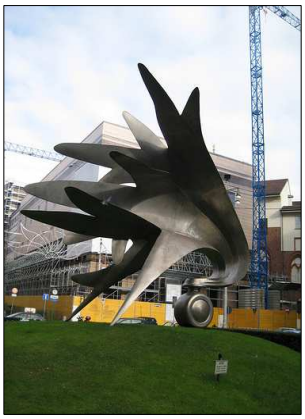

Educating Engineers for Sustainable Development

Final Report
of a
Royal Academy of Engineering sponsored pilot study

University of Manchester
Faculty of Engineering and Physical Sciences

March 2009

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Photographs of Luciano Minguzzi's *Monumento al Carabiniere*, Milan, and Valetta City Wall by Bland Tomkinson
Photographs of student teams, with their permission, by Helen Dobson

Educating Engineers for Sustainable Development

A report to the Royal Academy of Engineering

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Preface

This Report is based on a quite remarkable cornucopia of enthusiasm, creativity and sheer hard work by a small group of colleagues. The quality and quantity of what has been achieved should be seen in the context of their considerable 'normal' workload. The design, production, implementation, assessment, monitoring and evaluation of this pilot course unit represent an important example of advanced practice in higher education. The Report sets out to document a sequence of student-centred, contextual, integrated, active, collaborative and reflective learning opportunities. Careful documentation, here amplified in the Appendix, should assist those who wish to replicate this approach for interdisciplinary development of generic abilities and skills.

This has been a splendid opportunity to progress from a proposal, for a wide ranging interdisciplinary course for the development of capability in adapting to change and participating in change, to the present exploration of education to this end: focused on Sustainable Development in Engineering. The process of research and development, here with an emphasis on an interdisciplinary component, has been enabled through a grant from the Royal Academy of Engineering and the support of the Faculty of Engineering and Physical Sciences. Colleagues in that faculty have been most liberal in trusting the project team to venture into the unfamiliar and yet not to stray too far beyond the University's rules and regulations. The members of the four advisory groups ensured that the course unit would be firmly based in the context of the practice of engineering. The Steering Group, under the chairmanship of the Associate Dean for Teaching and Learning, ensured that enthusiasm for innovation would be encouraged and supported within the administrative and financial environment. Despite the constraints of time and concurrent responsibilities the Project Manager, the faculty's Academic Support Teaching Innovation and Development Adviser, and the Project Officer demonstrated remarkable intellectual flexibility and creativity in adopting a quite novel educational approach and adapting it to the challenge of introducing Sustainable Development in Engineering. The students, from a wide range of different cultures, participated with remarkable resilience despite acting as 'Guinea pigs'. Considerable appreciation is due to the facilitators who adopted their 'non-teaching' role with great flexibility and, indeed, with enthusiasm and commitment to 'their own group' of students.

The evaluation of the pilot course unit identified both success and concerns. Success has been encouraging in the evidence assembled in response to '*How acceptable?*' was the experience for the students and for the facilitators and '*How effective?*' was the course unit as demonstrated in the summative assessments. Both groups suggested that interdisciplinary learning would be further enhanced by increasing the range of disciplines beyond those of the faculty. On the other hand, the team regretted that, due to excessive pressure of other duties and commitments, it was not able to communicate more frequently with the members of the advisory groups and that it could not devote more time to disseminating information about the novel nature of the pilot course unit both within and beyond the faculty and other potential stake holders. Any spare energy and private time had to be directed largely towards dissemination through conferences.

This Report includes the first two iterations of the unit which was designed to explore the educational, logistic and financial aspects of increasing the number of students and disciplines.

The Visiting Professor could merely inform, advise and applaud from his base in London. The team owes a special debt to the University Adviser on Pedagogic Development, whose wise and energetic support has proved to be central to the successful planning, implementation and evaluation of the pilot course and its first iteration.

Charles Engel
London
March 2009

Executive summary

This Report presents the results of a pilot project at the University of Manchester, supported by the Royal Academy of Engineering through its Visiting Professorships scheme, to introduce a course unit on sustainable development available to students from a range of engineering and science disciplines. An interim report was issued in 2008 and this final report unashamedly draws heavily upon the interim one.

The overall approach stemmed from a longer-term interest in social issues of global complexity and the role of the professions in ameliorating the 'wicked' problems that the world faces (p 1). The specific application is in an interdisciplinary single semester course unit on Sustainable Development for Engineers and Scientists (p 2).

The Report outlines the novel approach taken to the design of the curriculum, ie structured to foster active, contextual, cumulative, integrated, collaborative and reflective learning, and the exercises that are its key constituent (p 3). Using a number of advisory groups, with members drawn from among the academic staff of the faculty, questions were addressed about the attributes and capabilities that graduates need in order to make a contribution to global issues of environmental literacy and sustainable development and the educational processes to develop those attributes and capabilities.

During the semester the teams of students tackled five complex and diverse issues, set out by academic experts from many fields (p 4). They worked together in interdisciplinary teams of about eight, facilitated by specially trained post-doctoral research associates (p 6). The pilot course involved 48 students from four different disciplines, and a wider range of programmes from within those disciplines, as well as a range of nationalities; the second run of the pilot doubled the intake and also increased the range of disciplines covered (p 8). The third run will feature a similar number of students but from a slightly wider range of disciplines.

The educational approach required an appraisal of the most appropriate forms of assessment for the unit. There was an emphasis on formative assessment, partly to provide practice in the forms of assessment to be used summatively, but largely to provide feedback to the students (p 9). For the second run the forms of assessment were modified in response to feedback on the initial pilot.

The course unit has been monitored and evaluated in a number of ways (p 10). Both students and facilitators found the programme very rewarding and there is evidence of change in student approaches to learning as well as in their attitudes to, and knowledge of, sustainable development (p 11). The second year of operation tested more fully the financial viability of the unit, but the evidence suggests that it could be sustainable (p 12).

The project team has widely disseminated the ideas and results of the pilot project, through conference presentations worldwide as well as book chapters and journal articles (p 13). A Symposium was convened in Manchester in December 2008 to investigate ways of moving the agenda forward more broadly.

The novel approach to the use of the Royal Academy of Engineering Visiting Professorship scheme was vital to the project but the project has generated a wealth of resources that can be used to foster the a similar scheme in other institutions without the same level of external support(p 15).

The approach has scope for extension in a number of ways: to other universities; to a wider range of disciplines within the university and; to a greater range of levels within engineering and science programmes, both as a short unit at postgraduate level and also as a strand running through undergraduate courses (p 16).

