working together to enhance understanding, commitment and participation in engineering

engineering the future

Engineering the Future

Newsletter 3

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Introduction

As we move through the second year of the Engineering the Future Project we are circulating this third edition of our Newsletter. There is a lot to report.

If you would like a copy of our previous newsletters or if there is anything in this Newsletter to which you would like to respond or on which you would like to comment or about which you wish to obtain further information, please contact:

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[1] Responsibility for any errors or omissions in this newsletter is George's

Engineering the Future

Engineering the Future is a 3-year project funded by a major grant from the Engineering and Physical Sciences Research Council which is 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 very good teaching of it in both schools and universities

Founded on models of transformational change already in practice within Scottish education, EtF is exploring innovative means of developing a sustainable and transferable model of activities which encourage young people to study engineering and support them as they make the transition from school to university. EtF is 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
- provide experience of engineering activities within school classrooms
- 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.

The reasons for relatively low numbers taking up and completing engineering courses are likely to be complex, but one significant problem is the lack of understanding at the school university interface. A central aspect of the work of the project is the development of collaborative networks of school and university staff. Using Electrical and Electronic Engineering (EEE) as a pilot study, the project will enable staff and students from schools and universities to work together to create exciting and innovative programmes for school pupils, supported by world leading engineering research groups. Both face-to-face and on-line interaction will be involved and the development will include staff development opportunities for school teachers. In universities the focus will be on collaboration to redesign first and second year university programmes so that they build on young people's prior experience.

There are two areas of parallel activity. One focuses on developing better understanding of contemporary engineering through enhanced partnerships between schools and universities (local and national). The other promotes and sustains better understanding of engineering through engagement with local and national policy communities. The project uses collaborative ways of working that, according to research evidence results in real, valuable and sustainable change.

School Developments

Where did we get to last year?

Our last newsletter provided descriptions of the engineering related curricular inserts which had been developed for science and physics courses from S1 through to S6. For reference there follows a note of the inserts which partnerships developed last session. If you would like fuller information on these inserts please do not hesitate to ask for a copy (electronic or paper) of the last newsletter.

S5/S6

Holy Cross High School (Brian Smith, Linda Glancy, John Burns)
Strathclyde University (Roy Chapman, Tony Gachagan, Tony Mulholland)

The **S5/6 Higher Physics Electricity and Electronics Unit** was the area selected for development. The activities identified within this for development were:

- **the out of balance Wheatstone Bridge**
- **relationship between peak and r.m.s voltage**
- **relationship between frequency and current in a resistive circuit**
- **smoothing, op-amp saturation and calibration of a signal generator**.

Lanark Grammar School (Gerry Paterson, Aline Wilson)
Glasgow University (Catrina Bryce)

Here the focus was on **S6 Advanced Higher Physics**. Two **Practical Investigation units** were developed. The first required candidates in an **Investigation on the Speed of Light** to measure *c* using (i) Foucault's method, (ii) an electronic timing technique and (iii) measurement of ε_0 and μ_0 and insertion of these values into Maxwell's equation $c = 1/\sqrt{\varepsilon_0\mu_0}$ and to compare/evaluate their final results. For the other **Mobility of Charge Carriers Investigation**, 2 different methods were employed using the characteristics of a n–channel Mosfet Transistor and then by examining the Hall Effect in an n–Ge semiconductor.

S3/S4

Dollar Academy (Deborah Keys, Pamela Webster)
Strathclyde University (Gordon Hayward, Ivan Andonovic, Walter Galbraith)

The main focus of development was the creation of **a new S3/S4 'compressed course'** in which pupils would be taught 3 certificate courses in 6 lessons per week during S3/S4 rather than in the 9 lessons normally expected. The new course integrates Physics, Economics and Technological Studies (PETS). The intention was to streamline the teaching of Physics and Technological Studies with the possibility of freeing up teaching time to run additional activities and to organise trips and speakers. the integrating theme is that of reducing environmental impact of our activities.

Belmont Academy (Douglas McNeil, John McLellan, Ross McMahon)
Glasgow University (Tim Drysdale)

The school explored building engineering links into the **S3/4 Telecommunications and Electronics units**. Given the central role of electronics in modern engineering the main focus has been on this topic. A Project on LEDs and photodiodes was introduced into this unit which afforded S3/S4 pupils opportunities to use a wide range of equipment including signal generators, CROs, LEDs, coloured filters, fibre optic cable and a parabolic reflector.

