil, water and the contaminants, both in location (x,y,z) and in time. The plan was to create a resource that could be accessible both within the university and from outside, with the future potential of allowing access from engineering firms for training throughout the world hopefully to provide an income for the university and the RAEng. Martin

then demonstrated the web-based case study tool. The work of the students and the feedback they gave were both excellent.

Workshop discussion

Peter Guthrie (Cambridge) was in the chair

Lorna Walker (Sheffield) noted that a common theme of the presentations was that their success had very much depended on the people, including the students. Yet it had taken a long time to get to where things are now. She wondered if there was any advice on how best to engage people.

David Foxley reported that he had attended a conference on Engineering Education for Sustainable Development in Delft (November 2002) and he asked many delegates from all five continents what was the largest barrier to introducing the theme in their departments and the answers were unanimous – “our colleagues”. He felt that they would probably remain sceptical until it became apparent that they could make a good living out of it.

Peter Guthrie (Cambridge) thought Martin’s point was that he was aiming to get student engagement by replicating the environment of the workplace. A counter argument to this aim was that (for example in his own University) there were few academics who knew enough of what goes on in the work place to be able to make this approach work. He felt that, if it was agreed that universities ought to move towards the workplace environment, then some of the university staff would need to change.

Martin made the same point about teaching engineering design. While he had experience of the design office environment, a number of his colleagues did not. The Joint Board of Moderators had taken a lively interest in sustainability in the last couple of years and that would mean departments would need to introduce it into their curricula in order to keep their courses accredited.

Roger Venables (Queens University, Belfast) said that he was just coming to the end of his first year and he was extremely grateful to Adrian Long, his academic partner, for having set the VP scheme up at faculty level and made the appointment a faculty appointment. He had also identified champions in every department within the faculty who were aware of whom he was as soon as he arrived and so he (Roger) has so far been pushing at open doors. He has already been planning the first two major case studies that are infrastructure projects. He has identified the interest areas in the various departments and is now overlaying the case studies on the different departments to identify where there are gaps. These gaps will then be the focus for some smaller case studies. He has identified an LCA study of catalytic converters and some projects with significant political issues for some staff in the mechanical engineering department. The key issue, then, is to ensure faculty-wide involvement.

Paul Jowitt felt that the best successes had been achieved when the conventional lecture method had been replaced by alternatives. Indeed the new guidance from the JBM on introducing sustainable development into the curriculum had been as much about process as content.

David Fisk agreed that a faculty wide implementation was necessary to avoid separate SD courses being set up in each department. David also felt that the core business of Universities was facts and ideas, and they should concentrate on these two. There were not well-placed to deal with the process aspects of engineering.

Mark Fletcher (Bradford) had heard how valuable it had been for the VPs to be giving (at least some) of the lectures. But when the scheme ends the lectures will need to be given by the academic partners. He thought that it could be a scheme worth considering to offer secondments for academics to work in industry to get the sort of experience that would help develop their lecturing material.

Jim Poole (Cardiff) was concerned that enough was not being learned from the case studies. Many of them seemed to concentrate largely on technical and quantitative issues. Would it not be a more valuable experience for students to encounter the need to go and ask a lot of different (types of) people for their views related to a project and then to try and take account of these.

Anon found in the morning's session the benefits of learning a transferable skill from undertaking the case studies, and that skill was to base views and opinions on evidence. If we give our students facts we can be sure that they will be out of date in five years. We should instil in them the idea that there is a body of knowledge and give them the skills to access it and the framework to interpret it. She also felt there was, for instance in the work that had been described at Ulster, the opportunity of engaging engineers by introducing sustainability in quantitative ways which could then be introduced into the engineers quantitative models.

Alan Ervine (Glasgow) had found that a great many of the arts faculties were well ahead in their interest in SD – ethics, philosophy, medicine, geography. He thought that it would be best to try and engage the university as a whole into the SD ethos not just a faculty of engineering or a department within such a faculty.

