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Personal View

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'WHERE are we going to get enough engineering graduates?' could well be the cry of the 1990s. As one instance of this problem Japan's Science and Technology Agency has revealed that that country alone will need 980,000 scientists by the year 2005 in order to maintain its industrial development. That makes 440,000 more scientists than Japan has today and, of the areas considered, the field in which there will be the greatest shortfall is engineering—a total of 300,000.

This demand comes at the end of a decade that has seen an alarming trend in the number of youngsters worldwide who reach a high standard in technological subjects and then opt for a 'glamorous' life in the financial sectors in preference to careers in science and engineering.

What is the solution? There is no shortage of suggestions. Popular examples include: teach engineering in the secondary schools; pay higher salaries to practising engineers; make engineering careers more attractive; include business topics in engineering syllabuses; teach engineering students to enjoy life! The list is endless and an international consensus, even for a single solution, is not too likely. Yet all the signs point towards the need for a sound and practical goal and a guiding educational philosophy.

To me the educational goal of engineering education has long been clear. It is to produce graduates who, on completion of courses at any level, are able to take up challenging careers and make effective contributions in whatever areas they become involved. This would apply even if they have to work temporarily outside their chosen field. For more than 15 years my approach for meeting this goal has been aimed at developing a balance of competence, confidence and communication skill in students. This approach is known in short as the '3-C' educational philosophy.

The implication of the 3-C philosophy is that a high-quality graduate is someone with an ample and balanced supply of the three C's. It is important, however, to appreciate that each of them is interpreted in the broadest sense and applied to fit the requirements of individual situations. It is also particularly helpful to have established criteria for measuring how far the balance has been evenly maintained in specific cases.

The relevant abilities associated with each C can be summarized as follows:

Competence
- Understand the fundamentals.
- Acquire and classify information.
- Access and apply knowledge.
- Generate and develop ideas.
- Identify and prioritize options.
- Formulate and solve problems.
- Analyse and make decisions.

Confidence
- Select realistic goals.
- Manage time effectively.
- Develop positive attitudes.
- Win peer respect.
- Take on responsibility.

Communication skill
- Transmit and receive oral, written, visual and physical information.
- Overcome barriers, leakages and interferences in the communication medium.

In practice these abilities can be effectively implemented in many different ways. How this is done in individual cases will depend on customers' needs and the priority given by providers to the various conflicting demands. Furthermore a portfolio of assessment methods is needed for measuring success in the different areas.

The reactions I have had to this philosophy can be readily classified into three groups.

The first group comprises predominantly those who work in industry. Their response can be stated in a single sentence: 'We like it!'. This support is generally based on personal experience, particularly of those who have reached more senior positions.

The second group expressed concern that time for developing competence should be sacrificed or shared with the other two 'Cs'. To them competence is the main objective of engineering education. Every effort should be made to 'equip' students with the most up-to-date knowledge before they leave their educational institution.

The third group considered that there is merit in the philosophy but its members have difficulty in

seeing how such an approach can be put into practice without jeopardizing the technical knowledge so vital to the work of the engineer.

I can appreciate the genuine concern of the members of both latter groups, but believe that they have perhaps confused 'quantity' with 'quality'. To them I put the following question: 'How much of what you acquired *formally* in your educational course did you use in the first 5–10 years of your career?' Answers range from 'very little' to 'A maximum of around 20%'. I have circulated questionnaires on this at international conferences and the derived average was 15%. If this is indeed representative, I wonder why students should be made to spend so much time acquiring knowledge—and to pay for what is of no real value! The key reaction to this last point can be summed up in the comment: 'We do not know which 15% will be needed by the graduates'.

Sadly, it is misconceptions of this type that have resulted in the overloading of engineering students, in the belief that a course can provide all the knowledge that will be required during a career spanning 30–40 years! It is not surprising that many become disillusioned with engineering and this in turn leads to a failure to attract high quality young people to our professions.

The principles of the three-C philosophy can be readily grasped but their implementation requires careful planning and continuous interaction between supplier and customer. In essence, however, the approach is to provide students with a good understanding of the fundamentals in a total spectrum of subjects, from science and engineering to business, social and communication skills. Selected elements of each subject are then taken to greater depth. In the teaching, a strong emphasis is placed on developing learning skills in combination with achievement of competence as defined earlier. The students are therefore exposed to different ways of dealing with technical and non-technical topics while putting into practice what they have acquired. This produces graduates with a sound academic base plus experience in building up the three 'Cs'—a combination which should enable them to cope with the varied aspects of their daily work without having to depend solely on the knowledge gained during the period of full-time study. With time and practice, the habit of self-reliance will lead them to take on fresh challenges and to continue learning throughout their working lives.

There is no question about the amount of international interest in engineering education. What are the options? There has to be much closer co-operation between suppliers and customers: both customers for courses and potential employers of graduates. Such increased collaboration should lead to more relevant engineering curricula, better designed to meet practical needs, produce quality graduates and give the students academic stimulation. It would certainly provide a firmer basis for meeting the challenge of the current demand, up to the year 2000 and beyond.