



The Royal Academy
of Engineering



Forum for the Future



Sustainability Competencies for Engineers

Report of workshop held on 17th February 2004

**“Everyone, especially engineers, should have
sustainability literacy as a basic skill”**

Lord Sainsbury, 21st February 2003

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1. Executive summary

Sustainable development is probably the greatest challenge society has ever faced and has always been a key issue for engineers.

By the end of 2003, it had become an essential issue for engineers as changes to standards for professional registration mean educational and professional institutions have to prepare new recruits to the profession to be sustainability competent. This implies that teachers, trainers and employers of engineers will need to develop new skills if they are to provide the right sort of education and professional experience for the new generation.

The Engineering Council (EC(UK)) with Forum for the Future and The Royal Academy of Engineers (RAEng) joined forces to run a seminar which explored the challenge of the new standards with practitioners. Participants shared existing good practice and considered course design and employer needs in the light of sustainability competencies.

This report of what was a lively and stimulating seminar sets the scene for anyone interested in this topic. It contains details of the discussions, notes some conclusions and provides contact details of attendees.

Acknowledgements

Report prepared by Sara Parkin and David Foxley
With thanks to Diane Davy, Victoria Christison, Elizabeth White and Heather Cruickshank

2. Background

By way of background we leave the work of the three partners to speak for itself.

2.1 Engineering Council: New Standards for Professional Engineering Competence (UK-SPEC)

In December 2003, the Engineering Council launched its new Standards for Professional Engineering Competence (UK-SPEC). Recognising the importance of sustainable development to engineering practice, the new standards recognise the need for Chartered and Incorporated Engineers to:

“Demonstrate a personal commitment to professional standards, recognising obligations to society, the profession and the environment.”

Specifically, the new standard requires those wishing to register as professional engineers to:

“Undertake engineering activities in a way that contributes to sustainable development” suggesting that this should include the ability to:

- operate and act responsibly, taking into account the need to progress environmental, social and economic outcomes simultaneously
- use imagination, creativity and innovation to provide products and services which maintain and enhance the quality of the environment and community, and meet financial objectives
- understand and encourage stakeholder involvement.”

To develop these specifications, the EC(UK) invited two engineer graduates of Forum for the Future’s Masters programme in Leadership for Sustainable Development, Dan Rea (now with Ove Arup), and Ben Witchalls (now with BP plc) to contribute to the working groups.

- Visit www.uk-spec.org.uk for more details.

2.2 Forum for the Future: Engineer of the 21st Century

As the leading UK sustainable development charity, Forum for the Future has recognised that engineers and engineering solutions have an enormous role to play in achieving sustainable development. To help contribute to a wider understanding about this role amongst not only engineers in general but also their institutions and the standards that govern them, Forum runs the Engineer of the 21st Century initiative. This works specifically with the new generation of potential leaders to identify what they need from their education, institutions and employers in order to contribute fully to sustainable development in their professional lives. Two reports have been published, and a third phase of the initiative is currently getting underway:

The Engineer of the 21st Century Inquiry: Engineers for Sustainability and The Engineer of the 21st Century Inquiry: Change Challenges for Sustainability

- Visit www.forumforthefuture.org.uk/aboutus/engineerssustainability_page931.aspx for more details.

2.3 The Royal Academy of Engineering: Visiting Professor scheme

The Academy began its visiting professors scheme in Engineering Design for Sustainable Development in 1998. The scheme was inspired by the need to introduce into engineering education teaching materials based on case studies that could enhance both the understanding and the teaching practice around sustainable development. The scheme is a pioneering partnership between industry and academia and at the time of writing sponsors a total of 26 universities in the production of such materials.

- Visit www.raeng.org.uk/education/vps for more details.

3. The seminar: why, who and how

3.1 Purpose

The new standards for competence and commitment for Chartered and Incorporated engineers include specific reference to sustainable development. Similarly, technicians are required to commit to a code that recognises obligations to society and the environment.

The seminar sought to address what this will mean in practice for those who teach or train engineers, design or accredit courses, organise activities for Continuous Professional Development (CPD) or register engineers in particular engineering disciplines.

The seminar was organised to give a broad spectrum of people involved in the design, delivery, accreditation or procurement of engineering education and training to explore these questions. At the end of the day, it was hoped that attendees would:

- a) understand the purpose of the sustainability competencies and the benefits they bring to the registering engineer and his or her employer
- b) have confidence that integrating sustainability competencies into existing provision is possible and reasonably straightforward
- c) be part of a developing network of practitioners prepared to share learning and techniques.

3.2 Attendees

Attendees were from both the *supply* side - those who provide education and training) and the *demand* side - those who procure courses or employ the graduates.

3.3 Structure and process

The main part of the seminar engaged participants through sessions which addressed the key questions of:

- a) How to integrate sustainability competencies into existing courses?
- b) How to accredit or audit courses or CPD for sustainability competencies. What criteria or processes might be used by an employer or an institution?

There was also a Good Practice Fayre with eight quick presentations to remind attendees of what was already going on in this area.

The full programme is given in Appendix 3.

4. The seminar: report of sessions

4.1 Introduction: Chair, Julia King CBE, Head of Education and Training Committee, RAEng

The presentations that accompanied the introductory speeches can be found at:

http://www.raeng.org.uk/education/vps/events_1.htm

Julia King introduced the day by commenting on the great opportunity the seminar presented: for professional institutions to set the challenge; for the higher education sector to propose mechanisms for delivery; and for employers to identify and explain their needs.