S1/S2

Balfron High School (Roy Pearson, Phil Slavin)
Strathclyde University (Gareth Pierce, Craig Michie, Martin Judd)

The decision was made to develop a projects on **Bat Detector & Ultrasonic Propagation** in which each pupil builds a device using a transducer to monitor sounds inaudible to humans in order to track bats. This involves construction of the hardware, using the device to investigate the nature of ultrasound, using the device to survey a local bat population, working in groups and working out of school.

St Aloysius College (James Cluckie)
Strathclyde University (Stephen McArthur, Phil McGlone)
Glasgow University (Phil Dobson)

An **Electronics Module** based on the **Mars Rover** was developed for **S2** pupils which could also be used with Intermediate 1 or Standard Grade pupils in S3/4. The outcomes tie in with existing guidelines. It is characteristic of engineering in that it is solution-oriented, adopts a systems approach, makes use simulation and requires team work. The problem is based on a real situation and mirrors the reality of professional engineering. Motivation is enhanced in that the learning is driven by a particular need and pupils are given specific responsibilities. The learning is experiential, the pupils have responsibility and the principles of teamwork are addressed explicitly. Many learning styles are provided for and the very open ended nature of the project supports adaptation and extension.

Williamwood High School (Lyn Robinson, John Brown, John Honeyman)
Strathclyde University (Campbell Booth, Brian Stimpson)

The project is designed around an **Energy / Electricity topic** for **S1** pupils to fill a gap in current provision. Because at present there is no teaching of microelectronics at this stage a project in this area would be helpful. Pupils learn first hand in a practical way how to solve problems relating to home security. They learn about basic input-process output systems and the use of certain electronic components as the basis for many different systems. The basic scenario is to build a security system for a room incorporating several different methods of detection and different alarm systems. This builds on pupil interest in crime prevention and detection (CSI) and introduces them to aspects of modern technology.

Involving new schools

In our last newsletter we reported that Engineering the Future had welcomed three new schools as partners. One is in East Renfrewshire (Williamwood High School) and two are in Dumfries and Galloway (Dumfries Academy and St Joseph's College). Since then we have been approached by Woodfarm High School (also in East Renfrewshire) with a view to participation: and so Woodfarm is now one of our partner schools.

Sadly due to staffing pressures Belmont Academy in Ayr has had to withdraw from active participation this session. We look forward to their return next session.

Trialling

Each of these inserts briefly described above is being trialled both in the school where it was developed and, in some cases, in another school within the Project.

Developments this session

In addition to trialling inserts, school partnerships have also set themselves the task of developing new inserts this session. These again cover all stages of secondary school and a wide range of engineering related experiences.

S5/S6

Holy Cross High School decided that they would like to extend the teaching approach they had developed to the **Higher Physics Radiation and Matter unit** over the next two years. In the current session they are exploring the possibilities for engineering-related activities associated with this Higher Physics Topic 3, specifically activities involving photo-diodes and solar cells, measuring the wavelength of an ultra-sound transmitter and engaging, practical applications of MOSFETs.

S3/S4

In *Balfron High School*, the intention is to expand last session's 'bat detector' development to provide opportunities for S3/S4 pupils to work on **ultrasound and reflection**. The school is experimenting with sonic tape measures, individual ultrasonic effects, lensing effects and car reversing systems. It is hoped to hold a whole school **dedicated engineering day**. The school's wind turbines are now in operation and their effectiveness is being monitored. Another science teacher is currently running a Curriculum for Excellence development with S1 involving them in investigation of alternative energy sources, including solar, wind and tide systems. A cross-curricular geography-physics unit on hydroelectricity is being used with S1

pupils. Finally a further engineering activity is the SSERC 'Pimp my Trolley' activity which looks at car safety, asking pupils to design a crumple zone for a trolley; measurement will be done using a wireless accelerometer. This sits within the Standard Grade Physics transport section.

St Aloysius' College is developing activities related to **radioactivity and nuclear physics** associated with the Intermediate 2 Physics course. The engineering activities are based on chain reactions, building a radiation detector, nuclear plant simulator, advantages and disadvantages of nuclear power, and disposal and storage of materials.

