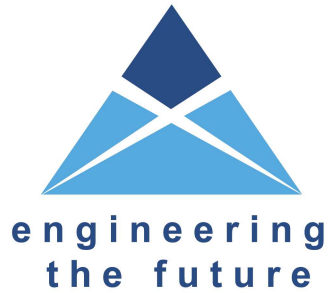


*working together to enhance understanding,
commitment and participation in engineering*



Engineering the Future

Newsletter 5

September 2009



EPSRC

Engineering and Physical Sciences
Research Council

Introduction

As we move towards final stages of the Engineering the Future Project we are circulating this fifth and final edition of our Newsletter which provides a summary of what we have achieved and some pointers to the future.

If you would like a copy of our previous newsletters or you would like to discuss anything or obtain further information, please contact:

Elsa Ekevall
Engineering the Future
Department of Educational Studies
University of Glasgow
St Andrew's Building
11 Eldon Street
Glasgow
G3 6NH

0141 330 8204

e.ekevall@educ.gla.ac.uk

Engineering the Future

Engineering the Future (EtF) is a 3-year project funded by a major grant from the Engineering and Physical Sciences Research Council which has been exploring new ways of bringing together schools and universities to:

- enhance awareness of engineering as a profession within and beyond the school community
- promote enthusiasm for engineering among school pupils
- increase the numbers of young people embracing engineering as a career
- develop and sustain first-rate teaching of engineering in both schools and universities
- support young people as they make the transition from school to study engineering at university.

Founded on models of transformational change already in practice within Scottish education, EtF has explored innovative means of developing a sustainable and transferable model of activities. EtF has been working with researchers, policy makers, practitioners and the industrial community to:

- identify key skills, mind-sets and dispositions needed by engineers to face changing demands through their working life
- develop innovative engineering curriculum inserts that provide pupils with practical engineering experiences within school classrooms and e-learning materials
- support students' motivation and learning across the school-university transition and into studying in university
- develop pedagogy in university which challenges and supports students to extend their prior knowledge, skills and dispositions to become successful engineers
- embed these developments within national curriculum, assessment and qualifications policies and practice.

School Curriculum Developments

What have we achieved?

Through the school university partnerships Engineering the Future has developed teaching units for use in science and physics classes at all stages of secondary education. Lower secondary units are directly linked to Curriculum for Excellence statements of experiences and outcomes, in the sciences and in technologies, literacy and numeracy; there are also clear pointers to interdisciplinary work. Units for older pupils are directly linked to learning outcomes of SQA Physics courses (Intermediate 2, Higher, Advanced Higher).

These materials are being launched at our final Conference on 6th October on the project DVD. They will all be available through the National Group for Sciences in Glow, the national Scottish schools intranet; a number of them are also being selected as exemplars for use by Learning and Teaching Scotland in supporting the Curriculum for Excellence sciences curriculum.

The materials available are:

S1/S2	S3/S4	S5/S6
Building a Lighthouse	Pimp my Trolley Engineering	Wii Sports Unit
Fun with Bridges	The Sun'll Come Out! (solar energy)	Wheatstone Bridge Engineering Unit
Wind Turbines	Nuclear Debate	
Mars Rover	Ultrasound	
Bat Monitoring	LEDs and photodiodes	
Security Unit (electronics)		
Hot Potato (thermistors)		
Light and Dark (LEDs)		

Work in schools has gone beyond this and includes:

- the development of Advanced Higher Physics Practical Investigations related to engineering which can be carried out in schools
- the development of model for Advanced Higher Physics Practical Investigations in which candidates worked in a university Electronic and Electrical Engineering Department where the used state of the art electronic engineering material and drew on the expertise of the university
- A compressed interdisciplinary S3/S4 course focussing on engineering and alternative energy through which candidates gained Intermediate 2 awards in Physics, Technological Studies and Economics in the time usually taken for two such courses
- And there are still more teaching units under development (building a radio, black boxes (electronics) and wireless devices).

What have we learned?

There were initial reservations about the feasibility of finding space to include engineering topics in existing courses; this was especially so in the case of certificate courses. In fact, it has been possible to find space and links to embed these topics in existing and planned curricula. In all of these materials it has been possible to develop the problem solving and team working approaches needed by tomorrow's engineers.

We have also learned that pupils enjoyed these engineering experiences and, even more importantly, pupils and teachers described them as supportive of learning. In the words of pupils involved:

- *It's more fun – so you want to know more about physics.*
- *A lot of work – challenging but you've accomplished something it 'clicks' and you remember it.*
- *It's like a physics experiment. but instead of being told step by step what to do you get to vary it yourself.*
- *...when we looked at the things before they were made, it just looked like things you would find about the house, apart from the diode and stuff like that. But then when you put them together it just kind of looked ... I don't know, it just made you feel really smart once you'd done it.*

And we have recently learned that young people who carried out the Practical Investigations developed in the project, both those which were school based and those which involved working in the university, achieved high grades in their Advanced Higher Physics.