4.1.1 Philip Greenish CBE, Chief Executive, RAEng

Philip Greenish said that the new EC(UK) requirements for Chartered and Incorporated Engineer (CEng and IEng) put into words a responsibility that good engineers have held for a long time. Development without sustainability can only lead to crisis.

Of all the professions, he said, engineering will always be central to reversing the trends of unsustainable development - whether through manufacturing technology or through infrastructure in terms of delivery. Engineers are servants of society and have a responsibility to society, so must decide what is meant by sustainable development. Since 2000, he said, the Engineering Council has been stressing quality of life and he urged us to remember that there has always been that context to engineering.

Greenish also reminded us of the Victorian engineers who he described as visionaries, promoters and entrepreneurs, who also drove improvements in quality of life. Twenty-first century engineers must, he stressed, be lead and be driven by the ethics of the day. Engineers can lead with the intention to undertake activities that contribute to sustainable development.

Using as examples of manmade catastrophes, including the reduction of the Aral Sea, Aberfan mining village disaster, Twyford Down road scheme, the pollution of the Barent Sea, and the Three Gorges Dam, he went on to say that engineers must embrace the social and ethical dimensions of our work. We must improve our problem understanding skills and see the whole picture and enable better decision-making by providing the right information.

With regard to engineering technology and quality of life, the 1,250 RAEng interdisciplinary fellows are already leaders in their field. In 1992, RAE took sustainable development as a major programme theme, which added authority to the guidance offered, and since then RAEng has provided seminars to brief government about key issues. There are now 26 visiting professors across the UK and two research chairs (at Imperial College and Cambridge University).

Philip Greenish concluded by saying that we should develop the new skill sets that will be needed and focus on training engineers. We must ensure that sustainable

development is routine in engineering careers and provide clearer responsibility to the profession. He said that the new UK-SPEC is timely and that the seminar provided a great opportunity to position the profession in the vanguard.

4.1.2 Richard Shearman, Deputy Director, Engineering Council (UK)

The new UK-SPEC published on 1st December 2003 put more stress on competence and commitment of entrants to the register, and less on the routes whereby they arrive at them. There is a new framework of competence, and within that is a commitment to sustainable development. Richard then commented on the three categories of registration: CEng, IEng, and EngTech and the three elements that lead to registration: education, professional development, professional review.

UK-SPEC has five main headings. The difference between the categories was explained, with a stress on leadership and management ability, which is a requirement for CEng, and in technical and commercial competence that is required for IEng. Effective interpersonal skills are required for both categories. Richard Shearman noted that the wording is similar to SARTOR 3 but in the new UK-SPEC commitment to the environment is included as a separate category.

Richard commented that the working groups reviewing the standards were made up of professional institutions and industries with a remit to match competency requirements with the needs of employers. He noted that the “hard-boiled” professionals were complemented by some aspiring young engineer leaders recently graduated from Forum for the Future’s Leadership for Sustainable Development Masters and he referred to the benefits of Sara Parkin’s work with the new generation engineers through the Engineer of the 21st Century initiative.

He also suggested that the outcomes of the seminar should be widely communicated. These points are covered by the requirements for commitment but how these are developed, demonstrated and appraised will need careful consideration. It would not be enough to take a partial approach, commitment is needed across the board of competencies and continuous improvement will be needed to properly demonstrate commitment. He suggested that the professional institutions should reflect on the generic statements and take steps to take sustainable development into their mainstream work, emphasising that engineers would need to derive relevant learning outcomes for accreditation purposes.

Richard concluded by underlining Philip Greenish’s point that engineers should become leaders in sustainable development, and that UK-SPEC will help engineers to take that lead.

4.1.3 Sara Parkin OBE, Programme Director, Forum for the Future

Sara Parkin underlined that sustainable development was not a fashion, nor was it far-fetched but was here to stay. It was not intended that human activity had led to such extensive changes in key ecological systems of the earth that the Government

Chief Scientist, Sir David King, had called climate change the greatest threat we faced,¹ yet this is the situation we are in.

It is currently estimated that the human economy consumes about 50% of the land's biological resources – and is struggling to cope with the consequences of that and our consumption of fossil fuels and minerals. Engineers learn the basic science that governs the way energy and raw materials are transformed and therefore understand how pollution and waste is the inevitable consequence of the current lifestyle of richer developed countries. Engineers have much to contribute, therefore, to our understanding of how we can detach resource consumption from economic growth. The Treasury in the 2004 spending round required government departments to report on their contributions to sustainable development. There also are expectations on business (corporate responsibility) and education (DfES Sustainable Development Action Plan) to deliver.

The key to understanding how to do it is to remember that sustainable development was about progressing our social, economic and environmental goals, at the same time. It is the at-the-same-timeness that would make development sustainable – avoiding negative impacts and trade-offs. It has to be remembered though, that the real bottom line is the environment. If it can not support life, then the rest is irrelevant.

She stressed that sustainable development ideas are not new, but do require new ways of thinking that allowed decisions and actions to be appraised. And the bedrock of getting it right is respecting the physical laws that govern the way the natural world works. Engineers not only know these laws, but should know how to apply them so that our economic progress fits with rather than undermines ecological progress. As an example of mission possible, Sara showed a slide based on data from one of the major UK Waste Companies, that showed the huge amount of wastage in the pathway of resources from their source to their use in the home. For every 1000 kg purchased (of which half is food) around 10 times that weight of resources is mobilised, and after 6 months, only 100 kg is retained in use. Huge capacity for improvement in efficiency, and perfect territory for engineering innovation.