Williamwood High School are developing activities involving S3 pupils in collaborative investigation of **'hidden circuits' in 'black boxes'** with clear engineering functions and applications. This is situated within the electronics section of the course. Pupils will be provided with six closed boxes containing a potential divider with equal resistors, a potential divider with resistors in 10:1 ratio, a resistor and capacitor in series, a diode to give half wave rectification, and a MOSFET circuit. In each box the circuits are in a different order. Pupils are given a list of desired outcomes and have to identify which circuit can be used to produce each outcome, having available low voltage AC and DC inputs, voltmeters, ammeters and hand-held oscilloscopes.

S1/S2

Dollar Academy's university partners are working with the school to develop an insert for use in an S1/S2 **Communications** unit; this will involve pupils being sent messages to their iPods from plants that require watering; senior pupils will write some of the software. Dollar Academy will also be involving S2 pupils in an **engineering challenge**.

Dumfries Academy has developed an engineering-based unit of work related to **wind turbines**. The school are using a wind turbine kit from MUTR that takes 2/3 weeks to complete. The challenge is to find a design configuration to produce as much power as possible.; pupils can change the angle, number and type of blades and measure power through a voltmeter and an ammeter. This is set in the context of the Energy section of the S1 course where the course book used includes work related to renewable energy sources (wind turbines, bio-fuels, solar power, fuel cells).

Lanark Grammar School has developed an **engineering challenge** with an enterprise link involving all S1 pupils in the construction and testing of bridges within their science classes, the winners going on to a final full day event where they will use K'nex to design and build a fairground attraction with help from S5/S6 pupils. A professional engineer will be involved in judging the outcomes.

In *St Joseph's College* the focus is on S1. The partnership is developing a **radio project** to fit in with the S1 telecommunications topic. Pupils build a radio with everyday materials such as toilet roll tubes, crystal earphones, diodes, terminal blocks, breadboards, aerials, lemon batteries and capacitors.

Woodfarm High School is focusing on S2. The development involves circuits with three different input systems: LED. LDR, thermistors; each should firstly involve pupils in an investigation of the impact of varying the input which would include recording and analysis of results; each should then provide pupils with an application to investigate. In the case of the LED investigation centres on the relationship between current and voltage for three different colours; the application involves pupils developing a flashing LED which would trigger flashing in a receptor. In the case of the LDR, input voltage to the bulb which was providing light to the LDR is used as a surrogate for light intensity; pupils note the effect of varying this voltage; a saturation test could be considered; the application will be light controlled lamps. For the thermistors the relationship between temperature and resistance in the circuit will be investigated; the application will focus on the differences in temperature within a frankfurter or similar as it was heated.

Careers Education

Information provided by school pupils and university students through their questionnaire responses raised concerns about the ways in which young people develop their understanding of the requirements of careers in engineering. There were several aspects to this.

Of the school pupils who had completed questionnaires 96% had received advice on subject choices from some source. The important role of guidance colleagues (and other senior staff) in school is evident; even more obvious is the key role of family and/or friends; and just as obvious is the limited recollection of any input from careers advisers. Proportions of pupils across stages noting such advice were:

- careers advisers (17%)
- senior/guidance staff (54%)
- other teachers (3%),
- other sources [e.g. internet] (25%)
- family/friends (86%)

It was similarly obvious from the responses supplied by year 1 university students that many of these had received much of their information from parents and family and comparatively little from careers advisers; a considerable number had received encouragement to study engineering because a parent or other close relative was employed in the engineering industry.

The comparatively limited impact of careers advisers may reflect the current form of careers education in schools. Staff in schools confirmed the view held by members of the team that the philosophy that underlies careers education in Scotland's schools is one that seeks to empower young people by expecting and supporting pupils to take responsibility for identifying their needs and interest and then responding to their expressed views by pointing them towards sources of information.

In the context of engineering there are weaknesses in this approach. Firstly pupils do not start with positive or even accurate images of what engineers do; this contrasts

with the position of such career areas as medicine or the law. Further very many adults and young people in our society hold limiting stereotypes of what engineers do which provides a barrier to further investigation of engineering as a career. Thirdly many parents do not have immediate experience of engineering occupations; those who do have such contact provided young people with positive messages about engineering as a career; those who did not have these associations presumably all too often shared the prejudices held by many. Because pupils are rarely directed towards information on any particular career unless they have expressed an interest in it, given these barriers to an interest in engineering, few young people are likely to be provided with information on this career.