Alan Strong (Ulster) thought there was a danger for all of us to start believing that we are the only people who know about sustainable development, that it is all related to engineering and how we can minimise impacts. There is also the danger that we are trying to be all things to all people. But he felt that we should aim to bring out the message through the various processes that act upon the universities – the JBM, the Teaching Quality Assessment and the Research Assessment Exercise. He also felt it was important to look at the nature of the case studies that are being developed. They not only need to address the design process but also the multidisciplinary aspects of design and to involve all aspects of sustainability, especially the social issues. While the details of case studies soon go out of date the framework of sustainable development will be with us for much longer and we need to send out graduates with an understanding of the philosophy and the attitudes and the open-mindedness and an awareness of the issues beyond the immediate brief. The danger might be that we send out graduates with expectations that are too high and that cannot be realised.

Harry Eccles (Edinburgh) wanted to emphasise the matter of managing expectations. WE are not going to achieve everything in 3 or 5 years. They have limited the scope of what they are tackling. The key issues is to do what you can do and change what you can change – don't try to shoot the holy grail, because you will miss. Harry felt that the students with knowledge of SD would be more valuable (to future employers), but achieving this was a slow process.

Anon felt that case studies helped students develop new impressions that would then help them to form new ideas. It is also important for students to learn that, even when they are asking questions, these are already based on their own preconceptions. A sustainable approach is always to find the simplest and most elegant approach rather than to elaborate it and compound the problems.

Peter Guthrie brought the discussion to a close recalling Kepler's law of ecology - that nature uses the least of everything. He was, however, rather worried that he thought he had picked up the idea from several people that industry knows what sustainable development is, and is claiming that it is doing it. His experience was very different. Both misunderstanding and misconceptions were widespread and there was even a touch of the Emperor's new clothes.

Plenary Session 1.

1345 – 1500

Bill Addis presented a summary of the review of the VP Scheme he had undertaken for the RAEng. It was based on interviews at the first five Universities who had hosted a VP. The text of this summary has already been distributed to delegates

Discussion

1. Roger Booth (Oxford) commented the balance between lectures and workshops. While he agreed that a half day workshop with 25 students was much preferable to a one-hour lecture to 180 students, there was the matter of logistics. While it is quite easy to fit in 1, 2 or even 3 lectures to a timetable, it is extremely difficult to schedule 6 or 8 half day workshops with the VP and lecturers. He wondered how other universities managed to solve this.
2. Bill replied that, as several universities have found, it is easier if something already exists in the curriculum that can be adapted. Most courses now have a design project and this can be an opportunity. But that is not the only answer.
3. Anon picked up on one of Bill's last points that implied that the major restructuring in many departments seemed to be heading towards lecture-only tuition. This was an oversimplification and, in some cases perhaps incorrect. While there has indeed generally been a reduction in staff contact time, it can mean a reduction in the numbers of lectures students need to attend and newer methods of (computer-based) learning are being employed for which the case studies are well suited. It could be that the reduced contact time may encourage the use of new methods of learning and teaching.
4. Bill said he had found the general feeling was that the case studies worked best when they involved more contact time between staff and students. the introduction of these new methods were, however, perhaps challenging the idea of what it is that our universities are offering as education.
5. Adisa Azapagic (Surrey) said that in her university they make use of PhD students, researchers and research fellows who are, it appears, rather more enthusiastic about sustainability than many of the academic staff. They are very good value. They want to get involved and work with students and see it very much as part of their personal development. This has reduced the burden on the academic staff, with excellent results.
6. Mark Hadfield (Bournemouth) agreed with the point made about publicising the RAEng and the VP scheme on the web. At Bournemouth they introduced a prize of £350, paid for by Smith and Nephew, for the best project, which is awarded at Graduation when all the parents are there. That goes a long way to publicise the RAEng and what the department is doing. He wondered if the Royal Academy had thought about doing the same thing.
7. Bill replied on behalf of the Academy saying that it had already provided considerable funding to the universities and would not want to spend any more. He noted that several universities had used some of the RAEng funding for expenses such as prizes and this was just the sort of expenditure that the RAEng had anticipated, rather than the funding being spent mainly on salaries, as had sometimes occurred.
8. David Foxley returned to Adisa's point saying that Bill had been rather more forceful in some of his private comments. It was vital that the full-time academics be exposed to and influenced by the VP scheme rather than more junior and temporary staff since only in this way could there be a lasting impact on the University and the curriculum. One of Bill's warnings to us was to look very

carefully at a secondment that seemed to depend heavily on a “cheap” researcher, since this may not give the best value (to the RAEng) in the long term.