It has, however, become evident that if young people are to become aware of engineering there must be explicit links and references to engineering made during the activities.

This whole project has demonstrated the effectiveness of partnership working in promoting consideration of issues of content, skills and pedagogy between schools and higher education that extend beyond existing valuable liaison processes. When colleagues from different sectors discuss a matter of mutual interest, not only do they share information, they also make their assumptions explicit and develop their thinking.

Thanks

Thanks go to our colleagues in Balfron High; Belmont Academy, Ayr; Carnoustie High, Angus; Dollar Academy; Dumfries Academy; Holy Cross High, Hamilton; Lanark Grammar; St Aloysius' College, Glasgow; St Joseph's College, Dumfries; Williamwood High, Clarkston; Woodfarm High, Giffnock, and in the EEE Departments of the Universities of Glasgow and Strathclyde. Without their planning and hard work these units would not exist and be available for colleagues throughout Scotland and beyond.

We also thank colleagues in the schools who trialled these materials and thereby subjected them to critical examination and tested their value and the possibilities for wider use; and the University of Edinburgh School of Engineering and Electronics who are supporting the schools in the Edinburgh area. These are Armadale Academy, West Lothian; Eastwood High, East Renfrewshire; Liberton High, Trinity Academy, Edinburgh; Lochgelly High; Milne's High, Fochabers; Tarbert Academy.

We would also like to thank Grange Academy, Kilmarnock, for their work on improving numeracy skills and understanding in physics.

Careers Education

What have we achieved?

We have developed and trialled careers materials for pupils at key option points (S2 and S4). These are informative, accurate, present engineering in an attractive light, and are attractive to young people; they can be used effectively with young people at key choice points in their schooling to challenge the stereotypes that all too many hold. Young people have expressed their appreciation of these.

What have we learned?

Few young people have an informed idea of what engineers do or of what a career in engineering might encompass. Some have no idea; others hold highly inaccurate stereotypes which involve dirty hands and heavy tools or routine maintenance of white goods. Parents often share these misconceptions. This is a major issue since the evidence from this project and others is very clear that parents are key sources of information for young people as they make careers choices.

The model of careers education widely used in Scotland rightly aims to empower young people to make their own decisions and to take the initiative in seeking information. This does indeed work well for occupations which are known to and understood by young people and their parents. It does not work well in cases, such as engineering, where accurate information about careers is not widely known. Young people may never even start the search for information about a career if they have a negative image of it or if they have no idea at all of what it may involve.

High quality informative materials, especially when used by teachers who are themselves knowledgeable about engineering, can effectively challenge this ignorance. When this is associated with embedded engineering related content and explicit reference to engineering as this is taught, the message becomes all the more clear.

Perhaps most importantly, we now know that many young people want to be informed about engineering. They have told us this clearly and loudly!

“Do you think young people should know about engineering?”

- Yes. We didn't really know about it till S6. There's no engineering until your just told about it late in your school career (in physics). If it was in the curriculum more people would try it. Some who don't like physics/ maths might be motivated by an engineering applications treatment of these subjects.*
- Yes. Nothing would get done otherwise. There's a need to understand what it really is – not a stereotype – and not just for boys, and that it pays well. Its not just the guy that fixes the washing machine, its always developing, changing and society needs engineers.*
- It would help in High School if you knew about it in Primary. The world will need engineers in the future, so if people learn about it some will want to go on and do it, You'd enjoy it too*

E-learning

What have we achieved?

Funding from the Agilent Foundation in the USA supported the development of e-learning materials. The EtF team initiated a partnership with TPLD, a serious games software specialist company based in Dundee, which has resulted in the creation of the Biodome, an on-line game for younger teenagers which takes players through the processes of developing a viable society which ensures both human existence and comfort without damaging the environment. In so doing players recapitulate the development of technology. This too is being made available through Glow. Final development work is being carried out on this and an accompanying pack of interdisciplinary materials is under development.

What have we learned?

Our experience has confirmed the view that there is little point in creating e-learning materials that are no more than paper worksheets turned into electronic files. There are also strong arguments against providing simulations of experiments unless this is essential on safety grounds; learning science involves practical activities. It is possible (at a cost!) to use e-learning creatively in ways that integrate learning across a number of areas; one (but only one) key way is the creation of on-line games.

The principles which underpin good e-learning are no different from those which underpin good classroom pedagogy: interactivity; challenge; support; choice; cooperation and team-working. Good learning is enjoyable; that doesn't mean that it is always easy!

