Engineering and education - a partnership?

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Engineering and education - a partnership?

A V Matthews
Engineering Education Scheme, Wales

Abstract
Until relatively recently there has been, and still exists in some areas, a hierarchy of career choices for students in England and Wales at "A" level stage. Such professions as medicine, law, accounting, banking, veterinary science and teaching have quite naturally been at the forefront. A most important ingredient missing from that pot pourri is engineering, in its various forms. Sadly the "high flyers" are encouraged into careers from the original list and all too frequently engineering seems to end up as a consolation prize for the "also rans".

Research indicates that some of the factors to be taken into account include, lack of motivation, lack of information, inability of career advisers to discuss engineering careers adequately and all too frequently, lack of opportunity for students to sample at first hand.

The paper will highlight some of the shortcomings of the existing situation and discuss ways in which its particular model, which is the first step in a continuum administered by the Fellowship of Engineering, is attempting to redress the balance.

Many, in the educational field and elsewhere, have tried to define the word 'Technology' without marked success. Malpas and Watson in their paper on 'Technology and Wealth Creation' have been bold enough to attempt a broad definition which seems to give us a sound base line.

"Technology is the systematic harnessing of all knowledge and experience to result in something practical and commercially useful - a product, a manufacturing process, a system, a service."

Engineering is the vehicle which is central to the successful delivery of Technology. Education is the process which we all go through, to varying degrees, which trains our thinking and logic.

Technology is the driving force behind a large amount of the wealth creation in most civilised societies. Throughout this systematic harnessing of knowledge and experience investment is required to ensure commercial success and continued viability. Arguably, the most important investment of all (and perhaps the most neglected) should be in people. People with lively enquiring minds, a wealth of experience and a will to take forward the boundaries of technology to benefit our society. The carefully planned, long term, investment in people is the magic ingredient in the success, or otherwise, of industrial and commercial life which,
Mathews

**UCCA BRITISH APPLICANTS**

<table>
<thead>
<tr>
<th></th>
<th>85/86</th>
<th>86/87</th>
<th>87/88</th>
<th>88/89</th>
<th>89/90</th>
<th>90/91</th>
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<td>156981</td>
<td>166727</td>
<td>183623</td>
<td>194258</td>
</tr>
<tr>
<td>% Engineering</td>
<td>10.92</td>
<td>10.19</td>
<td>9.09</td>
<td>8.66</td>
<td>7.93</td>
<td>7.44</td>
</tr>
</tbody>
</table>

Figure 1

Invention to the point of sale. Traditionally British ideas have been at the forefront of invention but, somehow, the impetus to carry them through to fruition has eluded us.

Engineering and education are inextricably linked to each other in many obvious ways from, basic education, career inclination, advanced education, tertiary education, career choice, job satisfaction, career advancement, job specific training, technology updating, management skills, etc. The generic term for most of the people who engage in the process of technology is "Engineer", a most misunderstood term in the English language.

Is this because our engineers are too specialised and do not have the vision to see the process in its entirety?

Is it because our society is too ready to put us in compartments?

Is it that the educational process itself encourages tunnel vision?

Engineers are perhaps, with the exception of geniuses such as Brunel, Cockroft, Whittle, Bessemer, etc, as good as the education system which taught them. Bearing in mind that engineering is only one career choice available to the student leaving the secondary education system, but equally realising that a large part of British economy is concerned with manufacturing, is sufficient emphasis placed upon those subjects at

Malpas and Watson (Figure 1) make the strong point that the process of technology must be from

This Paper addresses the area of the professional engineer, the production engineer, the research and development engineer, the engineer in sales and management. Put another way, the leaders of the Technology Task Force!

Figure 2

**PCAS BRITISH APPLICANTS**

<table>
<thead>
<tr>
<th></th>
<th>85/86</th>
<th>86/87</th>
<th>87/88</th>
<th>88/89</th>
<th>89/90</th>
<th>90/91</th>
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</thead>
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<td>10069</td>
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<td>Number of Applicants for all Disciplines</td>
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<td>132588</td>
<td>137216</td>
<td>139140</td>
<td>155301</td>
<td>177622</td>
</tr>
<tr>
<td>% Engineering</td>
<td>10.73</td>
<td>10.00</td>
<td>8.70</td>
<td>7.24</td>
<td>6.83</td>
<td>7.01</td>
</tr>
</tbody>
</table>
Figure 3

secondary level which will enable students to enter careers in engineering? There are a number of other questions which could be posed:-

Is our educational system content with producing the "mixture as before" rather than looking at modern needs?