9. Paul Jowitt (Heriot-Watt) referred to Bill’s point about educating the educators. While it was probably the right thing to do, it was probably impossible. Paul said he had once put forward to the RAEng the idea of a summer school for all their lecturing staff to give them some total-immersion on the subject. He had suggested the same idea to the Joint Board of Moderators about the Accreditation Guidelines. It is not enough to issue the guidelines, there has to be some help with the delivery. It would be a good idea to immerse the lecturers and expose them to exactly what the students get. It might be a good idea to involve the Institute of Learning and Teaching. It might be possible to introduce something on sustainability in the induction courses that all young lecturers get.
10. David Foxley agreed that it was vital to try and get the message spread more widely than the hard-core enthusiasts who were in the room at the moment in order that the immediate achievements of the RAEng VP scheme are truly sustainable.
11. Jim McQuaid said that the IEE has already been running its own summer schools for 8 or 10 years. It was something that Paul might pursue in the Institution of Civil Engineers.
12. Rather than deflect this issue onto the Institution Peter Guthrie (Cambridge) proposed that the next time this meeting is held, it is converted into a summer school where we don’t talk about ourselves to each other, but talk to others who might learn from what we are saying. For those of us who have been to these meetings a few times, the excitement of hearing about sustainable design for sustainable development has been lost. He felt there was not much more to be gained for the annual meeting unless the group began to look externally. The RAEng could divert the money it spends on this annual event to an external event and might be able to attract additional funding for such an event.
13. David Foxley observed that there were a lot of nodding heads.
14. David Hicks (Bath) asked what was meant by a case study. From his industrial experience he thought it would be a substantial and complex body of information whereas in the educational context what was needed was something very brief – maybe 2 or 3 sides of A4 – which formed part of an educational process. He was not sure whether this workshop was intending to address the educational process or to focus only on the documented material that had been compiled and what had happened.
15. Bill replied that a case study could vary hugely. At Oxford it was the entire theme of “energy” as one aspect of SD to focus on, mainly by means of lectures and some projects. At Newcastle, on the other hand, one case study consisted of perhaps 25 sheets of paper in the form of a brief and key information needed to undertake the work. This was backed up by a large amount of further documents (a few kilograms) and some further information available through the Web. Other case studies might be very small and occupy perhaps only five minutes of a lecture. Ultimately it is a Humpty Dumpty word – it means what you choose it to mean. Bill agreed that the most important issue was the educational process or context in which the case study was used. There is little point in defining what a case study is until you have come at from the other end, so to speak. What are you doing with it? Why are you using it? What is the purpose of using it? What are the intended outcomes? What you actually do will depend on who you are, what subject you are doing, which department, and so on.

Roger Venables took the floor to address the question of how to influence every member of the lecturing staff or every engineering department. He asked the audience to imagine what they would do if they were asked to market sustainable development as if it were a product. We would need to consider various target markets, and the lecturing staff is one of the target markets. Consistently, across

a large range of product types, the purchasers of anything can be divided into five groups – the wacky innovator (maybe 5%), the early adopters (20%), the keep-up-with-the-Jones (50%), the careful considerers (finally persuaded by logic) (20%), and the laggards (5%). From a marketing point of view, the key message is that different marketing approaches are needed for each segment. In 1995 site environmental management was in the wacky innovator group; already, now, it is in the early adopters region. With sustainability we are now still in the wacky innovator stage. At this stage, therefore, we should not be devoting our efforts to converting the laggards or even the keep-up-with-the-Jones' – they are not ready for it. We must concentrate on the first and the second groups.

[During the above there was an animated discussion about whether we were talking about what people were actually doing or what they believed or said they were doing – it was agreed that too many people already (mistakenly) believe that are “doing” sustainable development.]