The Report is accompanied by an extensive volume of Appendices, designed to provide sufficient detail about the approach to enable others to produce their own versions of the scheme.

Educating Engineers for Sustainable Development

Introduction

How can a curriculum be designed that, alongside disciplinary skills and knowledge, assists students to develop enhanced professional skills which enable them to *make a difference* in their chosen careers? How can this be achieved for engineering and science students in the context of sustainable development?

This Report describes a pilot project that was the culmination of five years' development work by a small project team. Professor Charles Engel, who became the Royal Academy of Engineering Visiting Professor for the project, had been an advisor to the Victoria University of Manchester and UMIST in the area of implementing problem based learning. Interactions with him and colleagues in the two universities led to an enthusiasm to introduce his ideas of 'Interdisciplinarity with Societal Responsibility' (ISR) to both universities, through joint educational network meetings, starting in 2002.

Interdisciplinarity with Societal Responsibility raises essential questions about the nature and purpose of higher education and how universities are preparing their graduates to enter into the 21st century with the abilities and skills *to make a difference;* not only with regard to their technical expertise and because of their knowledge, but also their skills in working alongside other professions and pooling ideas and experience. Current provision has a tendency to be a narrowing experience, producing graduates who think 'in boxes' and believe their expertise to be limited, that is to say only related to their subject discipline. Once in their professions they may find it difficult to work creatively in interdisciplinary teams and to understand the 'cultures' of other disciplines (Engel: 2002). Subject-based education may not introduce ethical dilemmas to students although professionals need to be ethically aware in the choices and decisions which form part of their working lives.

Cross-university staff development workshops gave academic staff a taste of the experience that students might have when working in interdisciplinary teams and such events helped to create a climate for development. The ISR team was conscious of the concerns of the individual professions regarding ethical and societal awareness (Brundtland: 1987); the increasing global interest in inter-professional learning and the rapidly expanding demands for education in sustainable development, both in its disciplinary and broadest senses (EESD: 2004; Engineering Council: 2004; National Academy of Engineering: 2005). Further workshops were held to build awareness and encourage collaboration across disciplines for this initiative.

The upheaval of the merger between UMIST and the Victoria University of Manchester in 2004 had a sobering effect on educational creativity and, although the flame of ISR was kept alight, it was only in 2006, when the team received funding from the Royal Academy of Engineering, that the pedagogic research and development could really begin. This Report, which incorporates much of the material of the Interim Report, sets out the approach to the development and also a brief evaluation. Our aim is both to set out to the Royal Academy of Engineering the outcomes of the project and also to provide sufficient information to enable colleagues in other universities, and elsewhere, to replicate the experience in order to foster application in professional practice rather than focussing solely on 'literacy'.

The intention is that this report and its appendices can be used by others in order to ***replicate*** *present approach to curriculum design, implementation monitoring and evaluation. The individual case studies are described, but not in great detail. This is so that they are not used out of context: the important step is for curriculum teams to take on the learning experience of developing scenarios that are not only current but also fit into their local context.*

What were the aims?

Early in 2006, the Royal Academy of Engineering provided funding to support a project by the Teaching Support and Development Unit in the Faculty of Engineering and Physical Sciences.

> "An action research project relating to the design and implementation of a faculty-wide course/curriculum on sustainable development, initially on a pilot scheme. *The curriculum and methodology will be based on an understanding of the skills and abilities that students need to develop for their professional lives in order to initiate and manage change on behalf of society. The project will work within the Faculty Learning and Teaching Strategy and will seek to positively impact on student retention through providing relevant real world contexts, professional skills enhancement and engaging curricula.*"

The pilot course unit was originally conceived as an introduction, when students from different disciplines would work together, in *strands*, throughout their respective undergraduate curricula. This aim towards creating a cumulative learning construct in the context of sustainable development had to give way to reality. Initially it was intended to create a unit for first year students, to introduce ideas that could be developed in subsequent years and to work with people who had not experienced higher education before and therefore had no preconceptions regarding expectations. However, the timetable proved intractable and it was impossible to find a common time for that year group. Working with third years who could elect to come on the pilot was more practicable and so the project was initially developed for 48 students from four participating disciplines: Civil Engineering, Electrical and Electronic Engineering, Mechanical Engineering and Earth, Atmospheric and Environmental Sciences. In its second year of operation the numbers were increased to 93 and the scope was extended to include students form the Schools of Chemistry, Computer Science, Mathematics and Physics, some of whom were taking Joint Honours programmes. The programme has since been further extended and the next year of operation sees students from Geography and Life Sciences.

The remit

The outcomes of the project were to:

- Identify the attributes and capabilities that graduates will need in order to make a major contribution to global issues of environmental literacy and sustainable development.
- Create a pilot unit and teaching materials to develop these attributes and capabilities in undergraduate students, across the faculty.
- Assist academic staff in engineering and the physical sciences to enhance teaching, learning and assessment to ensure that sustainable development is included in course materials, using innovative learning and teaching techniques and enhanced pedagogy and a range of methods and media.
- Develop strategic interdisciplinary approaches to sustainable development curricula initiatives.

> *It was important to construct thinking in a highly disciplined way and not rush immediately into the trap of saying what information would be included or how the unit would be taught. The planning needed to be 'discipline neutral'. Only after consideration by advisory groups was the unit itself devised, with associated content and process and also appropriate assessment and evaluation methods. There was an additional requirement to produce teaching materials of potential wider applicability and to disseminate developments as widely as possible.*

What was the approach?

The organisation of the pilot included a Steering Group, chaired by the Associate Dean for Teaching and Learning, and four advisory groups. The advisory groups, each with a small number of different academics from the faculty, were invited to review and advise on suggestions assembled by the project team:

- Group 1. Review and advise on: the project's working definition of "Education for Sustainable Development in science and engineering"; the main aspects of sustainable development for scientists and engineers (based upon which case-studies would be developed); the professional activities which engineering and science graduates might be asked to undertake (in relation to sustainable development).
- Group 2. Review and advise on: the abilities and skills which would need to be developed for the management of the activities (reviewed by Advisory Group 1); a portfolio of case studies and associated study material for use in the pilot (introductory) course unit.
- Group 3. Review and advise on: appropriate and supportive approaches for formative and summative assessment of the students' progress and achievement, as well as review and advise on relevant recognition and reward for students' successful participation during the pilot course unit.
- Group 4. Review and advise on: the design of monitoring the implementation of the pilot course unit, as well as on realistic recognition and reward of creativity and quality of commitment in educational activities undertaken by individual academics.