Do we adopt too bookish an approach to secondary education and rely too heavily upon recall, rather than spatial awareness and divergent thinking?

Is too much emphasis placed upon the convergent thinking encouraged in many science and mathematics courses?

Are our "high fliers" given adequate information and opportunity to appraise engineering as a career choice?

Are we content that engineering continues to be a second choice for many after law, medicine, teaching, accountancy, etc., in the career choice league table?

It would be simple to satisfy such enquiry by supplying trite answers about parental bias, dirty hands engineering, snobbery, salary, lack of information, etc.

It is clear that whatever reason pertains, there are many traditional barriers to still be broken down, since Britain is still short of high quality engineers and the number of students applying for engineering places at university or polytechnics is still going down.

Correlli Barnett postulates that Britain has a major cultural problem of decrying practical capability at the expense of academic achievement. Sir Christopher Ball places much importance upon "Learning Pays". Both gentlemen would undoubtedly agree that practical capability can, and indeed must, go alongside academic achievement to produce highly capable, well qualified, divergent thinking engineers.

Sir Robin Nicholson, in the recent review by the Advisory Council on Science and Technology, warned that the education system is failing to supply industry with enough scientists and engineers. The problem is further exacerbated by the low level of investment by industry. The top 100 companies in Britain spend £1,530 per employee on research and development compared with £3,730 in the USA and £4,320 in Germany. The report states that there is concern that Britain has a two tiered workforce with a highly educated elite and a poorly trained
<table>
<thead>
<tr>
<th></th>
<th>1989</th>
<th>1990</th>
<th>% decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics 'A' level</td>
<td>44,871</td>
<td>42,564</td>
<td>5.15 %</td>
</tr>
<tr>
<td>Maths 'A' level</td>
<td>82,987</td>
<td>77,277</td>
<td>6.9 %</td>
</tr>
</tbody>
</table>

Figure 4

population. The post 16 education system is regarded as being narrowly specialised, requiring amongst other attributes more emphasis upon analytical and problem solving skills.

Mathematics and Physics, two highly desirable tools in the make-up of the professional engineer, are clearly not the most popular of subjects at GCSE or 'A' level and numbers of candidates in Britain presenting themselves for examination is dropping.

Comments from students include "Too much hard work" and "Softer options elsewhere".

In the ACOST report on Science and Technology, Sixth Form attitudes towards science courses were seen to be impersonal, tedious and high in factual recall. It would appear that not much female talent is exploited, since the typical science student is seen to be male, boring but clever!

The Institute of Employment Research estimate that by the Year 2000 the number of jobs in Britain requiring qualifications higher than 'A' level will rise by in the region of 1.75 million. Areas of concern are engineering and computing. The largest over-production is thought likely to be in the Social Sciences. The Association of Graduate Recruiters has come to much the same conclusion, that there will be a chronic shortage of engineering and technology graduates by the year 2000 in Britain.

A study by the Price Waterhouse Cranfield Project has concluded that excessive salaries and perks are not the answer to recruitment problems through Europe. An increase in training of new and existing staff is favoured as a means of solving the problem.

It would appear from the above statistics that the message has not got home to many British manufacturers, particularly when a recruitment exhibition by Careers in Industry offers a Ford Fiesta as a prize for visiting and next year's prize is expected to be at least three times as valuable.

It would be far too simplistic to suggest that employers need to sharpen up their act and realise that people are their best asset and training is the currency. Perhaps a rule of thumb suggested by IFF Research might apply:-

Figure 5
(Source: 1990 Price Waterhouse Cranfield Project Survey)

FIVE TOP RECRUITMENT SOLUTIONS
(Percentage of employers responding)

<table>
<thead>
<tr>
<th></th>
<th>FRANCE</th>
<th>GERMANY</th>
<th>SPAIN</th>
<th>SWEDEN</th>
<th>UK</th>
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<tbody>
<tr>
<td>Training new staff</td>
<td>82</td>
<td>63</td>
<td>73</td>
<td>57</td>
<td>83</td>
</tr>
<tr>
<td>Increased pay etc.</td>
<td>57</td>
<td>49</td>
<td>73</td>
<td>50</td>
<td>77</td>
</tr>
<tr>
<td>Retraining staff</td>
<td>48</td>
<td>46</td>
<td>75</td>
<td>54</td>
<td>74</td>
</tr>
<tr>
<td>Relaxing age limit</td>
<td>38</td>
<td>69</td>
<td>58</td>
<td>32</td>
<td>58</td>
</tr>
<tr>
<td>Part time work</td>
<td>35</td>
<td>62</td>
<td>21</td>
<td>36</td>
<td>54</td>
</tr>
</tbody>
</table>
GRADUATE OUTPUT BY COUNTRY