The impact of this is exacerbated by careers education material which unfortunately confirms the stereotype of engineering held by many in our society. This operates at various levels. A widely used careers pack aimed at younger secondary pupils offers car mechanic, electrician and engineer as examples of employment in engineering and technology and goes on to describe engineering and technology as 'using or fixing machinery, electrical or electronic equipment and cars'. A puzzle within this text on 'what's my job?' contains no examples from science, engineering or technology (car mechanic is the closest). In another exercise pupils are presented with a list of celebrities and their passions to illustrate how these relate to career choice; the celebrities are either comedians, singers, actors, TV personalities (chef, actor/archaeologist, comedian/birdwatcher), sports people, one entrepreneur and one politician.

A nationally supported self-access on-line careers package which is widely used in careers education by young people as they reach the point of leaving school does make it clear that engineering jobs are available at 5 levels: operative, craft, technician, incorporated engineer, chartered engineer and provides brief notes on the qualifications required for each of these. Although the site provides accurate information on electronic and electrical engineering this is likely to be reached only after the pupil has been informed that related jobs include meter reader, public lighting attendant, electricity distribution worker, security alarm fitter and television aerial rigger as well as broadcasting engineer, computer hardware engineer and control and instrument engineer. This is only likely to confirm stereotypes. Given that pupils are expected to work largely as individuals through this material their stereotypes may well not be challenged by a member of staff.

In the light of this it was agreed that Engineering the Future should develop its own careers materials and trial them with S2 and S4 pupils. It was agreed that these should be informative, accurate, present engineering in an attractive light and themselves be attractive in format to young people. Initial trialling demonstrates a positive response from pupils who have made it clear that they have rarely been provided with such detailed information about engineering as a career. Apart from providing attractive information these materials are perceived by pupils as sending a positive message about engineering as a career which cares enough about young people and respects them enough to go to the trouble of preparing specific materials aimed at them.

University Teaching

As the Project moves into its second year there has been an increasing focus on development work within the two University Departments as well as that within schools.

Members of the EtF team met with staff in both universities involved in teaching year 1 students. Within Strathclyde it was noted that there is a wide range of innovative and supportive practice developed at all levels from individual lecturer to course organisation but that not all of this is formally recorded. This may contribute to students not perceiving readily the overall rationale, structure and coherence of the course. There was agreement that the structure of regular small tutor group meetings is central to supporting students; this point was later strongly confirmed by students. More generally group work played some role. The central role of such key organisational features as induction week and consolidation in supporting transition into year 1 was evident.

This meeting led to further discussion in the University of Strathclyde with the EEE teaching and learning group. At this it was noted that problem solving is a fundamental issue in 1st year and courses require small group tutorials to address this. There are problems with surface learning - students lifting equations and applying formulas without thinking in detail about the problem; it is difficult to get students not to generalise inappropriately their learning and actually extract what they need and find the appropriate formula. Problems with conceptual teaching can be addressed through contextualisation and teaching through examples but this can also create its own problems.

A university wide move to 20 credit units has afforded the department the opportunity to rethink its provision. A bid for funds to the University's teaching and learning fund was successful in obtaining resourcing for a 0.5 FTE post to support the development of assessment within the processes of curriculum reorganisation.

A focus group of year 4 students in Strathclyde provided clear messages about teaching and learning which have been passed to the EEE Teaching and Learning Group for their consideration. Students were positive about their experience within the department but argued that teaching was often dominated by the demands of examinations and that formative assessment was not a common feature of teaching. Students recognised that some learning would be delayed learning: in retrospect this did not seem problematic provided students were made aware beforehand that this might be the case. The students argued that opportunities should be provided for such activities as presentations to their peers, mutually supportive peer learning groups, project work, and the practice of Year 4 students acting as mentors/tutors to Year 1 students while doctoral students and post-docs could act as mentors/tutors to Year 4 students which would allow more small group work. There could be more cross-reference by lecturers to practical applications of the theory they are teaching and more opportunities for work based placements.