Curriculum for Excellence

We welcome the clearer references to engineering in the final principles papers and statements of experiences and outcomes compared to those in the drafts published for engagement.

We actively participated in the engagement processes for both Sciences and Technologies in which we outlined the economic and educational arguments for ensuring that all young people in our schools are entitled to experience engineering education through embedding this in the curriculum.

- High level engineering is crucial to progressing the Scottish Government's principal purpose of sustainable economic development.
- It requires high levels of **scientific and mathematical competence** in the service of useful design, **creativity, innovative thinking, problem-solving, confidence, determination to succeed, teamwork** and **business acumen**.
- There is a need to create educational means of meeting the economic need to develop a much larger body of people with engineering awareness and skills to build a strong indigenous high tech economic base
- Many young people – including ambitious high achievers – have very limited or distorted ideas about what engineering involves. In particular, they do not associate a creative, inventive, problem-solving and entrepreneurial approach to life with their science and mathematics education.

The inserts developed by the schools partnerships clearly relate to CfE experiences and outcomes. More than this they embed experiential learning and offer opportunities for personalisation and choice and depth of study. We are pleased that a number of our inserts will be used as exemplification to be published nationally by Learning and Teaching Scotland in support of Curriculum for Excellence.

Building the Curriculum 3 makes powerful statements about the organisation of and contexts for learning. Secondary schools as they address these matters may be able to draw on lessons from this project. A number of schools involved in Engineering the Future have developed work that moves outside the classroom walls; several of the units developed afford considerable opportunities for interdisciplinary work, for the use of the local environment, or for special focus days.

National Qualifications and Scottish Baccalaureate

With colleagues in Scottish Government Schools Directorate and SQA we have been exploring ways in which joint working between universities and schools can support the Baccalaureate Interdisciplinary Projects, a key development in encouraging young people to develop their understanding of the central roles which science, engineering and technology play in our society and economy.

Engineering the Future contributed to the discussions which have led to the development in National Qualifications in Physics; these developments are likely to support the sorts of investigative learning and problem solving, leading to practical applications, which are central to engineering. We hope that this will enhance opportunities for engineering to be made explicit.

University Developments

What have we achieved?

As noted above, engineering colleagues in the Universities of Strathclyde, Glasgow and Edinburgh have played active and significant roles in the development and trialling of the school developments: curricular inserts, interdisciplinary courses and Advanced Higher Practical Investigations.

University staff have developed their knowledge and understanding of how schools operate, of what they can expect from students entering first year and of how they can build on prior learning. This matches well with the moves in universities to provide more structured support as young people make the transition from school to university and with the QAA enhancement themes related to the first year experience and to integrative assessment.

What have we learned?

One of the key messages is that change in education requires that all systems are aligned to support (or as a bare minimum, not impede) change. This is not easy to achieve within a sector which is as complex as higher education or even within a single institution of the size and diversity of a university. This is not just a matter of size. University staff are under simultaneous pressures from a range of directions: to teach existing students; to teach ever more diverse cohorts of students; to market their institution; to carry out internationally

recognised research; to promote inclusion at point of entry; to increase retention; to reduce costs. Improving the interface between schools and universities will not become a high priority unless it is clearly supported not only by each university but also by national policy.

Partnerships with Industry

We have benefited greatly from the support of Agilent has contributed to the project. Partner schools have made extensive and creative use of the digital oscilloscopes provided by the company. The funds provided by the Agilent Foundation have ensured that the project materials are ready for electronic distribution and as noted above have sustained the development of the Biodome.

Conferences and Journals

Engineering the Future has run two successful seminars to disseminate our work in progress and been represented at a number of conferences and seminars.

We have had stalls at the Institute of Physics and ASE Conferences where science and physics teachers from across Scotland showed considerable interest in the work we are doing. We have also been represented at two Science and the Parliament events in Edinburgh. Members of the EtF team participated in Engineering Tomorrow, an EPSRC organised event in the House of Commons and made a presentation to a recent meeting of the Engineering Professors' Council.

Members of the EtF team took part in EE2008, a major engineering education conference in Loughborough, where we presented a paper and ran a workshop. We presented a symposium at BERA (the British Educational Research Association) 2008; we held a seminar and two round table discussions at the Scottish Learning Festival 2008; and we prepared two papers for SERA (the Scottish Educational Research Association). We presented papers to the SEFI (European Society for Engineering Education) conference in Rotterdam in July and to ECER (European Educational Research Association conference) in September 2009.

We have had a paper accepted for a forthcoming Special Issue of the IEEE Transactions on Education which focuses on outreach to prospective electrical, electronic and computer engineering students. We are currently writing papers on a number of other topics.