While the advisory groups ensured the profession-specific relevance of this project, its members became familiar with a range of advanced concepts and practices in higher education. It was hoped that they would pass their interests and new approaches in education on to other colleagues in the faculty.

Appendix 1.1

The educational design was based on the principles of *problem based learning* (PBL) (see, for example, Engel et al: 2007) within a curriculum structured to foster active, contextual, cumulative, integrated, collaborative and reflective learning. The aims of the course unit were to assist in the development of related abilities and skills, as well as enabling knowledge and understanding. Formative and summative assessments were based on the *modified essay question* (MEQ) (see, for example, Knox: 1980), group reports, observation of group behaviour and peer appraisal.

Appendix 6

The sequence of five tasks, each spread over three weeks, was designed to help the students to explore a range of relevant aspects of Sustainable Development, in its broadest sense, and to begin to develop a number of related abilities and skills within the time constraints of the (introductory) pilot course unit.

Definition, of Education for Sustainable Development, for this project:

"*Education for Sustainable Development aims to enable the professional engineer to participate, with a leading contribution, in decisions about the way we do things individually and collectively, both locally and globally, to meet the needs and aspirations of the present generation without compromising the ability of future generations to meet their own needs and aspirations.*"

How was it implemented?

All of the learning on the course unit took place through a series of case-study exercises. *There were no lectures or material handed out about sustainable development theory. These were not case studies in the format of showcasing a previously solved problem, but were "live" unsolved problems, preferably based on developments currently taking place.*

Case-study exercises

Each exercise was championed by an academic member of staff or visiting expert, working with the Project Officer. Having one person overseeing the development of all of the exercises ensured that all were in line with the vision of the course and were both complementary and cumulative. The lead authors included a lawyer, an architect, a mechanical engineer, a chemical engineer and an external consultant in Corporate Social Responsibility (CSR). Each worked with the project team to produce the exercise briefing, background information, information for facilitators and, for the first year, a *modified essay question*. Involving academic staff from a diversity of subject areas encouraged different viewpoints of sustainable development and avoided superficiality, since each was an expert in the specific topic.

The expert in each exercise produced detailed written feedback for each group on the outputs that they submitted. The project brief might be presented as a written document, a short video presentation or a live presentation, and was supplemented with additional information and a list of useful links to get the students started with the task. The student output was also required in a variety of forms: for example formal reports; press releases; presentation slides.

In designing the exercises, a number of requirements were taken into account:

- Problems should be messy or 'wicked';
- Scenarios should be in context for a recent graduate;
- Exercises should develop skills in the management of change;
- Problems should bring out core principles of sustainable development;
- Exercises should develop professional skills;
- Each exercise should be cumulatively built on previous ones;
- Issues should be current, wherever possible;
- Exercises should foster thinking across disciplinary boundaries.

Wickedness. The concept of 'wicked' problems was originally formulated in the arena of urban and regional planning, but has spread to other areas, such as computing and engineering, and has much wider applicability. Horst Rittel and Melvin Webber (1973) describe a wicked problem as having: no definitive formulation; no clear end, no 'stopping rule'; a solution that is 'good or bad' rather than 'right or wrong'; no immediate or ultimate test of its resolution; consequences to every solution, there is no possibility of learning by 'trial and error'; no well-described set of potential solutions; uniqueness; symptoms of another problem; causes with no unique explanation; expectations that its 'owner' will find the 'right' answer. It is not necessary for all of these to be present for a problem to be 'wicked', but it is clear that many types of problems that we face on a global scale, whether social, economic, environmental, political or technical, fit very closely with these determinants.

Context. Each exercise had to be appropriate to the context in which graduate engineers or scientists would be working in the first few years of their career. Hence, in each exercise, students took on the role of employees of an organisation, as if they were working as a professional team. This, naturally, defined the scope of sustainable development challenges that could be set. The "deliverable" the students were asked to produce for each exercise was expected to be in the format appropriate to the task, written as if they were a professional team.

Management of change. One of the key educational objectives of the course unit was to develop students towards becoming effective agents for change. Rather than simply understanding the challenges of sustainable development, students were encouraged: to identify the mechanisms for driving and implementing change; to learn to predict the short term and long term consequences of change, taking into account all stakeholders and; to identify the barriers to change that must be overcome, including social, environmental, technical and financial pressures and restrictions.

Development of professional skills. The professional skills to be practised through the group exercises were:

- Verbal & written communication;
- Collaborative team working;
- Interdisciplinary working;
- Researching data;
- Handling large quantities of information (and misinformation);
- Filtering and analysing data (critical appraisal of information);
- Handling uncertainty and incomplete information;
- Problem resolution;
- Decision making;
- Justifying and defending recommendations.

The students were not used to being asked to make decisions and recommendations and to justify and defend their points of view. Some groups found this aspect particularly challenging, especially at the start of the course unit, but it is an important skill that engineering and science students have little opportunity to practise in the usual didactic style of teaching.

Sustainable development principles. It was important that students absorbed sustainable development principles through the exercises. Elements of these were included in all the exercises:

- Balancing environmental, social and economic consequences;
- Considering impacts of change on different stakeholders;
- Corporate Social Responsibility;
- Life Cycle Approach;
- Benchmarking / Assessing sustainability;
- Cost/Benefit Analysis.

Cumulative learning. The exercises were designed to foster cumulative learning, as far as possible, so that aspects from earlier exercises would be applicable to those in later ones and students could extend their learning by building on their previous work.

Topicality. The arena of sustainable development is a fast-changing one, with new Directives and Regulations introduced each year; new technologies being developed and public perceptions changing, for instance regarding energy and climate change. Case study exercises needed to be based on subjects of current interest. Thus, replication of this educational approach, by other institutions, would need to be based on updated or alternative contextual exercises.

Interdisciplinary collaboration. The tasks were designed to span disciplinary boundaries, so that no students would be unfairly advantaged or disadvantaged because of their discipline. The cohort included environmental scientists who had spent three years learning about environmental issues and management, so it was important that material was challenging to them whilst also being appropriate to the engineers. It was also important that the course unit did not focus on engineering design or mathematical modelling. None of the exercises required discipline-specific knowledge. The facilitators for the studies were drawn from a wide range of academic disciplines.