David Fisk agreed with the points Roger had been making and said that far too much government money had been wasted trying to hit all groups with a single message. However, there was an important proviso to recognise. The problem is that it is from the large populations of the keep-up-with-the-Jones that the counter attack comes. Unless some early attempt is made to achieve full market penetration then someone else may get there first and successfully sell a rival product (or idea).

Plenary Session 2.

1545 – 1700

Jim McQuaid introduced and chaired the session and began with a discussion of the morning's workshop sessions at which the experiences of VP secondments at thirteen universities had been presented.

The question for discussions was whether there was any such thing as a *core body of knowledge* about sustainable development that engineers need?

- ⇒ Jim Poole (Cardiff) felt it was important to distinguish two types of knowledge – information and principles. He felt we were not learning enough from the case studies to pick out a set of principles that engineers can use and apply in their workplace.
- ⇒ Geoff Evans (Cardiff) said that Jim started his course with some definitions of sustainable development, including a model (a diagram) which students probably find easier to remember, and took it on from there.
- ⇒ Peter Guthrie (Cambridge) was worried that each of the VPs might be introducing the subject in a different way. He felt there was a need to synthesise something that should be presented in the name of the RAEng. This might be a minimum core knowledge or a perhaps a master specification which contains everything that we would all wish to include, from which people can draw what they most need. He felt strongly that there needs to be something that is seen as a common position advocated by the RAEng.
- ⇒ Alan Strong (Ulster) felt there should not be a core body of knowledge for engineers – rather there was needed a body of knowledge for all undergraduate students, something that goes across all the disciplines – a generic set of knowledge. He felt it would be a sad outcome if we, as representatives of 21 universities, could not come to an agreement on what the basic underpinning knowledge is.
- ⇒ Adisa Azapagic (Surrey) said she liked the paper on teaching SD for engineering students that has been published by Forum for the Future about four years ago. It distinguished between concepts and solutions – the core concepts that engineering students needed and the tools and approaches they need to be aware of to arrive at sustainable solutions. She felt that we should go back to that paper and build upon it, because it was a very good starting point.
- ⇒ Paul Jowitt (Heriot-Watt) wondered whether a sort of update to “Engineering for the 21st century” was needed.
- ⇒ David Foxley noted Forum for the Future paper had been reviewed by several RAEng people and had not been received well. One thing that did come out was whether there was a difference between a “core knowledge” and “principles of design” for sustainable development.
- ⇒ David Slater wondered if Forum for the Future was still closely linked with The Natural Step, and wondered whether we should be associated with such a “pseudo-philosophical” approach to the subject. Do we need a document with a more philosophical bent or one with a more engineering flavour?
- ⇒ David Fisk (DTI) was clear that there was a difference between the use of principles and a core body of knowledge. He mentioned that President of the Royal Society (Sir Robert May) gives a good lecture on Sustainable Development in which he says there may be more than one type of solution to achieving sustainable development. In his experience, more people agree on what is *unsustainable* than what is sustainable. Rather than arguing about different solutions, what we may all have in common is knowing what *doesn't* work. Taking this approach avoids having to be telling people how to do it.

- ⇒ George Drahun (Aston) felt it was important to find a way a way of introducing the social issues along with the numerical aspects of engineering.
- ⇒ Matthew Simon (Sheffield Hallam) wanted to disagree with the idea that there was (or should be) a single core of knowledge for all of us. He felt different universities, and different subject areas within the same discipline, should have the freedom to develop their own idea of what Sustainable Development is about. He thought everyone should be able to choose what is right for their own subject. We should be educating students to develop with another world view - not training them to use certain skills. Different people will end up with dark or light green ideas of Sustainable Development and will be equally effective in their work. He felt it was unlikely that we would come to agree a core body of knowledge for all subjects.
- ⇒ Jim Poole (Cardiff) felt it was important not to focus only on the needs of engineers. It may be that others do not want an engineer's view of sustainability. There is a need to involve others: it must be a team solution. The most important thing was to listen to others and for the outcome eventually to be decided in the democratic process.
- ⇒ Paul Jowitt (Heriot-Watt) found our response was rather typical of engineers – lets define a core knowledge, lets develop a code ... we should just get on with it.
- ⇒ Roger Venables (Queens University Belfast) mentioned a document he found useful called “Professional Practice for Sustainable Development” produced by a team led by the Institute of Environmental Scientists. It is one attempt at drawing things together and is very much process driven.

