Int. J. Engng Ed. Vol. 8, No. 2, pp. 86–88, 1992
Printed in Great Britain.

0742–0269/91 $3.00+0.00

Personal View: What Are the Qualities we Shall Look for in Engineering Graduates in the Year 2000?

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The qualities which we shall seek in engineering graduates in the year 2000 are conditioned by four historical factors in the UK.

First, the Industrial Revolution placed Britain in the industrial forefront of the world and ushered in a period of innovation and wealth, which was unfortunately followed by the development of an anti-industrial ethos, prominent today in our schools, in the media and in many branches of society, including members of both political parties. To read C. P. Snow's *Two Cultures* is a depressing but illuminating experience and I know of no comparable situation in overseas countries. On the contrary, in those countries science, engineering and wealth creation are highly regarded and are generally seen as the means of providing the artistic fruits of a cultured and wealthy society.

Second, we inherited an elderly industrial base and a management of industry based on that dichotomy which could most charitably be described as amateur. For too long, dynastic systems of management, usually technologically illiterate, dominated the British engineering manufacturing field. That has now changed and as a result, British engineering industry is more professional, innovative, and dare one say, prosperous. But the change is recent, and consolidation and restoration of past damage will take time.

Thirdly, because of this historical hangover, government attitudes to engineering and manufacturing and their competence in evaluating issues connected with those sectors has been extremely low, no matter what the persuasion of the government. This stems from the fact that the House of Commons contains few scientists or engineers, the Cabinet currently none, and there are some 42 permanent secretaries at the head of the Civil Service, not one of whom is a scientist, engineer or accountant. I would not wish to suggest for a moment that any of those populations should be dominated by numerate disciplinès, but a reasonable representation would be welcome, and who can doubt that the quality of many national decisions would be greatly improved by such an import of numeracy and technological literacy.

There is of course a great reluctance amongst engineers to entering politics or the Civil Service because of the antagonistic ethos which stems from the technological illiteracy I have described, but this is a vicious circle that has to be broken.

In this respect, our industrial competitors have a distinct edge. In France, Germany, Japan and the United States, ministers and civil servants commonly have a technological fluency that would be foreign to us in the UK. In addition, mobility between government and industrial circles is greater and more readily welcomed than is normal in the UK.

Of course, this has to do largely with the historical evolution of competing countries and with the development of educational systems. It is no accident therefore, that in Germany, France, Japan and the United States, scientists and engineers are more highly regarded than is the case in the UK. This technological divide has been much discussed and has to be overcome in the UK. There are some encouraging signs that this is taking place, but they are early and not to be relied upon. We must remain active and vigilant in the prosecution of a technology-aware government, Civil Service and educational sector in the UK.

Finally, I think that the British engineer is distinguished by the formation of his or her training. The norm in this country is a three-year degree course (four in Scotland) which can be compared with five or six years elsewhere. On the other hand, our training is more formalized and, I believe, effective and chartered engineering status—the goal of most British engineers—demands not only a satisfactory content of the degree course but also formal training and supervised experience. As a result of these features, British engineers are highly regarded throughout the world, as can be seen by the number of expatriate engineers one finds overseas, not only in former Commonwealth countries, and also from the strength of our engineering

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consultancy firms. Indeed, it can be no accident that the British engineering formation has been accepted as a basis for the European engineer qualification.

Perhaps I can digress for a moment to discuss what is often described as the fragmented, institutional life of British engineering. True, we have more than 50 institutions, but apparent untidiness should not lead to presumed inefficiency. Our engineering institutions maintain high standards in education and training, and command great loyalty from their members. Their voice is heard either singly or together through the Engineering Council, which has grown in stature over the past decade. Those who attack our engineering institutions are, I believe, ill-advised, and various proposals to demolish and to consolidate them into a mega-body fail to recognize the discontinuities and loss of identity that would result.

In this respect I think that the Finniston report was ill-conceived. It proposed the abolition of the existing engineering institution structure and a fresh start with an unproven body. I believe that the British culture favours an evolutionary approach rather than a revolutionary *coup*, and so my time in engineering institutions and at the Engineering Council has been directed towards an orderly movement towards greater unity, while exploiting the strengths of the individual institutions.

Let us now look at some of the possible problems for British engineering in the 1990s. I have already referred briefly to the low regard in which engineers are held by society in its various forms. This can be irritating to the individual, but is extremely serious in its effect to the recruitment to the profession. School leavers are encouraged to take soft options and the image of the engineer, in spite of many initiatives by industry and the engineering institutions over recent years, remains dull. We do not appear to communicate to our schoolboys and girls the excitement and romance of engineering and its positive contribution to a successful and enjoyable society. Every possible effort has to be made to overcome this continuing hurdle and I must say that there are some small encouraging signs of success.

In Rolls-Royce, we are fortunate in having an active and committed training staff. Evidence of their success is provided by the fact that three Youth Opportunities people have proceeded to full degrees and that in the last six years of company training awards, half of the successes have been won by youngsters leaving school at 16, being recognized by our training officers for daytime release and then proceeding to full-time courses.

I am proud to say that at Strathclyde University 20% of the intake of first degree courses occurs through non-traditional routes. The notion that university access is only available through advanced school education is a restrictive and outdated one. Many youngsters mature late and to block them off because of timetable obstacles is unfair and wasteful. The analogy of the iceberg is a good one. One-ninth of its mass is readily visible, but the eight-ninths of its mass below the water line is highly significant.

Demographically, the number of 18 year olds is set to fall quite dramatically during the 1990s and for that reason the recruitment of women engineers will be of growing importance. University entrance levels show a growing proportion of young women, and engineering companies are awakening to the fact that they must attract them and use them properly, offering adequate promotion prospects and career break arrangements. Companies who fail to do this will regret it in a few years time because they will no longer be competitive in an increasingly difficult recruitment market.