Appendix 3.5
Appendix 4.1

Table 1: Details of student problem scenarios

2006-7	Task	Aspects
Wheels	Recommend sustainability initiatives for a manufacturing company. A consultant's letter provides a list of projects that students may decide to investigate and could choose to include in their plan.	Implementing change within a company; Sustainability definitions, tools and techniques; Corporate attitudes; Understanding stakeholders' perspectives.
Shelter	Develop a strategy for transitional accommodation (housing, schools, clinics, etc) after a natural disaster. Analyse possible alternative approaches and propose a sound and sustainable strategy for their construction. Achieve a realistic and workable balance between international aid and local skills and manpower.	Implementing change across national boundaries. Impacts of natural disasters on communities; Stakeholder cooperation; Infrastructure and logistics; Cultural etc differences; Sustainable design.
Rules	Provide guidance for small companies regarding the UK's implementation of new EU Directives concerning electronic equipment manufacture (e.g. WEEE, EuP and RoHS), produce a press release describing how negative life cycle impacts are minimised by the Directives and identify other stakeholders who will be impacted by the legislation.	Implementing change via regulation; Impact of environmental regulation on different stakeholders; Impact on supply chain: Minimising life cycle impacts.
Energy	Assess social, financial and environmental impacts of eg wind-turbines, solar water heating, geothermal heat pump and photovoltaic cells, with an initial cost-benefit analysis to determine their viability. Understand the implications of and barriers to introducing new technology.	Implementing change through new technology; Cost-benefit analysis; Barriers to new technology; Infrastructure support for new technologies.
Procure ment	Evaluate a fictional supermarket chain against industry good practice in terms of corporate social responsibility, review criteria for industry benchmarking and develop proposals to ensure approval by the ethical investment community.	Implementing change driven by investor pressure; Supply chain management; Assessing sustainability; Benchmarking.
2007-8	Task	Aspects
Plastic	Recommend steps for engaging with the public and other stakeholders regarding construction of a new PVC recycling facility, in the North West UK. Having identified the key controversial issues surrounding the suitability and safety of PVC as a material, presenting this to the public in a clear and balanced way using the format of a short information leaflet.	Implementing change through engaging with public and stakeholders; Understanding barriers to implementing technical solutions; Sustainability definitions, tools and techniques; Importance and methods of stakeholder engagement; Handling conflicting viewpoints; Unbiased information for decision making
Water	Evaluate the feasibility and desirability of a 'virtual water' labelling scheme within a high street commercial food retailer. Present this evaluation in a range of summary formats, suitable for commercial decision making, but with a strong awareness of the different viewpoints of a range of key stakeholders connected to this private enterprise. Apply sustainable development principles to a contentious and challenging practical issue in an easily comprehensible, non-technical format.	Mechanisms for change within a large organisation; Commercial pressures as a barrier to and a driver for change; Accurate product information for change in consumer behaviour; Corporate Social Responsibility and the Supply Chain; Social, environmental and economic factors; Handling conflicting viewpoints of different stakeholders; Unbiased information for consumers
Shelter	Develop a strategy for transitional accommodation (housing, schools, clinics, etc) after a natural disaster. Analyse possible alternative approaches and propose a sound and sustainable strategy for their construction. Balance international aid v local skills and manpower.	Implementing change across national boundaries. Impacts of natural disasters on communities; Stakeholder cooperation; Infrastructure and logistics; Cultural etc differences; Sustainable design.
Food	Outline possible strategies for how an agri-corporation could introduce a novel real-time tracking service to the food and perishable crops supply chain and extract a financial return from it. Identify overhead costs which would need to be covered, including: managing the activity, providing & servicing the equipment, training in its use, help-desk support and steerage of the on-going R&D development programme.	Supply chain management; supply chain carbon footprint reduction; reducing food waste; Implementing change through new technology; Cost saving as a driver for change; Cost-benefit analysis.
Dig	Identify the scope and implications of the requirements in the Companies Act 2006 for UK multinational companies in the mining and natural resources sector. In addition to the identification of legal requirements, the exercise requires recognition of key CSR issues and consideration of how these issues can be accommodated within a multi-stakeholder setting of competing interests.	How legal instruments can both foster and hinder change; how different stakeholder groups resist and favour different mechanisms of change; how system wide mechanisms can accommodate change. CSR to support sustainable development; how the law can underpin sustainable development; economic, social and environmental aspects of sustainable development within firms.

The Facilitators

Appendix 4

Each team of eight, or so, students (see below) had the benefit of a dedicated facilitator; a member of staff working solely with that team throughout the course unit during scheduled class time. Facilitators were employed on a part-time basis, for four hours a week for the semester in which the course unit was delivered. This provided a facilitator for each group plus two additional members of staff to act as understudy in case of absence for sickness or any other unavoidable reasons. In the second year of operation this proved especially valuable since student groups were located in two separate buildings.

An early decision was taken to employ Post Doctoral Research Assistants (PDRAs) as facilitators, and to pay these members of staff for their time in addition to their normal salary, given the level of training and input needed. This did cause some Personnel difficulties, since the PDRAs were already paid on full-time contracts and, after the pilot year, the payment level was reduced, giving each one an 'honorarium'. It was judged that PhD students would not be sufficiently experienced to be given responsibility for a group of undergraduates or to participate in the assessment process. Key facilitator responsibilities include:

- Facilitate group process;
- Facilitate problem based learning and group collaboration;
- Act as a resource broker;
- Advise students on relevance and adequacy of learning;
- Facilitate development of generic competencies;
- Administration: be familiar with the exercises; provide material to students at appropriate time; administer formative assessment papers;
- Professionalism: attend consistently and ensure start of group sessions as timetabled.

Recruitment and selection

Prior knowledge of sustainable development and problem based learning was not required, as the facilitators would be given support and training. One of the challenges was to encourage prospective facilitators to understand that they were required to facilitate rather than 'teach' and, hence, did not need full specialist knowledge of the subject matter. For the pilot year, thirty-five members of staff initially expressed interest in taking on the role of facilitator, including other research staff and at least one recently appointed lecturer. These were whittled down to twelve, who attended the training sessions and eleven participated in the final selection event. From these, eight were chosen. In subsequent years the level of interest was lower but still sufficient to provide a pool of applicants from which to draw. The novel approach used is attractive to a number of post-doctoral researchers keen to enhance their skills in teaching as a prelude to a lecturing career. For the facilitators the exercise could be seen as part of their professional development.

Two induction/training sessions were held before the final selection was made. The first two hour induction session included an introduction to the project and its aims and a general discussion about what is problem based learning and how it can be applied as a means of developing skills and knowledge. The candidates then took turns to practise facilitating small group discussions, on five-minute controversial discussion topics.