The meeting with Year 1 staff in the University of Glasgow covered a number of areas. These included current induction practice much of which is focused on getting students working together; the establishment of support network and study groups; a mentoring programme for 1st year students where ideally a PhD on the same degree acts as a mentor;. In addition at the start of the course students are provided with the big picture of electronics and an explanation of how each part fits in. A summer school is offered for 10 weeks covering basic maths and circuits which is essential for students with low prelim grades. There was agreement that the core way to inculcate deep learning is through the assessment system; to inculcate deep learning in the aeroengineering course the students are given a tutorial with questions that they have not been shown how to work out but they have all the information they need. Project work is also important in contributing to deep learning. During the meeting a number of other issues related to student teaching were raised. In particular many students have a lot of trouble with maths which needs to be explained in depth. While 1st and 2nd year students must make the transition to independent learning but some students are lost during this transition. Initial consideration was given to some possible solutions.

This meeting has led to further discussion between EtF team and Glasgow University staff on the promotion of more active learning and on the role that personal development planning can play in promoting independent and reflective learning.

Partnerships with Industry

Agilent

Digital Oscilloscopes

Agilent Technologies is a major US company based in Santa Clara, California; Agilent Labs, their central research organization, has a major presence in South Queensferry. The Project has enjoyed the advice and support of Agilent since its inception. The company's commitment was demonstrated by their making available to each school in the Project a digital oscilloscope, supported by the necessary software. The company also provided training for teachers in its use in the University of Strathclyde. This training had been useful; teachers noted very positively the contributions of both the Agilent colleague and the University technician.

School staff have used the digital oscilloscopes extensively. As originally expected schools were using this equipment in S6 Advanced Higher courses but it was significant that they had found it easy to deploy the digital oscilloscopes at other stages and levels (Higher, Intermediate 2, Standard Grade): in S5 in work on AC; in S4 work on AC; in S3/S4 on speed of electrical energy; in S3 in investigating the speed of light. Teachers noted the ease with which this equipment could be linked to smartboards for whole class demonstration purposes. An important point was the ease of storage of data and the flexibility that this afforded. Although using the equipment

had taken some practice it had proved possible to share this expertise with other colleagues in school.

Teachers welcomed opportunities for further development especially the availability of an expert who could either talk through matters of interest or difficulty face to face with the teacher with an oscilloscope on the bench between them or be accessible through an 'e-mail an expert' system when any problems arose.

Publicity

We were also fortunate enough to be able to draw on the advice of Agilent with regard to our publicity. This led us to think about the relationships between audience and format do message, about consistency, about the need for a single clear image and about clarity and brevity. This has resulted in the development of a single image and key messages to be used in all our external communications.

E-learning

Agilent has provided funding to the project to take forward the development of e-learning materials. This has supported the development of the scoping report described later in the newsletter.

Industry Questionnaire

Fifteen large engineering companies whose contact details had been provided by University staff with industrial connections responded to a brief questionnaire on the qualities they wished to see in engineering graduate recruits. The results were in line with larger national surveys but allowed us insights into the thinking of these organisations. The study carried out by Spinks et al had listed the key skills and attributes of graduate engineers under the three skill domains of technical, personal and business skills with the key dimension of each domain as shown here:

- technical — theoretical understanding
  technical breadth
  practical application
- personal — communication
  team-working
  creativity and innovation
- business — commercial awareness

Respondents identified technical and personal skills as highly important when they recruited graduate engineers but afforded less weight to business and entrepreneurial skills. Within the technical area a key message would seem to be that 'a more broadly based understanding across wider areas of EEE' was preferable to 'a deep understanding of a fairly narrow area of technical knowledge'. The respondents

surveyed stressed the importance of the 'ability to apply theoretical knowledge to real industrial problems'. There was a perception that graduates could be even better prepared in these areas. Interpersonal skills were perceived to be more developed: none of the respondents felt flexibility, team working skills or work ethic to be a common weakness.

Asked if engineering should be part of the school curriculum, all respondents believed engineering should be in the secondary school curriculum and most thought it should be part of the technology curriculum. Only 7 thought it should be part of science and 5 respondents thought it should definitely not be in the science curriculum.

It will be interesting to explore differences between the views we have obtained from those in large organisations and the views held by the managers of small and medium engineering enterprises. We speculate that they may place a higher value on entrepreneurial skills and dispositions for engineers than large companies with greater division of labour require to do.