Given the necessity to rekindle interest of high flyers in engineering as a career, Sara reported that the Engineers of the 21st Century initiative and the Forum for the Future Masters in Leadership for Sustainable Development is generating great role models and an image of engineering as a life-affirming career. Engineers of the 21st Century have produced two reports, the second of which, from February 2003, includes four “change challenges”. One of those challenges “to build the capacity of teachers and trainers to integrate sustainability into courses” was the focus of this seminar.

Sara concluded by pointing out, that future leaders stand on the shoulders of previous leaders, so this generation had a responsibility to get going now on what is an extremely urgent task.

¹ King, DA, “Climate Change Science: Adapt, Mitigate, or Ignore?”, *Science Magazine*, Vol 303: 176-177, 9 January 2004

4.1.4 Nick Harris, Director of Development and Enhancement, Quality Assurance Agency for Higher Education (QAA-HE)

Nick Harris began by asking what we are able to do and stressing the important context of the QAA. He reminded the audience that in the UK Higher Education Institutions (HEIs) are autonomous, with the power to award degrees. They cannot be closed down or stopped from awarding degrees. There are also devolved higher education funding councils, each having their own requirements for funding. Engineering, he said, was also devolved, being different in Scottish, Welsh, and English systems.

Changes mean that, since 2002, the QAA do not do subject reviews of courses but instead look at internal audits of how teaching is managed and how courses perform in a framework for academic standards. There are different methods of quality assurance including professional inspectorates and producer sampling and markets. These are implemented by the HEIs. QAA check these methods of assessment.

Assessment methods can involve: a framework, subject to national agreement; subject benchmarks, set by discipline communities; and programme specification, which has an institutional perspective.

Nick suggested that the implicit agenda is for a basic toolkit for course designers to integrate sustainability into what they teach but emphasised that QAA is not policing this (nor could it). Rather, it accommodates disciplines, respects institutional autonomy, and informs stakeholders. The aim of QAA is to secure respect and trust for the quality of academic delivery.

He concluded by saying that subject benchmark will be reviewed next year, that the context and efficiency of delivery are crucial, and there is a need to raise the stakes and avoid the unsatisfactory “tick-box” approach.

http://www.raeng.org.uk/education/vps/pdfs/Nick_Harris_handout1.pdf

4.1.5 Discussion

Raymond Clark of Society of Environmental Engineering asked whether sustainable development is sellable in the context of registration. Directed at Richard Shearman he asked whether section E3 of UK-SPEC could be imaginative and innovative in the six lines available; and to Philip Greenish he asked how interest can be added.

Richard Shearman replied that Engineering Council UK is a regulatory body and so is a bit dry, but could harness the efforts of others such as RAEng. It has a good website, with good links to imaginative websites. **Philip Greenish** replied that there is a need to inspire future generations through a disparate group of EC(UK), academia, institutions, and RAEng. He emphasised that a better focus is needed in order to present the right face of engineering. **Sara Parkin** commented that this was the inspiration for Engineer of the 21st Century and the young, and not-so-young, know that this is the way engineering is going but that engineers are not good at selling themselves.

Andrew Furlong of the Institution of Chemical Engineers asked whether there was consensus among the speakers and reported that of 100 chemical and process engineers questioned, 14 thought sustainable development was a fad or a gimmick, 51 were unclear as to the agenda, 31 thought the issues were serious and only 4 thought it needed to be implemented.

Sara Parkin commented that those ratios were unsurprising and, referring to her earlier comments, said something must be done about the attitudes.

Martin Hogg of Thales Group suggested that sustainable development is an attitude, as is innovation, and there is a need for a change of hearts and minds. Philip Greenish, he recalled commented on the RAEng leadership, professorships and the like, but, he asked, how should awareness be raised and how can industry and academia establish links?

Philip Greenish said that this was a detailed question that could be directed at David Foxley. **David Foxley** said that he would answer during his presentation (See 4.2.1).

Richard Shearman congratulated the IChemE for carrying out the survey, which, he said, indicates that the vast majority think sustainable development is a good thing but that many have doubts about commitment to progress. However, only 14% are in doubt according to the survey. Richard emphasised again that engineers need to take a leadership role but noted that less than 20% of current FTSE CEOs are engineers by origin. He urged the need to capitalise on this. **Sara Parkin** suggested that so many positive responses in the survey is good, we are after all on the cusp of implementing solutions. The Lambert Review² underlined the need for a proper dialogue between industry and academia in general – that dialogue must include sustainability. Student demand was rising, supply of relevant courses was lagging behind. She emphasised that business wants sustainability literate graduates but needed help to articulate what that means. **Nick Harris** agreed that the meaning of masterly-ness is difficult to get from employers. He noted that Europe is moving towards bachelors and masters qualifications but consideration should be given to the expectations of lay people that these qualifications include ethics and issues of society.

Adisa Azapagic of University of Surrey asked about the practice of foreign engineers, reporting that in Canada, Chemical Engineers swear an oath that includes obligation to society and the environment, then the employer.

Philip Greenish suggested that swearing an oath is a very un-British thing to do, but that if it focuses attention on the issues, then it is something that we should consider. **Richard Shearman** suggested that ethics seems to have fallen from visibility and he personally wouldn't want to tell engineers to swear an oath. **Sara Parkin** said it was an interesting idea. There is no longer a social consensus around the sort of values or ground rules advocated by People and Planet and Engineer of the 21st Century for example. New generations seemed to want some shared values and a sense of common purpose. **Fiona Geddes** of the Environment Agency commented that for those candidates seeking to be engineers a commitment to

² Lambert Review of Business – University Collaboration Final Report, Dec 2003, HMT

society must be emphasised. **Shahad Mirza** of EC(UK) suggested that these issues are covered in the code of conduct and are by default a requirement of being an engineer. She stressed the engineer's duty of care.