The second two hour induction session started with a briefing on group-working using academic papers on the subject: group properties and stages of development, conflict resolution and dysfunctional groups, and examples of criteria for assessing group interactions. The candidates were then introduced to a method of analysing problems by: listing (i) the information known about the problem, (ii) hypotheses or possible solutions and (iii) questions that need to be followed up to test each hypothesis or solution. Having been split into three groups, the candidates were then observed by members of the project team whilst facilitating the rest of the group in tackling a ten minute exercise. This technique was used, as a means of selecting successful candidates.

The criteria used to select the successful candidates were as follows:

- Good listeners;
- Good communicators;
- Encouraging to students (positive);
- Sensitive to students' concerns;
- Confident;
- Able to resist the temptation to direct the group;
- Open to new ideas.

The project team was impressed with the performance of the candidates, who came from a wide range of disciplines within the Faculty of Engineering and Physical Sciences and were of different nationalities. A few, unfortunately, had to be rejected because their quality of spoken English was not felt to be sufficient to cope with fast-paced discussion by a group of students. The project team was also concerned that the facilitator should be capable of avoiding interfering too much in the students' activities when no intervention was needed. The chosen staff attended an additional training session, before meeting the students, in order to be briefed on the first case-study exercise and the running order for the first session.

Background and role

In the pilot year, the facilitators came from the Schools of Chemical Engineering and Analytical Science; Electrical and Electronic Engineering; Chemistry; Computer Science; Earth, Atmospheric and Environmental Sciences and Mechanical, Aerospace and Civil Engineering. One of the eight facilitators was female and five came from countries outside the UK, although all had an excellent standard of spoken English. Only one of the facilitators was working in the field of Sustainable Development research, from a chemical engineering perspective. In subsequent years the disciplinary field has broadened but with the same rich mixture of national origins.

The facilitators were present for the two hours of every teaching session and then for another two hours following each teaching session, where the previous session and exercise were discussed in detail and briefing provided on the following session and exercise. The debriefing after each session was partly to further the facilitators' learning and partly to allow the project team to keep in touch with what was happening in the groups and to provide briefing for subsequent exercises. In the pilot year all of the facilitators were new to the experience but in the subsequent years a number have continued and they have been able to assist the newcomers. The discussions in these sessions ranged from experiences of group interactions to comments on the case studies and reflections on the development of the teams.

The principal role of the facilitators was as the main point of contact for the students in their group and as resource broker in the student exercises. Each facilitator had a Master Folder for each exercise, containing all the necessary information. The students were given a short trigger at the start of each exercise in the form of written material, sometimes accompanied by a verbal presentation or short video. All written material was handed out by the facilitator, and in some exercises the facilitators had extra information that they could provide *if the students could justify why they needed it*. In some cases, information needed to be given out in a particular order for the students to progress through a problem logically.

The students were initially surprised that the facilitators were not experts in Sustainable Development, or in the case study exercises, but this encouraged them to find out information for themselves rather than relying on the facilitator to 'teach' them. As the course unit progressed the students came to understand more clearly the role of the facilitators.

Appendix 4

The Students

Recruitment and selection

In the first year of operation, Year 3 undergraduate students from four disciplines were invited by email to apply for a place on the course unit. Forty-eight student places were available and, in order to create balanced teams comprising two students each from each discipline, only twelve students from each discipline were required to register. The students who were offered places were divided into six teams of eight, each with two students from each discipline, and each group was allocated a member of staff as facilitator. Previous performance was not taken into account when devising the teams and neither students nor facilitators were given any choice about the team to which they were allocated. The female and overseas students were identified and divided evenly between the teams. Four students in the cohort were registered as dyslexic, having been tested by the University's Disability Office. No special arrangements were required in the group tasks but these students were allowed extra time in the final examination. In the second year of operation the numbers were increased but a similar selection process was employed. Because of the way in which the university operates, we initially expected about 110 students but eventually this number settled down to 93. These were divided into twelve teams with some teams having the same mix as the previous year, for comparative purposes, and the remainder having a more mixed group. For the coming session the number of participants has fallen slightly as a result of one department restricting third-year options but two additional subject areas – Geography and Life Sciences – have been added from outwith the Faculty. Students from other areas have expressed interest but timetabling difficulties still exist.

Appendix 5

Groups of about eight students are intended to foster active, collaborative, interdisciplinary learning, where every student is encouraged to participate in discussion and in sharing what they have learned. Teams larger than this preclude such involvement by all team members and can lead to the formation of sub-groups.

Induction

The students were given a folder at the start of the course including a timetable, class list and basic information about the course unit, such as a brief description of problem based learning and the assessment process. Once the students had been placed in their teams, a short introduction about the aims of the course unit was given by the project manager, followed by a brief presentation given by the team member from the Library on researching literature and, in the second and third runs, an introduction to the supporting technology.

Appendix 5.1

Time commitment, attendance and punctuality

The scheduled class time for the unit was 9-11am on a Wednesday morning for twelve weeks in Semester 2 (February – May). For the pilot, half of the first session was used as induction; Week 11 was used for feedback and Week 12 was used for the final examination. In subsequent years a full session was given to induction and the examination was dropped (see below). The rest of the class time was used in the five group tasks, practice exam questions and group discussions on performance and group process. As well as meeting for two hours in class each week, the students were required to research questions relating to the task and construct the report outside the scheduled class-time. Most of the groups also arranged regular team meetings on a Friday and communicated frequently by email in order to carry out the task and write and edit their group reports.

Students were expected to behave as professionals; to inform their facilitator and colleagues in advance if they had to be absent from a session, and take steps to ensure that their absence did not disrupt the group task unduly. At the end of the first task, students were required to discuss, select and document ground-rules for their team, which reinforced professional behaviour and to which they could return periodically to reflect on process issues.

Attendance on the course was excellent, with 93% attendance (98% if those with a valid excuse who informed the group in advance of the session starting are included). Punctuality was a more difficult issue, although one that did improve through the course unit. Students were informed at the start of the course unit and reminded frequently that they must arrive on time but, even towards the end of the course unit, a small minority were turning up to sessions up to three quarters of an hour late. Some groups introduced penalties for students arriving late as part of their team ground-rules. Leaving early also became an issue, as activities were often timetabled up to the end of the two-hour session and some students felt that they needed to leave up to 20 minutes early in order to get to their next lecture at the other end of campus. A Certificate of Successful Completion encouraged maximum participation. After an initial two-week phase where the faculty allowed transfers between course units, none of the students left the course, yielding a 100% retention rate.