One could, I suppose spend a long time discussing engineering degree course design and content. It is a sobering experience to chair a committee of academics and industrialists, as I have done for some years, to discuss these topics. Long and earnest discussions result in the inclusion of more and more material, necessitating, at least theoretically, extension of the course length, and this is combined with determination on the part of the industrialists to reduce the course length. I have to say that all attempts at squaring this circle are at best compromises. Perhaps one solution, proposed by the Engineering Council, is the development of an engineering course covering all disciplines at a general level with post-graduate specialization, either on a full- or part-time basis. Such developments are taking place and while I would not advocate the exclusive adoption of such a route, it would nevertheless provide a valuable approach to the inter-disciplinary work which is becoming so much more important in present day engineering.

Post-graduate courses can cover such specialized and diverse fields as finite-element analysis, materials technology, pressure vessel design or financial management. All are relevant in different ways and the central need is to direct engineering toward a competitive base and an adequately managed activity. For this reason, every engineer ought to include in his or her career development some knowledge of financial matters such as budgetary control, product costing and simple balance-sheet preparation. Without such disciplines, engineering is as irrelevant to economic wealth creation as, let us say, anthropology.

Let me at this point indulge a personal prejudice and say that I am against management training as a first degree. To manage others presumes established qualities in one's self, capable of generating the respect of those one purports to lead. That in turn requires achievement and a self-respect and confidence which can only be produced by practising one's own craft. For my part, therefore, management qualifications for engineers fall firmly into the post-graduation sector.

I mentioned earlier post-graduate qualifications and it is encouraging to see the number of part-time initiatives being adopted. Among these are the integrated graduate development courses developed notably at Warwick and Cranfield where modules of two or three weeks alternate between the university and the company with jointly assessed work leading to the award of an M.Sc. Other universities are providing part-time higher-degree courses at master and doctorate level, and I am sure that the reluctance of industry to release responsible engineers for an extended period coupled with the reluctance of those engineers to step off the promotion ladder will result in a growing demand for such courses, the more so as the need for continued specialized updating is recognized by employers and employees alike.

Let me now turn to some of the challenges for engineering during the 1990s. First among these will be the development of new materials with their promise of higher temperatures, weight savings and corrosion resistance. The challenge of these developments has already resulted in substantial changes in university departments, which now have to cover not only metals, but ceramics and composites as well, and also in establishment of research centres concerned with the new technologies of filament bonding and distribution in composite materials and with the interface between material design and product needs. Rolls-Royce established a centre at Warwick University staffed by University and Company personnel to examine this design/manufacturing interface, for new methods have to be developed and the opportunities are exciting indeed.

In this sense, materials technology has entered on a new phase in which metal alloys will remain important of course, but in which a wide range of fibre-reinforced matrices will emerge and develop. Development of these materials is a competitive international area in which the UK is not strong, yet it is likely to hold the key to much advanced engineering.

Another major challenge for engineering in the 1990s is the growing use of computers to aid design and manufacturing. Well established in most manufacturing companies by now, these techniques offer tremendous scope for bringing design close to manufacture, for reduction of batch numbers and for substantial cost reductions through design and manufacturing technique optimization. But computer-aided design brings also the danger of remoteness from the product. Gazing at a computer screen with a powerful programme and a seemingly infinite menu of alternatives is exciting and challenging, but provides a poor substitute for contact with physical processes and failures in service. The gap between theory and practice is thus enlarged and has to be bridged if engineering is to remain healthy, for from failure stems humility and there is no substitute for common sense of the machine operator or the user, whose dialogue with the designer needs to grow steadily closer.

In addition, there is a need for feedback from customers and field operatives and perhaps even more important, a need for a formal mechanism for passing on experience from older engineers to newer engineers.

Many of us will have seen the repetition of simple errors such as the creation of stress raisers, or avoiding incompatible materials which seem to raise their unwelcome heads at intervals of ten years or so. This brings the need to drive the lessons home with each new crop of young engineers and is best done in the operating company, by organized teaching and experience.

The 1990s will unquestionably see a growth in international companies and, as a result, the mobility of engineers around the world. This in turn will bring a need for language skills in spite of the pre-eminence of English in the industrialized world, and will I think inevitably drive British engineers' salaries upwards and with it the status of engineers in British society. Already, in travelling around the world, one finds colonies of British engineers in international companies holding their own and often providing an innovative spur.

Not before time, our concern with preserving and even improving the environment is growing at all levels. Manufacturing industry has done much to damage the environment in the past, but most of the solutions to environmental damage and most of the means available to avoid it in the future rest upon engineering effort. We shall, I believe, see much more concern at the design and manufacturing stage of the manufacturing industry in environmental protection and, in addition, environmental damage mitigation measures such as effluent treatment and flue gas treatment will assume increasing importance. We have yet to see the subject take its proper place in an already crowded engineering syllabus.

Many of the world problems that so concern us today can be tackled by engineers. Effluent control, clean water, communications, energy supply, health and, of course, economic wealth creation—all of these problems in the Third World require a growing engineering contribution. While the economic life of the Third World is improving, there will be increased competitiveness among the industrial nations, often seeking to sell inappropriate products to an underdeveloped economy. They too will need to adapt, and no doubt the adaptation will be driven by the increasing self-help of the Third World.

Most problems are not unique to the UK but some aspects of our history and organization make solutions more difficult. On the whole, though, I think that British engineering in the 1990s is well placed to take advantage of the new technologies and concerns—technological and social—that dominate the profession and the world. We need to be open minded and adaptable to new ideas and new industrial structures and to new education and training methods. We need to be proud of our craft and willing to adapt it to the international problems of manufacturing efficiency and environmental care.