Partnerships and Links with Scottish Education

Curriculum for Excellence

Science

Engineering the Future team members have maintained discussions with Learning and Teaching Scotland colleagues involved in developing the science curriculum and in writing the Science Experiences and Outcomes in the period before and since the publication of these Experiences and Outcomes. We believe that the published documentation provides clear indications of the potential for engineering activities within primary and early secondary science; engineering education will be seen to be not only possible. However to ensure that all young people experience engineering education we have argued that the title of the area should be extended form Science to Science and Engineering

The inserts being developed or planned by the schools in the Project clearly relate to draft experiences and outcomes while, more generally, the principles which colleagues have used to underpin their planning relate clearly to the commitment to experiential learning, personalisation and choice and depth of study within Curriculum for Excellence. Teachers involved with the Project agreed that engineering fits in well with the science outcomes but noted that pupils need to realise they are doing engineering and the word must be explicitly linked with the work. Teachers have said that they would have no problem if Science was changed to Science and Engineering in the curriculum.

We were happy that it was readily possible for a number of our inserts to be written up as exemplification to be published nationally within Curriculum for Excellence as

exemplars of ways in which Science experiences can be provided and outcomes achieved. We believe that others can also be so written up and publicised.

The Engineering the Future team will be responding to the on-line questionnaire on science within CfE to promote the case for formal recognition of engineering within the school science curriculum and we hope to support those working with the Project in continuing to play an active part in engagement over the statements of experiences and outcomes.

Technology

The Curriculum for Excellence programme has more recently published experiences and outcomes for pupils related to Technologies. Aspects of engineering are relevant to this broad curricular area, too, and there is a potential for schools to choose to promote understanding of engineering in inter-disciplinary courses or projects, perhaps in a secondary school involving staff from the sciences and from other subject areas such as technical education and art and design.

Before publication Engineering the Future team members were in dialogue with colleagues as they developed the experiences and outcomes in order to ensure that there were opportunities for developing at all levels the knowledge and skills required to support education for engineering. We believe that the outcomes do provide such space and further work is being done collaboratively to group selected Technologies experiences and outcomes to provide a framework for classroom learning in engineering; in so doing use is being made of the inserts developed within the Project.

Building the Curriculum 3

We await the publication of the Curriculum for Excellence document *Building the Curriculum 3* which will make important statements about contexts for learning. Curriculum for Excellence is built on the principle that learning takes place not only in the subject classroom but through interdisciplinary projects and the wider life of the school. *Building the Curriculum 3* will, we believe, take forward practice in this area. A number of schools involved in the project have developed work that moves outside the classroom walls: through interdisciplinary work; through the use of the local environment, through special focus days, and through events and competitions.

Other curricular links

The links between enterprise education approaches and the work in some of the Engineering the Future inserts is evident where these have opened up the methodology of science teaching to include the motivating practical applications and problem-solving that pupils are finding more engaging than some previous science experience. The recent HMIE Improving Enterprise in Education report provides strong evidence that the additional breadth and depth of learning associated with enterprising approaches had exerted a positive influence on the wider achievement of

pupils. This also reflects recommendations from the OECD 2007 report on Scottish education, promoting broad-based vocational experience which adds relevance and motivation for learning for all pupils.

SQA Review of Physics

As many will know the Scottish Qualifications Authority has been reviewing Physics qualifications at Higher and Advanced Higher levels with the aim of promoting deeper learning. This will entail: reducing content knowledge to provide more space for problem solving and enquiry learning; teaching some aspects of the course through 'themed' units which require the candidate to examine theory through applications; introducing a case study and a physics skills unit at Higher; and maintaining the current Advanced Higher investigation. Much of this chimes with the approaches being developed within Engineering the Future.

More specifically, from the EtF point of view the inclusion of case studies at Higher which made reference to engineering would be very valuable. The intention was to have a single case study per year but we propose that it is possible to think in terms of a bank of case studies which could be assessed through a presentation and through questions in the examination which would require candidates to explain the development of their thinking. It would also be feasible to integrate the teaching of physics skills into some sort of mini-investigation rather than through decontextualised exercises. Both of these approaches would afford opportunities for the teaching of engineering related topics.