<table>
<thead>
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<th></th>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Engineering and technology</td>
<td>20</td>
<td>20</td>
<td>27</td>
<td>45</td>
<td>25</td>
</tr>
<tr>
<td>Science, maths and computing</td>
<td>23</td>
<td>33</td>
<td>10</td>
<td>8</td>
<td>27</td>
</tr>
<tr>
<td>Medical and health related</td>
<td>8</td>
<td>5</td>
<td>13</td>
<td>13</td>
<td>15</td>
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<tr>
<td>Social sciences, law, business studies</td>
<td>35</td>
<td>58</td>
<td>46</td>
<td>95</td>
<td>87</td>
</tr>
<tr>
<td>Arts, humanities, education</td>
<td>36</td>
<td>77</td>
<td>42</td>
<td>57</td>
<td>43</td>
</tr>
<tr>
<td>Other*</td>
<td>10</td>
<td>9</td>
<td>7</td>
<td>18</td>
<td>33</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>132</strong></td>
<td><strong>202</strong></td>
<td><strong>145</strong></td>
<td><strong>236</strong></td>
<td><strong>230</strong></td>
</tr>
</tbody>
</table>

Figure 6

1. Improve the dissemination of information about job opportunities.
2. Be flexible in the response to recruitment problems.
3. Have a planned progression of training and development.

In what could be described as a "chicken and egg" situation we must look at the appropriateness of the education system to the recruitment of high quality engineers, for it may well be that one of the most important reasons for poor recruitment is to do with a teaching method which does not stimulate and is insufficiently divergent in its approach. Marton and Saljo maintain that there are important distinctions between the "deep" and "surface" approaches to learning. Surface learning consists of memorised information whilst deep learning means conceptual learning, or grasping the concepts that underpin understanding and seeing how to apply them. Traditional teaching methods have resulted in students studying largely as individuals. Marton and Saljo found that group working is more student centred, benefited by:

- a) common problems and challenges
- b) student presentations
- c) team dynamic, including "proctoring" or peer group teaching.

Problem solving projects and design projects make significant demands upon student understanding and their grasp of concepts. Strictures currently prevailing for some 'A' level courses lead them to be heavily reliant upon factual recall. It is therefore not surprising that many find the course boring. Other examining bodies such as BTEC and Baccalaureate have moved away from this and are gaining popularity.

To use a metallurgical analogy, the base metal of our amalgam, the young people upon whom our wealth creation will depend for the future, do not appear to be wearing down the path to a career in engineering. A number of studies have highlighted the serious concern for the shortfall to the year 2000; there does not appear to be an instant solution to the dilemma. Industry has got itself into it is most unlikely that the academic system can respond to the call for change sufficiently rapidly, even if it wanted to.

Whilst pupils can readily understand what the career of a doctor, dentist, lawyer, teacher, accountant,
etc, is broadly about, there is a vast ignorance, or misunderstanding, as to what the role of the professional engineer is in society. In a recent survey in West Wales 84% of pupils had not considered a career in engineering and 86% of the companies surveyed had a staff shortage in professional, technician and skilled workforce. It would seem that the Career Service is only used by under 20% of the school population, though experience has shown that comparatively few of that service would feel sufficiently knowledgeable on the wide range of engineering careers.

Amongst the large, and perhaps confusing, number of education initiatives there are some which stand out as being particularly important milestones in information acquisition and development for students, and accord strongly with the sentiments of the DTI White Paper - The Department for Enterprise - CMD 278. A chronological progression which is particularly apposite to the need to inform through experience is:-

1. The Neighbourhood Engineering Scheme -
This is a scheme organised nationally by the Engineering Council as an awareness programme during the secondary phase up to GCSE and has recently recruited its 1,000th school. The object is to link practising professional engineers to a school to help with giving the pupils a perspective upon the world of engineering at an early age.

If young people still, after an introduction to engineering via the above scheme, have an interest in a career in professional engineering, an initiative which is gaining strength and respectability in both education and industry is the ENGINEERING EDUCATION CONTINUUM administered by the Royal Academy of Engineering. (Known by some as the Sainsbury Trust Scheme, since that Trust does help to financially support it.)