Jim McQuaid said that, after several years' experience of the different ways that VPs and lectures had been introducing SD to their students and courses, he felt convinced there would be benefit in us pooling this body of knowledge , together with convincing examples and data to back them up. This would, at least, help to establish that idea that there is actually an issue to address. He found that many lecturers and practising engineers still felt that the idea of “sustainable development” was a political slogan and had nothing to do with engineers. If nothing else, there was a job to be done in collecting our knowledge and experiences to convert such people.

There was also the more general body of knowledge that we share related to the evolution of our socio-political system and the consequent conventions, rules and obligations that derive from it. Leslie Hempel from the University of Ulster has undertaken a study of how the concept of Sustainability has come into our political system in the form of treaties, conventions right down to local agendas. She would be sharing this vast wealth of information with the RAEng.

Jim McQuaid then turned to the next subject of consideration – whether there are different (new) skill sets that engineers need to develop in order to address Sustainable Development issues?

- ⇒ George Drahun felt that assessing risk and dealing with decision-making were important. After the various impacts have been assessed, how then is a decision taken?
- ⇒ David Fisk felt we have been training engineers in the past to answer precise questions set by somebody else. What we seem to be picking up on a lot of the work done by the VPs is that there was a strong need to help engineers to deal with “fuzzy” questions. Engineers also need to develop an ability to listen. That is a skill that needs to be acquired by training. We (engineers) are also often put in the position of being set up against groups of stakeholders or the “the public” (for instance in risk assessment), forgetting, perhaps that we too are a member of that set – we too are stakeholders! Engineers should not be seen as separate from stakeholders, or the public and we need to develop an understanding of how we need to approach this.
- ⇒ Lorna Walker (Sheffield) observed that we – those dealing with the built environment – have difficulty enough in communicating with each other. Hardly surprising that we are not good at communicating with non-engineers or the public. We are not good at listening and we also

have to learn to communicate with the people who need to hear what we have to say, and to check that the communication has been successful.

- ⇒ Roger Booth (Oxford) emphasised the need for the ability to work in teams, especially multi-disciplinary teams which engineers are required to do more and more.
- ⇒ Anon said that in research we construct the body of knowledge and then come up with questions. It may be more realistic for us to be seeking to create a common set of resources to draw upon rather than to seek a common body of knowledge.
- ⇒ David Fisk felt there was a need to prepare people for dealing with more complex problems and systems.
- ⇒ Paul Sharratt (UMIST) thought that many of the skills we have been discussing are adequate for us to be delivering best practice or developing existing engineering solutions that are better fitted. However, addressing issues of sustainability is going to mean step change technologies rather than incremental changes and these skills are not going to be able to deliver this. We are going to have to deal more with innovation, entrepreneurship and leadership of step-change vision, rather than incremental change.
- ⇒ Anon said he had found the following in the draft paper on Principles of Engineering for Sustainable Development (by David Fisk and Jim McQuaid) “all engineering decisions begin with a clearly defined need”, which was not his experience. However, it went on to say that we must think in systems terms, identify interdependencies, decide the system boundary, examine the footprint, and so on – all the soft issues we have been talking about. So it is there in the paper. The emphasis is on the soft issues that students generally don’t want to know about. It is quite easy to get hold of the narrow (technical) information. We need to learn how to deal with the wider issues.
- ⇒ Jim McQuaid felt there was a need for a better grounding in systems thinking – echoing the point made by Richard Dodds (in his morning presentation) on sustainable product design that “systems thinking” has the greatest potential.
- ⇒ Paul Jowitt (Heriot-Watt) said he had been doing a systems course back in 1971 when he was among the “wacky academics” when no-one else wanted to know about it. The subject is generally still not widely accepted and we should admit it will take a long time to bring about change. He felt the most important issue was decision-making – not necessarily multi-criteria variable . . . the most difficult is multi-people decision-making. It is here that you encounter conflict that is not based on technical issues.
- ⇒ Michael Corcoran thought he might be the only non-engineer in the room. He felt that, before defining a need, you must understand what you are doing, and understanding other people’s views. He observed that there seems to be a reluctance (by engineers) to believe that students can be interested in soft issues. He felt they probably are interested in these soft issues! The growth in university courses is certainly in the soft areas!