4.2 The Good Practice Fayre

This session whetted the appetite of participants for the afternoon session by a series of stimulating presentations from practitioners who are already engaged with the development of sustainability competencies. Several posters were present to elaborate the points made briefly in the presentations, and web-sites details are given where more details may be obtained. The Good Practice Fayre presentations may be found on:

http://www.raeng.org.uk/education/vps/events_1.htm

4.2.1 David Foxley, Manager, Engineering Design Education, The Royal Academy of Engineering

David suggested that solving the problems associated with sustainable development will not just be a matter of technical application. It is necessary to identify the problems accurately and traditional engineering courses do not develop the skills for the complex problem solving that are required now, but are limited to providing more theory.

David argued that encouraging more exposure to practising engineers from industry and having them develop case studies of best practice in association with academics could enhance engineering courses. This, he said was the essence of the RAEng Visiting Professors scheme that initiated involvement of 26 engineers for 30 days per year each in universities across the UK.

David urged that the idea that one solution will fit all cases is not appropriate in the field of sustainable development engineering.

<http://www.raeng.org.uk/education/vps/sustdev.htm>

4.2.2 George Howarth, Visiting Professor, University of Bournemouth

George noted that sustainable development is very complex and covers a vast range of subject matters. He stressed that industry needs to look more externally and consider its issues at a more strategic level.

George urged that everybody must be involved and used the example of the Shell Brent Spar to emphasise the need to involve all stakeholders. He stressed that people are very important when considering sustainable development that necessarily has a strong social aspect. George agreed that there is no one answer to the issues and that there is a need to come to a balanced judgement, appreciating that quality of life has become part of everyone.

In conclusion he suggested four key elements to implementing sustainable development: awareness and understanding, practical tools, stakeholder

engagement, and balanced judgement. He commented that in his role as Visiting Professor a car study example had been used to illustrate these points in regard to risks and benefits.

http://www.bournemouth.ac.uk/news_and_events/georgehowarth.html

4.2.3 David Bartholemew, Visiting Professor, De Montfort University

David talked about the work that he had initiated in his role as Visiting Professor. Material had been developed for use in MSc courses at the Institute of Energy and Sustainable Development. He stressed the focus on contextual issues such as the human factors and the benefits of applying systems thinking.

David demonstrated the content of the three multimedia CDs that have been developed and showed how it works with the physical entities that engineers deal with. He also highlighted the hundred or more original source documents included in the CD library and commented that this method of delivery had proved a very effective way of covering the issues of sustainable development for engineers.

<http://www.iesd.dmu.ac.uk/msc>

4.2.4 David Fisk, RAEng Professor of Engineering and Sustainable Development, Imperial College London

David began by reporting on the student drive that had resulted in the inclusion of a sustainable development module in the course, which resulted in the start of an extension MSc module in Civil Engineering with Sustainable Development in October 2003. He commented that international students were particularly interested in the issues of poverty and sustainable development.

David had noticed that dated textbooks often used on engineering courses are missing coverage of contemporary and future issues. In contrast he said that the UNEP GEO3 report is "full of agony" and used this to emphasise that addressing sustainable development is not easy and the point that it is not a soft option must be stressed in the methodology of implementation.

David urged the need to "tune up" the political angle and draw up a contemporary design guide that covers current issues. He reported that in the second part of the popular course, students apply sustainable development to contemporary problems.

http://www.cv.ic.ac.uk/courses/msc/pg_sustdev.asp

4.2.5 John Dickens, Centre Director, Learning and Teach Support Network Engineering

John reported that LTSN started in 2000 and has links with professional institutions through web-based communication. A resource database contains useful learning resources relating to sustainable development, highlighting good practice and making it available.

LTSN encourage practice sharing and John noted that 92% of UK universities have engineering programmes with 81% having engineering departments. John urged for more events to share information and to facilitate integration but noted that it means “pushing at an open door” as students are evidently keen for sustainable development to be included.

<http://www.ltsneng.ac.uk>

4.2.6 Fiona Geddes, Institution of Civil Engineers

Fiona began by pointing out that civil engineering is increasingly about managing complexity, not just doing things that are complicated. She highlighted the Engineering Education Task Group and its link with the RAEng Visiting Professors scheme. She also reported on the work assisting with the running of RAEng sponsored summer schools and the development of a sustainability knowledge map.

http://www.ice.org.uk/about_ice/aboutice_sustainability.asp

4.2.7 Eb Adeyeri, Project Manager, Sustainability Metrics, Institution of Chemical Engineers

Eb commented on the accreditation guidelines and noted that sustainable development is an integral part of the curriculum rather than an add-on. As a good example of integration he pointed to the work done at University of Surrey (see below) and in terms of education he said it was the way to adopt sustainable development into the psyche of chemical engineers. He advocated the use of sustainability metrics and the use of subject groups or special interest groups to promote sustainable development practice.

http://www.icheme.org/new_membership/index.asp

4.2.8 Adisa Azapagic, Reader, Department of Chemical & Process Engineering, University of Surrey

Adisa began by saying that there was a move to promote educating the “honest broker” engineer at graduate level. Also that integrated and introductory modules on sustainable development are used that examine human activities in terms of energy and resource flows. Adisa urged engagement in open decision processes and consideration of sustainable development decision-making in terms of scope and criteria.

<http://portal.surrey.ac.uk/pgstudy/engineering/taught/sus.jsp?n=165>

4.3 Reports from the syndicates

Each syndicate was given questions to address. The syndicates were run concurrently, twice, with chairs, facilitators and scribes remaining in place, and attendees divided into two groups that rotated between the two syndicates. The second round was asked to build on the work of the first round.