Appendix 5.2

Space and organisation

The student teams worked independently in their own space. Initially, all of the teams were housed in the Centre of Excellence in Enquiry Based Learning but lack of availability of suitable rooms, either there or elsewhere, meant that four teams were in shared rooms: two teams to a room with room dividers in-between to separate the space and reduce interference. In practice, the teams found that they were able to work in this physical environment without too much distraction from their neighbours, though this varied over time. Each team was equipped with its own flip chart. In subsequent years the increased number of teams meant that a wider variety of rooms had to be used, across the campus. This caused some difficulties for the project team that was partly resolved by involving additional 'co-ordinating' facilitators.

Assessment

In the first year of operation, the course unit had four methods of assessment for which marks counted towards the overall performance:

- A 1-hour individual examination was set which comprised two compulsory questions in the modified essay question - MEQ (Feletti & Engel: 1980) format. Students were given briefing documents to enable them to prepare for the examination; Appendix 6.1
- The final exercise, with a group report submitted in hard copy; students received a mark for the report, given equally to all members of the group;
- Peer assessment (Conway et al: 1993). At the end of the final exercise, each student in the group was asked to complete a simple, anonymous, check-sheet for each of the other members. The assessor distributed marks, individually, to each student for his or her contribution to the project and to the group report, based on these sheets; Appendix 6.2
- For the final exercise, a facilitator from one of the other groups acted as an observer to note a number of parameters of the performance of that group as a whole. These were used to provide a group mark that was given equally to all members of the group. In this context the role performed was one of assessment rather than facilitation and it was important that the role of friend and mentor to the group was not prejudiced by using the group's facilitator in this role. Appendix 6.3

Responding to comments from both staff and students, in subsequent years the assessment regime was amended to three methods of assessment for which marks counted towards the overall performance:

- An individual reflective report, including a reflective log spanning all five scenarios and a reflective conclusion bringing the log entries together ;
- For the final exercise, a group mark was given equally to all members of the group. However, this was modified by:
- Peer assessment. At the end of the final exercise, each student in the group was asked to complete a simple, anonymous, check-sheet for each of the other members. The assessor distributed marks, individually, to each student for his or her contribution to the project and to the group report, based on these sheets. This score was used to modify the group mark to produce a separate mark for Appendix 6.2

each individual in the group, but maintaining the group average at the level of the group mark.

The lack of familiarity with the MEQ, on the part of both students and staff, meant that the formative exercises were misunderstood by students, who became focussed on marks, as for traditional assignments, rather than on feedback as a learning process. This meant that they were less well prepared for the final summative MEQs than we would have wished. The reflective report was introduced as a means of not only identifying the knowledge and skills development that had taken place, on an individual basis, but also the extent to which that had taken place in the context of professional practice.

What was monitored and evaluated?

In this context, *monitoring* is taken to be a process to provide information about the conduct of the course unit, at the time it is being implemented, in order to effect immediate interventions, should these prove necessary, and to provide detailed data for evaluation of the whole educational intervention. *Evaluation* is intended to provide information for strategic decision making.

Appendix 7

Robust procedures were set up to monitor and evaluate the programme, according to three principal parameters:

- Acceptability: Is the course unit acceptable to both students and staff?
- Effectiveness: Is the course unit achieving what we set out in the proposal? Is it making a difference to student learning?
- Sustainability: Does the programme offer future viability?

Monitoring was assisted by a series of weekly meetings with facilitators as well as frequent meetings of the team. These enabled some important changes to be introduced and also an appraisal at the end of the first year's pilot. Students and facilitators also participated in *nominal group processes*, (see, for example, Delbecq et al: 1975, Mackay: 2003) at the mid-point and at the end of the pilot and at the end of the second run.

Appendix 7.1

In the pilot year 'secretaries' were appointed by each group who were able to communicate confidentially with the Project Manager if there were any difficulties, thus providing a neutral guide if any infelicities were to appear in the system. In practice, communication seldom occurred and the scheme was discontinued in the second year of operation, though it might be reintroduced.

The evaluation of the project looked at issues of effectiveness and acceptability as well as efficiency and sustainability (eg: resources, effort, time expended by the stakeholders). In addition to some analysis of the cost data, the evidence has been gathered from a number of sources:

- The reflections of the project team as we have gone along;
- The weekly debriefings of the facilitators, as a group;
- Students' self-perception questionnaires;
- Student and facilitator feedback through use of the *nominal group technique*.

To evaluate issues of effectiveness, three questionnaires were administered to students at the beginning and end of the pilot course unit. Mattick and Bligh's (2006) Readiness for Inter-Professional Learning questionnaire was adapted from a health situation to a more generic one; the ETL Project's (2005) shorter experience of teaching and learning questionnaire (SETLQ) was modified by changing one question that related specifically to a lecturing situation and; a locally-designed questionnaire was also administered that tested students' confidence in sustainable development. The students' ability to apply what they has studied was tested in a number of ways (vide supra). For the second cohort only the modified ETL questionnaire was used.

Appendix 7.2

To evaluate issues of acceptability, the *nominal group process* was used, which has a number of variants. The student nominal groups were based on their task groups: their facilitators explained the process to them and then withdrew. Each group was asked to produce a list of positive and negative factors and then to rank them by voting on them. The informal feedback suggested that students had much more difficulty in coming up with negative aspects than with positive ones and this was borne out by the fact that most of the positive comments received the unanimous support of group members, but few of the negative ones did.

Appendix 7.1

What were the results?

Acceptability

The overall results of the *nominal group process* suggest that there was unanimity, particularly at the end of the course, about the value of interdisciplinary working. Group collaboration featured in most of the responses in both mid-semester and also at the end of the semester. The course content also featured in the top three positive aspects on both occasions, occurring in half of the groups. The variety and nature of assessment featured positively at the end of semester but had not featured at all in mid-semester, although the learning approach and feedback were both mentioned. On the less positive side, timetabling issues featured prominently. These varied from difficulties of trying to get together students from different programmes (many groups met in-between their timetabled sessions) to lack of enthusiasm for 9 am starts! Timing also featured in two other ways: timing of assessments (both formative and summative), particularly where this conflicted with major pieces of work for other course units, and also the structure of the weekly two-hour sessions. A concern for a lack of contact with other groups in mid-semester disappeared by the end of the semester, by which time the noise of other groups, working in nearby areas, had become an issue! Interestingly, one of the minor negative aspects expressed by the students was the number of evaluation questionnaires.