Scottish Survey of Achievement: Science

There was clear evidence from the 2003 Assessment of Achievement Programme science survey that P7 and S2 pupils' overall attainment was not good; pupils lacked conceptual understanding and experience in investigating skills, discussion of science issues and communication beyond answering closed questions. We look forward to the publication of the 2007 Scottish Survey of Achievement in Science which will provide up to date evidence about the state of pupils' science experiences and attainment across the country following the impetus given by the recommendations of the HMIE report Improving Science Education that science teachers should review how they teach practical work in order to broaden the range of investigative skills being taught and practised, because pupils need to develop both a secure knowledge base and good decision-making and problem-solving skills, and that pupils should be helped to make links between related aspects of learning, for example between science and geography or science and technology. We believe that the engineering inserts being developed provide considerable opportunities for these activities. Pupil reports within Engineering the Future demonstrate their awareness of the differences in pedagogy associated with the inserts which they have experienced and their enjoyment of practical experiences the challenging nature of which promoted effective learning.

Policy Developments

The election of new government has led to developments in policy fields which may well impact on engineering and on the development of Engineering the Future. These include **Skills for Scotland: A Lifelong Skills Strategy** in which the Government articulates its fundamental belief:

> 'It is vital to Scotland's economy that we have a steady supply of workers skilled to higher levels. A steady flow of graduates and technicians is vital in order that industries in which Scotland operates at the leading edge … can continue to compete favourably. … our modern knowledge economy will be ever-increasingly reliant upon a steady supply of skilled scientists, technologists and engineers. The demand for scientists in the future looks positive and the total employment for science occupations is projected to grow at a faster rate to 2014 than that expected for non-science occupations. Moreover, Scotland must continue to increase technology transfer from our worldclass research base into viable products and processes. Encouraging technology start-ups (including assisting scientists and technologists to develop entrepreneurial and business skills) and helping them to grow into our large companies of the future, will prove an ever-increasing priority.'

This is precisely the rationale which underpins Engineering the Future.

To carry out this fundamental aim the Government argues that 'pupils should have the opportunity to build up a strong foundation of a wide variety of skills and be able to present and demonstrate their skills in a way that will be of high value to themselves, their parents and carers, employers, colleges and universities'. In order to 'encourage young people to stay in education and training post-16' the Government argues that 'good options and clear pathways out of school are essential to ensuring continuity and progression in learning and achievement'. We believe that these aims are in fact being realised through the work that Engineering the Future has been doing within school and across the transition to university study.

What is more challenging is to extend this work across Scotland. Engineering the Future has explored various means of so doing. These have included centrally the work that has been done with Curriculum for Excellence colleagues. However, to embed in the curriculum the development of the knowledge, skills and dispositions needed by successful engineers (which are of high value also to those who do not go on to pursue careers specifically in engineering) requires clear and consistent messages to be sent to and received in schools. EtF has proposed that the Scottish Government should name as *'Science and Engineering'* the curriculum area currently called *'Science'*, explicitly highlighting the engineering elements within the many aspects of applied science and conveying a clear expectation that the concepts and activities central to engineering should form part of all pupils' science experiences. We argue on the basis of our experience to date that such a move would not only give appropriate emphasis to engineering but would also contribute significantly to improving learning and teaching in science.

The **Scottish Budget Spending Review** introduced the concept of the Concordat with local authorities some of the key indicators of which are:

- Increase the percentage of Scottish domiciled graduates from Scottish Higher Education Institutions in positive destinations
- Improve knowledge transfer from research activity in universities
- Increase the proportion of school leavers (from Scottish publicly funded schools) in positive and sustained destinations (FE, HE, employment or training)

Engineering the Future seeks to contribute to these indicators by encouraging young people to study engineering, by seeking to improve the quality of graduates resulting in more positive outcomes both for individual students and for the economy and society in general.

Although not a policy document the recent OECD review of Scottish education **Quality and Equity of Schooling in Scotland** provides a benchmark. There are implications for EtF of the government commitment to vocational education in the context of this review, the following extracts from which suggest parallels with our work:

> 'A Curriculum for Excellence aims to deepen and enrich the demands made on students. … International experience suggests that Scotland would gain from a bolder, but also broader approach to vocational studies in schools than it has so far demonstrated. Vocational education and training should not be seen too narrowly in terms of employability … In this report, we consider vocational studies to involve a mix of courses which place an emphasis on applied and collaborative learning, problem-solving, sharing of learning tasks, overt meaning and purpose, formative and competency-based assessment, and real-world orientation. Vocational studies are intended to form the whole person and to be motivational and constructive of broad capacities. However, their economic rationale is important, should be explicit, and must involve proven quality of training.'