The goal for each syndicate leader group was to draw together the key discussion points, and to present the three key points to the plenary debate. Conclusions of the questions set out below are provided in a detailed note in Appendix 4.

4.3.1 Syndicate 1: Course design

Q1 Should the method of delivery be by add-on course or integrating elements in existing courses?

Q2 What tools and techniques are needed to develop sustainability competencies?

Q3 Who should implement these changes?

The conclusions of this syndicate were drawn into three areas:

a) Integration

Separate courses could be the way in, with gradual integration. Making it enjoyable and winning extra time was important, rather than cramming. There was a lobby for immediate integration – considering which course needed it.

b) Competencies

The delivery mechanisms were important and needed to be defined. Living case studies were more useful than case histories. The task was a multi-disciplinary one requiring input from other departments. And it was important to consider whether everyone needs to be a sustainability expert or whether they need enough knowledge to act appropriately.

c) Responsibility

Certainly in the first instance it may be necessary to draw in people from outside the institution, using the right people who know and can deliver. The information must be accessible.

4.3.2 Syndicate 2: Specifying for courses

Q1 What are employers requirements in relation to sustainability competencies?

Q2 How might these be embodied in accreditation requirements for undergraduate and CPD courses?

The conclusions of the syndicate were drawn into two clusters:

a) What employers want

Sustainability competency for employers means engineers who understand the big picture, who have good communication skills, and sustainability awareness. And who can use these to inform their decision-making and judgement.

b) Issues around accreditation

Engineers should be able to frame a technical problem, and its solution, in sustainable development terms. Their capacity to do this should be tested through essays, interdisciplinary projects and interviews.

4.3 3. Plenary report back and discussion

After the feedback from the syndicate groups and some preliminary discussion Sara Parkin thanked the presenters and attempted a rough drawing together of some headlines she had gleaned from various parts of the day, before throwing the discussion open to the floor for more comments. The final conclusions would be brought together when the proceedings were written up. Her headlines covered the following areas:

1. What employers are looking for, and educators and trainers are challenged to provide are engineers who can apply what they do in the context of the world "outside". A transferable skill could be the capacity to examine a problem and design a solution in terms of sustainable development.
2. A challenge will be to work out at different levels (from first year of studies to fully registered and continually professionally developing engineer) how to evaluate competencies.
3. Integration was the way forward, but whether this was via a "big bang" or more gradually depended on different approaches being more appropriate in different circumstances. A process for understanding sustainability competencies and translating them into learning outcomes was needed.
4. Making it happen remained a challenge. Employers probably need help to better articulate their demands and need to get involved in the accreditation process – as much will depend on demonstrating experience in the workplace.

Points raised in discussion:

Mark Fletcher suggested a piece of research could be done to look into methods of implementation

Peter Guthrie noted that academia does not produce practicing engineers at the end of a degree and urged professional institutions to take responsibilities for the second half of the engineer's education and training

Sara Parkin asked for better collaboration between the institutions academia, and employers and Andrew Furlong advocated involving industrial participation in course content.

John Stephens pointed out that the professional review interview is the established mechanism for assessing competencies of engineers, so therefore training panel members had to happen if the process was to be effective

Fiona Geddes cautioned against reinventing the wheel. ICE reviewers were being retrained, and ICE is already on the way to delivering new sustainability competence requirements – in discussion with the EC(UK) and the RAEng.

John Britchard championed the concept of lifelong learning, and pointed out that many employers could not afford coherent training schemes, so would struggle to deliver the ICE implementation proposals for education and training. Engineering professional institutions needed to own the problem and create its own cohesive and coherent architecture for delivery.

Martin Hogg suggested that sustainable development was as fundamental to engineers as numeracy and literacy and so schools needed to be included in the dialogue to make sure the right things are taught there too.

5. Summing up: connecting to the UK-SPEC process and next steps

Richard Shearman was invited to make some closing remarks, in particular connecting what happens next to the on-going UK-SPEC process.

He commented on the very interesting nature of the discussions. With reference to John Pritchard's remarks he emphasised that the profession (the Engineering Council and the Institutions) have a great opportunity to share views and move forward together. Engineers had a great tendency to self-flagellation but that the situation was not so grim as it is often described. He said there is a strong pull from employers to make changes.

Richard said that all branches of the profession can use UK-SPEC as an underpinning common standard. The next step is for institutions to put flesh on to the competence statements for their specialities and to note what is already happening in terms of outcomes. The wider community could be more alert to these.

Replying to John Stevens, Richard said that the professional review is useful and now assesses competence and commitment in a more holistic way rather than just box-ticking. Professional judgement is involved in assessing professionals – for sustainability and other requirements. Especially in new and complex areas like sustainability, while the professional review process is robust enough, reviewers need to be supported (they are, after all, volunteers). While the Engineering Council could state rules, it is those actually carrying out the assessments who must make them vivid.

Regarding the accreditation of degrees, Richard stressed the need for integration. He was concerned that both the Roberts Report and the Lambert Report had mentioned the view that accreditation could be over-rigid and inhibit innovation. It was important that this view did not take hold, and that the profession did not act in a way that gave it credence.

Opening discussion to the floor again, **Sara Parkin** picked up on Richard Shearman's last point and asked about the Sector Skills Councils and accreditation.

John Stevens suggested that in terms of sector skills the institutions are branching out.

Annie Hall suggested that the sector skills council can help by making sure that implementation is "joined up" and that it occurs right through the sector from professional review to operation.

Nick Brown said there is a need to look at the political agenda and to push the issues of sustainable development there too. Discussions are focussed on engineers and engineering but there may be engineers for other things and other people in engineering who should be included. He suggested that we should identify overarching generic competencies.