Jim McQuaid moved on to the third theme for discussion – whether we need a different approach to teaching sustainability, compared to other engineering subjects.

- ⇒ Peter Guthrie (Cambridge) felt that teaching at Cambridge is perhaps 15 years behind where it should be and we really need to be teaching all engineering in new ways. We do not need something new particularly for Sustainable Development.
- ⇒ Jim McQuaid pointed out that the UK government is currently spending £65 million on trying to establish lessons for the UK from MIT. One of the studies is on engineering education at Cambridge and MIT which are just about at opposite ends of the spectrum – proportions of lectures, practicals, tutorials, and so on.
- ⇒ Peter Guthrie (Cambridge) observed that MIT students do not challenge what they are told.

- ⇒ Jim Poole (Cardiff), who is not an engineer, nor a sociologist nor an economist, has been involved in the last three years with projects that have included sociologists and economists and, on the way, has now learned quite a lot about those disciplines. Jim felt that we (educators) should not restrict ourselves to what the students learn in college. Your (engineers') focus should be on how they perform in the workplace once they have graduated. You would be better off sensitising the students to be receptive in the future, rather than trying to ram a load of facts into their heads while they are with you. I come back to principles – if you teach them to listen and teach them communication skills that might serve them better in the long run than knowing every last bit of information about global warming, or whatever.
- ⇒ David Hicks (Bath) thought there are three characteristics of the pedagogical issues related to teaching about sustainable development: for Type 1 problems you can formulate technical solutions; there are Type 2 problems where you decide to treat it through the people, for instance, rather than make more energy-efficient equipment you can make people more aware of energy and modify their behaviour; and there are Type 3 problems where you don't have enough information, and there aren't any right answers for those problems. These three types of problem need different types of education. Sometimes students must be prepared for only Type 1 problems where they get on and solve it. For those they should not have to deal with all the social and political issues. Most importantly, students also need to learn how to distinguish between them.
- ⇒ Paul Sharratt (UMIST) found that the barriers between disciplines are more pronounced in the UK than in the US. He felt there was a need for a continuum of engineering skills. He cited the example of the Commodore games computer that had been designed by a journalist. In the US it was much easier to cross boundaries. These boundaries make it extremely difficult in universities to present courses that are of their very nature cross-disciplinary. There needs to be some cultural engineering to make the climate for learning more receptive to subjects such as Sustainable Development.
- ⇒ Anon sounded a note of warning about going straight to multidisciplinary – engineers need their specialist skills too. It was important to lay down good foundations of individual disciplines. If not we are going to run into severe problems.
- ⇒ Roger Booth (Oxford) observed there was a need for engineers to be able to come up with their own view. They had to be able to gather information, analyse it, synthesise an outcome and then come to a view. Their ability to think for themselves is far more important than the facts they know.
- ⇒ Anon had generally found that students want to fill up with information – to learn the easy way. A key skill set is the ability to think for themselves.
- ⇒ Rover Venables thought there was no need to amend the way we teach engineering. It was important to teach students how to think. Picking up on what David Fisk had said, there was a need to come out being able to deal with the open-ended problems. Not those with one “right” answer.
- ⇒ Mark Fletcher (Bradford) found that students are being groomed by the education system to pass exams, especially at schools. Maybe the RAEng should drive them further upstream – at what is happening in schools with the university students of tomorrow.
- ⇒ Jim McQuaid said he had been surprised to read in a recent edition *Ingenia* that engineering is about “unadorned facts and unbiased technical views”. It seemed to him that the truth was roughly 180° out – very rarely are the facts unadorned and very rarely can people take a technical view that is unbiased by their previous experience. He said there would probably be a reply to that!