E-learning

As noted above funding for Agilent supported a scoping exercise to take forward the development of e-learning materials. The most effective form for well designed and sustainable e-learning and teaching in schools to support engineering education was not clear at the start of the Agilent funded initiative. However the EtF team had articulated in its bid certain premises which accorded with its principles.

- The project must motivate pupils strongly to use any ensuing facility.
- It must successfully engage them with key ideas in the field of electronic and electrical engineering.
- It must be sufficiently flexible to avoid the vagaries of fashion.
- It is likely to make use of a media-rich suite of activities and resources
- It must have the potential for global delivery.

The EtF team initiated a partnership with TPLD, a serious games software specialist company based in Dundee, which was commissioned to carry out detailed scoping work on this project. TPLD is a spin-out company of the University of Abertay

Dundee whose School of Computing and Creative Technologies is among the international leaders in this field. Since TPLD was formed in 2001 it has been at the forefront of research and development in the serious games market and has developed educational and training games for use in schools, the health sector and business and commercial contexts.

Based on findings from research and from the experience of teachers in the Project, it was agreed that the solution would ensure that pupils at key points within their school careers when major educational decisions are taken develop broader and deeper understanding of what it means to be an engineer and improved understanding of the key roles played by engineering in our society:

- by developing the knowledge, skills and mindsets which underpin engineering
- by using these to solve real world problems in a safe and enjoyable virtual context
- by developing the capacity to understand how manipulating systems causes particular effects
- by allowing learners to try out alternative courses of action in specific contexts and then experience consequences
- by providing an enjoyable experience of the challenge of engineering
- by enabling learners to play collaboratively in a safe environment in which they can bolster each others' enthusiasm for the discipline
- by providing increasing levels of challenge

The scoping study has established the feasibility of creating a prototype engineering laboratory centred on games based learning. The following are the key features of the proposal:

- The target audience would primarily be younger secondary school pupils
- The virtual environment would be modular in structure
- The game would utilise a typical massively multiplayer online role-playing game (MMORPG) structure
- Players would work together in teams to solve a variety of real world, engineering-based problem
- A range of scenarios would be provided each of which would permit players to undertake different roles
- Pupils would be encouraged to extend the roles they undertake
- Modular missions would relate to the content of national curricular policies and would develop the skills identified as fundamental to successful engineering
- The Management System would allow for new modular missions and challenges to be added
- Within this structure content will initially be focussed on electronic and electrical engineering.

The EtF team hope to take this proposal forward.

Discussions with teachers in the Project revealed the breadth of existing e-learning on which they already draw. This included:

- a number of sites which provided advice or examples of simulations (such as bridge building)

- a number of commercially or publicly funded learning systems such as SCHOLAR, Crocodile Physics, Crocodile Technology, the Virtual Physics site and Focus Educational software
- one school is a partner in a COMENIUS programme on developing the use of Moodle for courses across the curriculum in schools
- one participant had intended to set up a website as a repository of information for pupils but commercially available systems such as Yahoo bookmarks had proved effective and efficient means of sharing information with pupils
- on line commercial catalogues of equipment and materials provide opportunities for pupils to seek information relevant to engineering related work in science classes:

Teachers considered that e-learning has significant contributions to make to the implementation of Curriculum for Excellence in terms of contributing to investigative learning in time freed up for project type work, of supporting links between subjects and interdisciplinary learning and supporting personalisation and in depth learning. There were concerns expressed that hands-on in-class experimentation should not be replaced by simulations.

All agreed that school pupils could contribute effectively to our learning in this area.

Research

Reference has been made throughout this newsletter to a number of means by which information has been gathered to promote the development of the Project. Our model of collaboration requires that all participants contribute to the research processes. This has been effected not only through questionnaires, but through participant observation in classrooms, interviews with teachers, focus groups of learners, and detailed records of meetings. We have sought to ensure that information is fed back to participants and have sought to ensure that their views are clearly reflected in the development of the Project.

Conferences

Engineering the Future presented a poster at Science in the Parliament and at a Quality Assurance Agency conference which focused on the first year university experience. We will also be present at the Institute of Physics Conference in early June.

EtF will be represented at a number of conferences and other educational events this summer and autumn. These include EE2008, a major engineering education conference in Loughborough in July where we are presenting a paper and running a workshop, BERA (the British Educational Research Association) where we are presenting a symposium, the Scottish Learning Festival where we are holding a seminar and two round table discussions, and SERA (the Scottish Educational Research Association.