Appendix 7.1

> "I would just like to say that this has been the most enjoyable course I have done over the last three years. Love the concept of continual group work and assessment, and think the teaching staff to student ratio is superb."
>
> *Final year Mechanical Engineering student*

The *nominal group process* for the facilitators was also conducted on two occasions. The results of the mid-semester exercise showed their key positive points to be the imaginative and varied tasks, the use of problem based learning and the use of communication skills and group learning. The facilitators also felt that it had been a valuable learning exercise for themselves. By the end of the semester the multidisciplinary nature of the course unit featured more prominently amongst the positive attributes, together with the currency of the issues raised in the scenarios and the professional development aspects. The two key concerns at the mid-point were the narrow range of disciplines represented by the students and the roles of the two 'reserve' facilitators (we had recruited eight facilitators to cover six groups, but it meant that for some weeks there were facilitators present without a group to facilitate: in such cases the 'reserve' facilitators usually helped with other project tasks). The imprecise role of the 'reserve' facilitators was still prominent in the end-of-semester session but was joined by some unease with the *modified essay question*s and a suggestion for a broader range of topics.

The scores given on the standard university module satisfaction questionnaire were very high on most attributes and the course unit had 100% student retention. In the first run, the student satisfaction results suggested that: 100% of students found the coursework helpful to learning; 98% thought the skills learned were valuable; 98% valued the supporting materials; 96% found it intellectually stimulating; 96% thought the staff helpful and approachable. The second cohort produced similar, but slightly lower, figures.

Effectiveness

In terms of final marks, no student in the first cohort failed the course unit but, equally, no student gained a 'first class' mark overall. Individual scores varied between 26% and 80%, but students who did well on assessment modes geared to the individual often fared less well on group items and vice versa. The effect of combining the four sources of assessment was to reduce the variance in the marks, suggesting that the scores were relatively independent. Tests showed that there was a significant correlation between the overall 'examination' MEQ score and the mark obtained from peer review, but not

with the marks for the group report or observed group behaviour, or between other pairs of marks. For the second cohort, only three methods of assessment were used and the spread of marks widened, though still no student failed the unit. Overall marks ranged from 56% to 80%, though in individual elements the scores ranged from 28% to 89%. There are questions about the use of 'marks' in this type of approach and the project team were concerned that students demanded 'marks' for formative assignments. This is perhaps unsurprising for third-year students inculcated with the paramount importance of marks, though it can run counter to a beneficial educational experience.

The self-perception questionnaire showed a demonstrable improvement in perception of skills in relation to the learning, over the course of the course unit. The SETL questionnaire showed significant increases in deep learning, and commensurate decreases in surface learning, but the RIPL questionnaire showed no significant change. The last of these came as little surprise since the initial RIPL scores were very high, perhaps reflecting a large element of self selection. In the second year of operation only the SETL questionnaire was used and this demonstrated similar significant increases in deep approaches to learning (including the monitoring and organising sub-scales) and decreases in surface approaches.

Appendix 7.2

One slightly unexpected factor that came out of the reflective logs and also, more informally, from students, facilitators and academic staff, was the way in which the course unit honed students' research skills. Exercise authors expressed delight at some of the ideas offered by the teams and the mature way in which they had approached the problems. In at least one instance teams generated fruitful thoughts for future research threads. Within the reflective logs a number of students were able to demonstrate the development of their research skills and their interest in pursuing this further. There was also a marked increase in perceived confidence to participate in future interdisciplinary teams.

Sustainability

Looking to the future viability of the course unit is probably the most problematic element of the evaluation. In financial terms it has proved difficult to separate out the costs of design and evaluation from those of running the course unit. The university has an internal load transfer model that provides funding from home schools according to student numbers and this certainly covered the costs of employing the facilitators. There are those within the university who believe that post-doctoral research staff should not receive additional payment for teaching duties and for the second cohort the honorarium was reduced in order to meet this objection. For the pilot study, the costs of the part-time Project Officer were largely met by reducing the stipend for the Visiting Professorship. The Project Officer was heavily involved in design aspects as well as organising and monitoring the weekly sessions and a not insubstantial assessment load. For future cohorts there will be a need for further design work, to ensure currency and to avoid plagiarism, and also organisational and assessment components are likely to grow. Other members of the project team contributed extensively to the design, organisation and assessment of the course unit, but this level of support could not be accorded in the future. However, having undertaken the initial work in these areas, the demands on staff in future years should be much lighter. Moreover, the design and organisation loads are relatively independent of the student numbers so that expansion would add marginally to costs whilst still attracting an average transfer value for the students. The internal load transfer model is not without its difficulties and some subject strands have set limits on participation, or withdrawn completely from later years, largely for financial reasons.

For the 48 students in the pilot scheme, the internal transfer value was £15,952 of which £1595 was taken as an administrative overhead by the Manchester Science Enterprise Centre, £4200 was paid to facilitators and £4000 to external scenario authors; £461 was spent on books, stationery and equipment and £332 on refreshments, leaving a balance of £5364. All but £2500 of the Project Officer's salary costs were met by the Royal Academy of Engineering, but this would not be available for future years and the project could not be sustained at this level. The honorarium for the Visiting Professor

was also met by the Royal Academy of Engineering but the other costs for development, monitoring, evaluation and dissemination were met by the university. For the second cohort of 92 students, in round terms the income is £39,000 of which £4000 is taken as an administrative overhead, £3000 as facilitators' honoraria (at a lower rate than for the pilot study); £28,500 as the salary cost of a part-time Project Officer, £1000 for external scenario authors and £500 for equipment and consumables, leaving a balance of about £2000. At this level, the course unit becomes viable but if the facilitators were to be paid at the same rate as for the pilot study the unit moves slightly into deficit. Moreover, the approach requires constant review to ensure the immediacy, level and relevance of its exercises and this impacts on the work of the Project Officer. Other members of the project team were uncharged and this would be particularly noticed in their contribution to the assessment process.

Publicity and dissemination

As part of the project, the team undertook to disseminate widely both the idea and the results. Some of the ideas, leading up to the pilot course unit, had already been promulgated prior to the support of the Royal Academy of Engineering; for example at: the 2004 EDiNEB Conference in Maastricht; the 2005 International Conference on Civic Engagement and Service Learning in Galway; the 2005 Education for Sustainable Development Conference in Bournemouth and; the 2005 International Society for the Scholarship of Teaching and Learning Conference in Vancouver.

Within the university, dissemination took place through informal meetings and through feedback to the Steering Group and the advisory groups.

Externally, the team focussed on dissemination through conference papers, both within the UK and internationally. During 2008, 2007 and the latter part of 2006, papers about the project were presented at international conferences in Coimbra, Dunedin, Graz, Perth, Sydney and Windsor (Ontario) and, in the UK, in Bournemouth, Bradford, Guildford, London, Loughborough and Plymouth. The interdisciplinary nature of the project was emphasised in that these represented conferences for diverse interest groups: ecosystems, education, engineering, global citizenship and sustainable development. The project has also been written up in five book chapters (Engel and Tomkinson: 2006; Tomkinson, Engel, Tomkinson and Dobson: 2007; Tomkinson, Engel, Tomkinson and Dobson: 2008 and two to appear) and a journal article.