The Continuum has a number of phases which are sequential and complementary to one another:-

2. The Engineering Education Scheme -
This is the first phase of the continuum, dealing with an awareness of the work of the professional engineer for the well qualified Lower Sixth form student who may wish to experience work with practising engineers. It is designed as a project phase, duration 6 months, for teams of 5 students to solve industrial problems and submit project reports. All this is completed prior to the submission of UCCA and PCAS applications so that their experiences in the project can help to shape their career path.

Many of the positive points mentioned earlier in this Paper concerning educational method are present in this phase. For example, Team work, Presentation skills, Peer group teaching, Concept teaching rather than recall, Time management, Report writing plus the ability to rub shoulders with the real professional.

3. The Higher Education Experience Week-
If, after having been involved with the phase above, students are still interested in pursuing a career in engineering, the above scheme arranges a tutored week at a university or polytechnic, of the student's choice, from a list of establishments affiliated to the scheme. This is designed to give a flavour of Higher Education with an opportunity to sample a little of a typical course in a specific discipline.

4. The Year in Industry Scheme -
Those who have applied, and been accepted by a college, may take a year deferment and join the Year in Industry scheme (formerly known as the Preformation of Undergraduate Engineers - PFUE). The scheme is one in which a year's real, paid work, is complemented by a training programme to enhance students' practical skills and general business awareness. This is intended to stimulate students' interest in an industrial career and gives companies an opportunity to identify and encourage future employees.

5. The University Programme -
This programme assists in obtaining sponsorship, identifies and selects students for 'Sainsbury Bursaries'. Bursaries are also available for travel or language study during vacations.

An advisory service exists through a mentor who is normally a senior practising engineer.

6. The MBA Programme -
Those who have graduated and taken up positions in industry may, after a few years, feel that, having gained some experience in engineering, they would wish to move into the management of the industry. This programme is designed for such an eventuality. Sponsorship for all fees and three quarters of the local cost of living is available upon selection.

All the above complementary initiatives in the Continuum are dependant upon a finite financial support from the Sainsbury ‘Gatsby’ Trust, but deserve to grow in order to serve as many students as possible in their quest for balanced career
information about industry. It is the wish of the Royal Academy of Engineering that some of the initiatives be self funding, so that the schemes can grow. This means an increased involvement on the part of the Engineering Industry is essential to enable us to take the embryonic engineer to engineering and help secure the investment in people, for Britain's development of its technological base.

Partnership?

A partnership between the Engineering profession and the Education profession would seem to have clearly defined benefits for the wealth creation of Britain. The time has come, perhaps it is long overdue, for suspicions and vested interests to be put on one side and dialogue to be turned into action plans for close co-operation.

The blinkered approach of educationalists towards teaching a subject for its own sake is a luxury the country cannot afford. That knowledge must be delivered in a state whereby it can be applied.

The short term gains of industrialists, who appear to ignore recruitment and training for long term benefits, owe more to the end of the year balance than growth for the future. Lessons ought to be learnt from many overseas competitors in forward planning.

Both professions would do well to realise that much work has still to be done in encouraging the "high fliers" towards careers in industry and to seriously support such initiatives as mentioned earlier in the Paper.

"I believe that in today's global economy the ability to create wealth will increasingly depend on the ability to transform technology into incrementally better products. I also believe that to do this we cannot rely on a few entrepreneurial heroes at the top of companies. Industrial success will increasingly depend on people at all levels having a wide range of skills.

Therefore, educating our children to have engineering and management skills must be one of our highest priorities as a country."

Mr. David Sainsbury in an address to the Council of the Fellowship of Engineering

Terminology

GCSE - General Certificate of Secondary Education - This is the examination system currently in use in British Secondary education up to the age of 16 years. (This has replaced the GCE - General Certificate of education and the CSE - Certificate of Secondary education.)

'A' level - This is the GCE - General Certificate of education - Advanced level examination. A two year course, normally, from 16 years to 18 years of age.

BTEC - Business and Technical Education Council

UCCA - Universities Central Council for Admissions

PCAS - Polytechnics Central Admissions System

MBA - Master of Business Administration Degree

DFS - Department of Education and Science

DTI - Department of Trade and Industry

Please note that the Fellowship of Engineering became the Royal Academy of Engineering in April 1992.