Jim McQuaid then moved on to consider the fourth theme – the draft paper on Principles of Engineering Design for Sustainable Development that he had produced with David Fisk. He reminded us that one of the objectives in the ROAMEF document was to distil these. But it did not say how that process of distillation would take place! It was agreed that he and David Fisk would compile a first draft.

He said the document would be based on the literature in the field (which would be credited) and that it would broadly follow the approach taken in the earlier RAEng paper on Principles of Engineering Design. There will also be an introductory section.

- ⇒ Madeleine Metcalfe suggested, if you don't want copies left filling up someone's garage, it was important to decide who the book was for, and whether it was to be published as commercial venture? Could it perhaps be for a wider audience than engineers, such as surveyors and architects?
- ⇒ Bill Addis also felt it would be important to decide who the paper was intended for. He found that, while the RAEng paper on the Principles of Engineering Design was a very succinct and intelligent summary, it was not clear whom it was really aimed at; it was a rather abstract paper. He found the same with the draft of the new paper and hoped that it might be more clearly focused on a particular type of reader.
- ⇒ Anon made the same point. ?? – The principles that you set out in the document are the very principles that should be applied to preparing the document itself:
 - all engineering decisions begin with a clearly defined need
 - all engineering decisions arise from a creative response to need
 - all engineering decisions result in a system, product or project that meets the need.These are exactly the criteria I am sure you will be applying when you think about this document - who it is for and what you intend from it.
- ⇒ George Drahun (Aston) wondered who was defining the need? All engineering decisions begin with a clearly defined need. Oh yea? The real issue is that engineers wait for somebody to tell them what to make. Until they get involved in defining the need and what to make, they will not be having their full impact.

Jim McQuaid said these issues will be addressed. Sometimes the need is very general – a need for mobility, or for shelter . . .

- ⇒ Anon wanted to go back to the issue of disposal (he did not like the use of new/unusual works like remanation). He felt that the idea of disposal fits in with the idea of the project life cycle. He felt that the main gap in the first part was materials. He thought that materials were one of the key issues for sustainability. While choice of materials is implied in the idea of design, it really needs to be brought out much more strongly.
The other thing he found problematic was the idea of vision (in need, vision and delivery). He was very keen on vision and values and he felt that it was important that the values are stressed more, because you need the values in order to get to the vision. He found that the draft confuses vision and values a bit. Unless the universities can set out their values and their vision for sustainability, we are all going to fail to achieve it.

Jim McQuaid replied that he did not like the word 'disposal' because it suggests that that is the end of the matter – we have got rid of it. For example, if you look at the way the Five Capitals model assess Sustainable Development, you can have depletion of natural resources like materials, and if that goes along with increases in social capital and people's ability to do things then you might argue that you are doing as much for sustainable development as is possible at the present time.

- ⇒ Peter Guthrie (Cambridge) wanted to echo the last two comments. He felt it was a great over simplification to say that all engineering problems begin with a well-defined need. He had never worked on a problem where the need was defined, indeed he had spent most of his life

trying to define what the need was! It was also the case that the need changes as the design and the process has gone on.

He also found the three phases rather simplistic. Design does not begin with a problem. It begins with values and so on, and that needs to be built in. While he could see why the authors were trying to simplify the process, but he felt that if a social scientist were to read this paper in its current form, they would be able to detect that it had been written by an engineer, and that immediately marks it out as a divisive and an unhealthy document.

Finally he also would suggest excluding any word that required people to go to a dictionary.

Jim McQuaid drew the discussion to a close, inviting people to pass on their comments about the draft paper by e-mail to himself or David Fisk or David Foxley.

David Foxley concluded the Plenary Session with news that the RAEng was considering to offer some further funding - around £3,000 a year for up to two more years – to the first 5 universities to enable them to embed the teaching materials and case studies that had been developed by staff in the curricula and to disseminate them more widely beyond their originating Departments. Gordon Baker suggested it might be a good incentive to award the money after the results had been achieved.