Sara Parkin noted that with regard to the research agenda, she said we need to address how to come up with different levels of competency and how to adequately express them. This may be of interest to EPSRC.

Fred Maillardet cautioned that design teaching is under threat and that case studies take time to prepare.

Sara Parkin asked whether a professional leadership network or communication system could be built, perhaps by RAEng. **Duncan Eggar** suggested that the way to achieve success was to as **Zaid Moswy** said, to make it fun!

Sara Parkin closed by saying that the events of the day would be written up into a report and that the partnerships established would build on and push forward the ideas, building the competencies and confidence of the people in key positions who will put the ideals into practice.

Appendix 1

Partner Organisations

Engineering Council UK

EC(UK)'s mission is to set and maintain realistic and internationally relevant standards of professional competence and ethics for engineers, technologists and technicians, and to license competent institutions to promote and uphold the standards. Under its Royal Charter, EC(UK) regulates the engineering profession in the UK and formally represents the interests of UK engineers abroad. It is a Designated Authority under the current General Systems Directives.

The engineering profession in the United Kingdom is regulated by the EC(UK) through 35 engineering Institutions (Licensed Members) who are licensed to put suitably qualified members on the EC(UK)'s Register of Engineers. The Register has three sections: Chartered Engineer, Incorporated Engineer and Engineering Technician. These titles are protected by the Engineering Council's Royal Charter and may only be used by registrants.

In general there is no restriction on the right to practice as an engineer in the UK. Registration, which is renewable annually on payment of a fee and provided that there has been no violation of codes of professional conduct, is recognised as desirable in many fields of engineering employment and provision of engineering services but is not mandatory. There is a small number of areas of work, generally safety related, which are reserved by Statute to licensed or otherwise approved persons.

All candidates for registration as Chartered Engineer, Incorporated Engineer or Engineering Technician must satisfy the competence standards set by the EC(UK) and be members of the appropriate Licensed Member engineering Institution. Applicants must show that they have a satisfactory educational base, have undergone approved professional development, and, at interview, must demonstrate their professional competence against specific criteria.

Entry to the Register depends on satisfying the appropriate membership requirements of one of the Institutions. These are based on the EC(UK)'s current regulation standards UK-SPEC . EC(UK) audits, on a regular basis, the application of these standards by the Institutions.

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Registered charity no. 286142

The Royal Academy of Engineering

The Academy was established in 1976 and brings together over 1,200 distinguished engineers who come from all engineering disciplines. Our aim is to promote excellence in engineering for the benefit of the people of the United Kingdom. To achieve this aim, we direct our activities into four areas: assisting the development of national policy on engineering issues; supporting engineering education; encouraging engineering research and closer contacts between the industrial and academic worlds; promoting the public understanding of engineering.

In 1998, the Academy started a scheme of Visiting Professors in Engineering Design for Sustainable Development, as a follow on to the Visiting Professors in Principles of Engineering Design. The move was in response to the realisation that there is no universally held understanding of what “sustainable development” means, even in the field of engineering, and that makes it difficult to find a broadly acceptable way of incorporating the requirements for it into engineering education.

In line with the multi-disciplinary philosophy that underlies all Academy activities, the requirements of sustainable development should eventually come to underlie the way in which all engineering is taught. Sustainable development should not be considered as a separate issue to be addressed by special courses. The Academy believes that the needs of sustainable development should become embedded in the thought processes and methodologies of all practising engineers and engineering designers.

Amongst practising engineers and teachers, there are differences in opinion about the extent to which current theory and practice will be able to cope with future sustainable development scenarios. The Academy believes that a body of well-researched case studies is one of the best ways to highlight the relevant issues and to show how engineering principles and practice can be used to address those issues.

The purpose of the Visiting Professors scheme is to develop teaching materials, based on case studies, which will enhance both the understanding and the practice of teaching of Sustainable Development. The general approach to be adopted will lead to sustainable development being embedded in the teaching and learning culture. During the academic years 1998 to 2003, The Academy sponsored a total of 26 universities to develop such teaching material. It is a condition of The Academy's support that any material developed will be made widely available to universities throughout the UK. Convincing case studies can only be developed by leading-edge industrial practitioners working as Visiting Professors in unison with experienced teachers, making this scheme a very close partnership between industry and academia.

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Registered charity number 293074

Forum for the Future

Forum for the Future is recognised as the UK's leading sustainable development charity. Our mission is to accelerate the transition to a sustainable way of life. It is one we share with partners, drawn from business, finance, local authorities, regional bodies and higher education. We publish Green Futures, the magazine on sustainability solutions, and run cutting-edge projects on a wide range of environmental, social and financial issues. We communicate what we learn with our partners to a wide network of decision-makers and opinion-formers.

As an educational charity, we have built a strong education and learning team who work with universities, colleges and the whole post-16 sector to make sustainable development a reality. We bring up to date knowledge of the latest sustainability debates in government and business to the education sector, and play a central role in making sure Forum for the Future is an organisation that actively learns and reflects on its work and workings.

The Education and Learning programme aims to set the standard for transformative sustainable development learning and change programmes by developing the capacity and resources for change within the education sector. Our flagship Masters programme in Leadership for sustainable development has led our mission for the last eight years. Pioneering projects including Higher Education Partnership for Sustainability and the Engineer of 21st century have made us major players at the intersection of learning, skills and sustainable development.

In the UK, there is a huge number of people going on to further and higher education, from an increasingly broad range of backgrounds. Imagine if everyone of those left their institution with not just subject or vocational knowledge and skills but with the competence and confidence to make decisions and act in favour of sustainable development. We'd like to see this change happen soon, and aim to accelerate the integration of sustainability into post-16 education policy and practice through our portfolio of projects.