Appendix 8.1

The Symposium

An invitation Symposium was held in Manchester on 15 December 2008. Following presentations on the inter-disciplinary course module and also on a Higher Education Academy Engineering Subject Centre sponsored Delphi consultation, groups of delegates considered potential future courses of action. A number of threads of discussion emerged but there were two principal perspectives that underpinned these. For some discussants, the question was one of broadening out the work done, on sustainable development for engineers, to a wider range of disciplines; for others the question was one of using the work done on sustainable development as a springboard for change in the undergraduate engineering curriculum.

Appendix 8.2

The broad outcomes of the discussions were that:

- The undergraduate engineering curriculum is in need of overhaul, both in terms of content and mode of delivery;
- Sustainable development is becoming embedded in the engineering curriculum though often in a mono-disciplinary fashion;
- A systems approach is vital for the future engineering professional, but this may be too complex for an undergraduate curriculum;
- The engineering curriculum needs to cover both knowledge and skills and a proper balance needs to be maintained;
- Learning to learn is more important that memorising facts;
- Engineers have to learn to place their professional work in context, particularly with regard to working with other professions;
- Learning together with other professions can enhance the students' abilities to place their engineering studies in context and to deal with complex issues;
- Student-centred methods (eg PBL, case studies, role play) can be effective in developing both skills and knowledge, but may have resource implications;
- Student-centred methods of learning can help improve student motivation and levels of retention;
- Curriculum design needs to be adequately resourced to be effective;
- Curriculum change needs high level champions, both within universities and also professional bodies.

The value of the Visiting Professor scheme

This project would not have been possible without the foresight of the Royal Academy of Engineering in allowing flexible use of its Visiting Professor scheme. It is important, therefore to comment on the success of this approach.

The Royal Academy of Engineering scheme was largely intended to bring senior engineers from industry into universities to provide case studies and to anchor studies to real-life examples, in this case in design for sustainable development. In our case the Visiting Professor, Charles Engel, came from a very different background - medical education - with expertise in the design and delivery of innovative approaches to teaching and learning. The 'case studies' have been formulated by members of staff of the university or external consultants. Whilst the value of industrial or commercial experience cannot be gainsaid, in this area it is important to bring in dimensions that may not even be within the everyday ambit of practising engineers and some of the case studies have been provided by, for example, economists or lawyers. Where academic engineering staff have provided material they have often had recent experience in industry or, for example, disaster management in a voluntary agency.

The core project team was very much an interdisciplinary one, with a wide range of disciplinary backgrounds. The original Project Officer, appointed partly by abatement of the Visiting Professor's stipend, had a background in Chemical Engineering, including industrial experience. Her part-time, temporary, replacement, as maternity cover, was an academic with considerable experience as a practising Architect. The wealth and diversity of experience in the team was complementary to that of the Visiting Professor and clearly of benefit. The advisory groups were more homogeneous in nature and their short-term nature occasionally led to a lack of resolution of disciplinary differences between some of their members and the Visiting Professor.

The value of the Visiting Professorship cannot be understated; without Charles Engel's input the project would have been much the poorer and he has provided many of the ideas and much of the impetus. Although the scheme was designed for expert *subject* practitioners to inject real-world experience, the present Visiting Professor was invited to provide innovative *educational* expertise. With such a diversity of talent and experience involved in the project, he has been the 'glue' that held it together. He held frequent meetings with members of the project team and kept in weekly, if not daily, email contact. The waiver of part of his stipend, to help provide initial support for a Project Officer, means that he has gone substantially under-rewarded for his efforts. This unusual approach has undoubtedly been a success and the Royal Academy of Engineering is to be congratulated on its enlightened approach.

In terms of replicating this approach elsewhere, we have tried to provide considerable additional resource in the Appendices to this report to enable schemes to be initiated without the support of a Visiting Professor, though we recognise that some external input might well be valuable.

Conclusions

As part of its consolidation into the mainstream, and to strengthen its position, the programme is to be located in an academic centre, the Manchester Enterprise Centre (MEC), part of the Manchester Business School. MEC provides a 'discipline-neutral' base for the programme: one of the key tasks was to ensure co-ordination and the cross-disciplinary collaboration of all the participating schools.

The original thoughts were for development in three directions. A sideways move has already started with the second pilot cohort, twice the size of the first, having expanded to include the Schools of Chemistry, Mathematics and Physics; the third includes students from Geography and Life Sciences. An upwards move is under consideration with a proposal in hand to provide a similar unit at Masters level. The direction of least movement is towards a 'strand', threading the idea, in a cumulative fashion, through all three undergraduate years.

During the course of the project several members of the project team were also involved in a *Delphi* consultation, supported by the Higher Education Academy's Engineering Subject Centre, seeking to gather good practice with regard to educating engineers in sustainable development (Tomkinson, R: 2008). The results of that study largely validated the approach taken in this project.

However, our approach is not confined solely to education for sustainable development. The core approaches and ideas could prove a useful starting point in redesigning undergraduate programmes in engineering and other subjects, though Medical and Health Sciences have already taken major steps in this direction. A Symposium on this theme was held in the university in December 2008 (vide supra) and a summary of its conclusions appears as an appendix to this report. At the same time, it is hoped to develop plans for a Centre for the Advancement of Education in Engineering in close collaboration with faculties at other Universities. The initial contribution would be the innovations that have been successfully tested in the present pilot course unit, specifically based on our curriculum design for active, contextual, cumulative, interdisciplinary, collaborative and reflective learning.

Students, facilitators, members of the Steering Group and outside bodies have all been fulsome in their praise for this development, but it would perhaps be premature to deem this scheme an outstanding success, despite it being Highly Commended in the Green Gown Awards scheme. This innovative approach has undoubtedly produced considerable benefits, but care has to be taken to ensure that the gains do not slip away and the educational approach 'revert to the mean'. Unlike the other Visiting Professorships, the focus here has been on the educational process rather than the content of the case studies; these have been carefully designed by experts in their fields but as a means to an end rather than as an end in themselves. The context of the case studies as part of a process of developing professional skills is important and care has to be taken in transferring them to other institutions in the context of the educational process. The University proposes to set up a continuing advisory body to safeguard the approach not just for this course unit but also others that might be developed at, for example, postgraduate level.

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