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Registered charity no.1040519

Appendix 2

Philip Greenish CBE BSc CEng FIEE, Chief Executive, The Royal Academy of Engineering

Philip Greenish was sponsored by the Royal Navy to read Engineering Science at Durham University, graduating in 1972. Postgraduate training qualified him as a Weapon Engineer and his early career was spent sailing the globe in that capacity in frigates and destroyers and in shore appointments in engineering training, front-line support and naval plans. He served for two years with the Canadian Navy in Halifax Nova Scotia.

In 1991 he assumed responsibility for the conduct of all trials and acceptance of naval weapon systems. This was followed by two years as military assistant to the MoD's Chief of Defence Procurement and a year at the Royal College of Defence Studies. In 1997 he was appointed Director of Operational Requirements (Sea Systems) and then as Director of Equipment Capability for the Above Water Battlespace following a reorganisation of the MoD. On promotion to Rear Admiral in 2000, he moved to the staff of the Commander-in-Chief Fleet to lead a major reorganisation of the Fleet command, on completion of which he took up a new appointment as Chief of Staff (Support) with responsibility for engineering, personnel and logistic support for the front line of the Royal Navy and Royal Marines.

He assumed his current role as Chief Executive of the Royal Academy of Engineering following retirement from the navy in July 2003.

Richard Shearman, Deputy Director, Engineering Council (UK)

Richard has held his present post since the formation of Engineering Council (UK) in March 2002, having previously been Deputy Director for Engineers' Regulation in the former Engineering Council. In this role he leads EC(UK)'s work relating to the formation of professional engineers and technicians. He managed the review of standards for registration which resulted in the publication of the United Kingdom Standard for Professional Engineering Competence (UK-SPEC) in December 2003. He has spent most of his career dealing with a range of education and training issues, initially within the former Department of Education and Science and then for 10 years as Director of Education at the Design Council. He has also worked as a consultant to a number of other bodies on education and training issues. He chairs the Steering Committee for the Learning and Teaching Support Network Centre for Engineering at Loughborough University, and is a member of the Education and Skills Strategy Group of the Engineering Employers Federation and SEMTA, the Sector Skills Council for science, engineering and manufacturing technologies.

Sara Parkin OBE, Programme Director, Forum for the Future

Sara is a founding Programme Director of Forum for the Future, where she set up and now directs the Education and Learning Programme. Originally a Ward Sister, Sara Parkin has been an independent campaigner, writer and broadcaster on environmental and sustainable development issues for over 30 years. She also chairs the Real World Coalition of 25 UK organisations campaigning on the sustainability agenda, and sits on

the Board of the Environment Agency, the Natural Environment Research Council and the new Leadership Foundation board. She is a Companion of the Institution of Civil Engineers and of the Institute of Energy. During the 1970s and 1980s Sara Parkin played leading roles in both the UK Green Party and the development of Green Parties world-wide. She was awarded an OBE in 2001 for services to education and sustainable development.

Nick Harris, Director of Development and Enhancement, Quality Assurance Agency for Higher Education

After graduate and postgraduate studies at the University of Bath, and a fellowship at Cambridge, Nick pursued an academic career at the University of Durham. This included teaching in biological sciences and leading a research group concerned with plant products. He has held a number of fellowships and other posts including a consultancy with the UK Biotechnology and Biological Sciences Research Council as a Programme Co-ordinator. As a visiting professor at Durham he has, until recently, continued with a small amount of specialist teaching and some research.

Nick has a longstanding interest in and commitment to quality and standards issues in teaching and research. He joined the Quality Assurance Agency for Higher Education (QAA) as an Assistant Director in 1998, and became Director of Development and Enhancement in 2002.

Appendix 3

Seminar programme

Outcome for attendees:

- Understand purpose of sustainability competencies and the benefits they can bring to registrants and employers
- have confidence that integrating sustainability competencies into existing provision is possible and reasonably straightforward
- can be part of a developing network of practitioners prepared to share learning and techniques

10.30	Welcome	Chair for the morning: Julia King, RAEng
10.35	SD is an all engineering matter: The role of the RAEng	Philip Greenish, RAEng
10.45	UK-SPECS: The new approach to Standards for Competence and Commitment for Chartered, Incorporated Engineers & Technicians	Richard Shearman, EC (UK)
10.55	Engineers for the 21st Century: the needs of the new generation of engineer leaders	Sara Parkin, Forum for the Future
11.05	Quality Assurance & Good Teaching: Collaboration of professional and academic quality leading to excellence of practice: the mechanics of making it happen	Nick Harris, QAA-HE
11.15	Question and answer session	
11.45	Good Practice Fayre: SD competencies in practice	
12.15	Lunch	Poster display
13.15 and 14.00	Syndicate 1: Course design (led by academic) Tools and techniques for integrating sustainability competencies into existing courses.	Syndicate chairs: S1 Peter Guthrie S2 Richard Dodds
13.15 and 14.00	Syndicate 2: Accreditation, specification (institution and employer led) Criteria and processes for accrediting or auditing courses or CPD for sustainability competencies.	
14.45	Tea break	
15.00	Plenary: Feedback from syndicates and general discussion	Chair for the afternoon: Sara Parkin, Forum for the Future
16.00	Close	

Appendix 4

4.3.1 Syndicate 1: Course Design

Chair: Peter Guthrie

Facilitators: Fred Maillardet and David Fisk

Scribes: Zaid Mosawy and Tom Randall

Q1 Should the method of delivery be by add-on course or integrating elements in existing courses?

Q2 What tools and techniques are needed to develop sustainability competencies?

Q3 Who should implement these changes?

Notes from discussion

Q1 Should the method of delivery be by add-on course or integrating elements in existing courses?

Consensus within the group was that integration should be the aim, but:

- Only integrate with relevant modules,
- Include case studies and design involvement and focus on problem based learning,
- A route map is required, maybe starting with a separate module in year one of the degree and then integrate in year two and three,
- Integrate engineering into sustainability and not the other way around,
- Integration could range from the level of two hours per week to a whole new module, and
- Sustainability should be implemented in every course.

Difficulties with integration were identified:

- There is a need to train the tutors and provide a mechanism to keep them up-to-date,
- Need to ensure tutors don't see sustainable development as obstructive to their traditional areas of teaching,
- There must be room in the course,
- If something needs to be taken out of an existing course, what should that be and how should it be decided, and
- Students are already dropping more technical courses for modules with a wider managerial role.

Solutions were proposed:

- Make the modules more efficient to make room for sustainability,
- Change the way people think, and

- Make the sustainability courses more technically demanding.

Additional questions were also raised based on previous experience of delegates:

- At St Andrews, sustainable development was provided as an optional course but demand meant it soon became a compulsory course,
- Consideration needs to be given to how sustainable development will affect existing Engineering degrees such as Environmental Engineering and whether it will result in them being simply re-badged,
- Also, it is important to think about what students will know when they come in and courses should take account of the content of the national curriculum.

Question 2: What tools and techniques are needed to develop competencies?

This question was based around ideas of what graduates are expected to know.

Process

- Identify the scope and influence that graduates will have,
- This should define learning outcomes, and
- This should define delivery mechanisms.

Techniques will be similar to those used in courses now, such as placements and Case studies, but:

- Train the trainer first
- "Walk the Talk" not just sustainable development on the course, but in real life too,
- Get people moving towards sustainability without pushing them - Make it Fun!
- Make sure the staff competencies are high,
- Make significant use of case study approach, and
- Including international, interdisciplinary, intercultural and human rights material in the course.

Issues were also raised regarding:

- Which subjects sustainable development should be integrated into recognising that some are more appropriate (such as design modules) than others (such as matrix algebra), and
- Should the aim be to develop a good awareness, not thorough competencies?

Question 3: Who should implement the changes?

- Everyone, but to know their role, not to know everything
- Integrate external parties to encourage greater industrial involvement, but ensure industrial speakers are properly screened, and are competent speakers,
- Integrated into all courses so sustainable development doesn't get pigeonholed.
- Even if integrating, there should be a core course; some integration but with initial specialist teaching.

More on the issues were raised regarding what to take out:

- Investigate whether there are some areas that employers would be happy to have removed from the curriculum, and
- Make teaching more efficient.

General comments about the overall aim included:

- There will be a need to balance producing general engineering leaders with specialist engineers; employers of specialists will not necessarily be interested in them having sustainable development competencies,
- Need to consider whether we are training graduates for the first two years of their career or the first twenty,
- Case studies, not case histories (i.e. participative) should be used, and
- Efforts should be made to bridge engineering science with the problems of the real world

4.3.2.Syndicate 2: Specifying for courses

Chair Richard Dodds

Facilitators David Bartholemew and Sandy Halliday

Scribes Dave Worthington and Ben Witchalls

Q1 What are employers requirements in relation to sustainability competencies?

Q2 How might these be embodied in accreditation requirements for undergraduate and CPD courses?

Notes from discussion

Question 1: What are employers' requirements in relation to sustainability competencies?

- Broader courses including social skills and enabling a deeper understanding of non-technical issues
- Ability of graduates to make judgements based on social and economic issues
- Sustainable development element to every course to increase graduate awareness of sustainability through their engineering training
- Improvement in the communications skills required to present technical solutions backed up by logical arguments
- Ability of graduates to act decisively
- Improved basic communication skills e.g. writing
- Ability of graduates to consider all relevant socio-economic issues prior to application of technical solutions
- Financial assessment ability required to demonstrate life-cycle costing advantages of sustainable development to investors

Question 2: How might these be embodied into accreditation for undergraduate and CPD courses?

- Working party could be established to offer universities the basis of a sustainable development course syllabus
- A common assessment at University level of a graduate's practical skills in sustainable development to aid employer interviews
- A measure of graduate's attitude as well as technical ability
- Graduates could be asked to write essays during an interview to demonstrate non-technical skills
- Problems and output requirements are easy to identify but solutions difficult
- Course decision makers will require yardsticks to gauge acceptability of syllabuses
- Projects and essays are seen as good tools for the demonstration of sustainable development knowledge and are already central to engineering coursework
- Industry involvement in project work should be encouraged to ensure that the outputs meet their requirements
- Only marginal changes would be needed to engineering courses to meet employers requirements
- Further research is needed to clarify employers requirements and provide Universities with clear guidance for course syllabuses
- Engineering courses should include a broader context to improve engineers' ability to effectively communicate a technical issue
- A general approach to sustainable development problem solving should be addressed
- Inter-disciplinary working should be considered e.g. inclusion of social studies for engineers
- A working group should present Universities with a wish list for accreditation of courses without providing a prescriptive method of assessment
- Graduates should be seen as having an accredited sustainable development qualification
- Sustainable development can be seen as an additional learning outcome rather than part of existing training
- Industry must assist in developing the systems thinking skills required from engineers which is seen as outside of the capability of academia

General points

- Engineering should not be taught too early to enable students to gain a broader skills base
- There is a varied desire amongst students to study a wider range of topics within engineering