THE EDUCATION OF THE ENGINEER IN AND FOR HIS SOCIETY

European Society for Engineering Education

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1. Participants The conference was attended by just over 400 people of whom about 170 were from France itself. The next largest group was from the U.K. (39) whilst participation from other West European countries ranged from 30 (W. Germany) to 3 (Norway). Nearly 40 of the participants were from 22 more distant countries such as Morocco (4), China and Mexico (3 each), Nigeria and Thailand (2 each), Argentina and USSR (1 each).

   Of the U.K. participants, 22 were from the University sector, 12 from Polytechnics and Colleges and the remainder consisted of an officer of a professional institution (I.Mech.E.), an S.R.C. representative, a consulting engineer and two from manufacturing industry (a managing director and a marketing manager).

   Only about 6 of the 400 or so participants were practising whole-time in industry as engineers or managers. The vast majority were from educational institutions. Some were college or university administrators but most were in engineering departments covering a wide range of engineering disciplines. I may have been the only participant from a management studies unit operating independently from an engineering department, though two other U.K. members (Stephen Wearne, Professor of Technological Management at Bradford and M. Tomkins of the Management Sciences Department of Imperial College) may be regarded to some extent as in the same category. Many of the participants from a variety of countries were, however, concerned with teaching management to engineers from within engineering departments.

2. Organisation of Conference The organisers had clearly gone out of their way to ensure that engineering was noticed by "society", especially in France. Thus, President Giscard d'Estaing was made the patron of the Conference and sent an encouraging message. There were also addresses by the Minister of Universities and the Environment Minister. A representative of The Director-General of UNESCO spoke of the importance attached to the theme of the Conference. Nearly half the Conference time was taken up in general speeches by dignitaries of one sort or another. Two or three were good but the rest were of little value.

The working sessions took place in four parallel streams as follows:-

a. Functions of the Engineer (...research...creators of enterprise, educators...public services...managers)

b. Significance of Urgent Problems (energy...materials...safety...)

c. Awareness of the Social Implications of Engineering Work (...economic, political...organisation of society...public relations)

d. Interaction between Engineering and Industrial Development (...influence on technological advance...recruitment of students ...brain drain...obsolescence...continued education...technological advances into education).

There were several areas of overlap between the streams, giving rise to a rather difficult choice between them. However, one unexpected basis of choice arose. Whereas in the plenary speech sessions there were full translation facilities, in the parallel streams none were available; when therefore it appeared that a succession of papers would be presented and discussed in French, a switch was made to a predominantly English stream.

3. Papers 130 offers of papers were received, 70 of which were accepted and of these, which came from 17 countries, just over half were presented orally, the remainder being in written form. Opportunity was given for discussion by the authors of written presentations but time was limited. In the following commentary only a few papers are mentioned but the full list is attached. Further information (e.g. synopsis) will be supplied on request.

4. Types of engineers The Finniston report gives the impression that all developed countries other than the U.K. have established satisfactory arrangements for educating engineers required for industry. Quite the contrary impression was obtained from the conference. There is dissatisfaction in many European countries about their systems of engineering education and the appropriateness of their "outputs" for meeting national needs.

J.L. Le Moigne of University of Marseilles divided engineers into X and Y types, which had some correlation with the McGregor classification. He indicated some of their many differences as follows:-

X	Y	X	Y
Algorithm	Heuristic	Pluri-discipline	Trans-discipline
Solve Problem	Define Problem	Efficiency	Effectiveness
Precedent	New Ground	Building	Designing
Mathematising	Formalising (incl. non maths)	Rationality	Multi-criterial reasoning
The Best	Satisficing	Superiority of expert	Humility of explorer

It was said in the discussion that France is producing far too many X-type engineers. What is needed is more Y-type, especially for work as design engineers - but it was not known how to train them. On the other hand Industry in France do not want engineers who are full of ideas.

Peter G. Hauenstein of the Ingenieurschule, Basle, described a two-stream approach for the training of industrial engineers which has some similarity to that proposed by Finniston. The Masters stream produces systems engineers who are theory orientated, able to undertake complex tasks and to operate at top management level. The Bachelors - stream requires apprenticeship in industry before entering an engineering college and develops problem solvers able to apply existing methods to development and production and to work at middle management level.

5. Non-technical attributes of engineers The need to improve the communication ability of engineers was referred to on many occasions by speakers from several countries (again contrary to the impression given in the Finniston report that the U.K. alone had this problem). S. Watson of E.E.C. thought that communication ability would be increasingly important - it would be more and more necessary for engineers to act as strong advocates. A similar point was made by Madame Saunier-Seite, Minister for Universities, who thought that engineers must reach out to society as a whole and that to do this they must be good communicators. Allied to this, the Minister thought that engineers generally needed to develop a warmth in human relationships and a sensitivity to ethical and moral issues.

Plint and Weaver, engineers who have for the past 25 years run a small manufacturing company, pointed out that for success in business attitude of mind is more important than knowledge. Many engineers today do not have the right character and qualities - for example they tend to be against the capitalist system and do not obey orders. They thought that Army training was an excellent preparation for leading a small business and that academics are unsuitable for inculcating the right attitudes. It emerged in discussion that a research manager who had earned their disapproval because he had treated their instruction as a mere suggestion had left the company and set up his own business - which had proved successful.

H.L. Beckers of Royal Dutch Shell outlined his company's expectations of engineers. First he pointed out that the group employed 150,000 people in 100 countries and that 10,000 of the 20,000 people in supervisory or managerial positions are engineers. Also, 5 out of 8 members of the Board and 50 out of 80 second echelon managers are engineers. The prime requirement was for success as managers in a wide range of cultures, leading to a need for a three-dimensional engineer characterised by engineering competence, managerial capacity and cosmopolitanism (belonging to all parts of world, free from national limitations). Change and complexity (not just in engineering but in other terms e.g. social, environmental, etc., etc.) are key characteristics of the situations with which their engineers have to deal and it is necessary to adopt an approach of open reasoned

argument in which all factors are brought to light. The competitive element in an engineer's make-up and the engineer's inclination to concentrate on quantitative aspects and neglect other non-quantitative features, ill-fitted most engineers to the open, comprehensive approach. Years of experience had led them to look for engineers with:

(i) the power of analysis
(ii) imagination
(iii) a sense of reality
(iv) a helicopter view.

The helicopter view, which was regarded as more important than the other three put together, was described as an ability to take an overview, to give simultaneous attention to many relevant details, to place facts and problems within a broader context and to detect relationships with systems of broader scope. Above all, the kind of engineer they were looking for should not lower the helicopter for fear of being shot down.

The Ideal Engineer Leonardo da Vinci was cited on many occasions as the ideal engineer. Clearly he could be classified in the Y category, having produced a number of major ideas - but he suffers from the drawback that he achieved very few of them. Possibly the adulation of Leonardo da Vinci as an engineer arises from his superb line-drawing ability. This must endear him to mechanical engineers but I wonder whether electronic engineers, whose basic design is at the more abstract level of circuit and semi-conductor processes rather than observable objects, are particularly impressed by this gift. Alternatively the esteem for Leonardo da Vinci as an engineer may be a reflection of the desire for breadth - this particular engineer is also recognised as one of the world's greatest artists and with his Mona Lisa in the Louvre how could he be other than the ideal engineer?

I found it necessary to repeat a remark I made two years ago at a Darmstadt Congress on engineering education, that the attributes being sought in engineers - technically excellent, first-rate communicators, a warm and fully understanding approach to fellow humans, able to operate with outstanding success in the political arena, etc., etc. required engineers to be demi-Gods or the engineering profession to be a corporate sub-God.

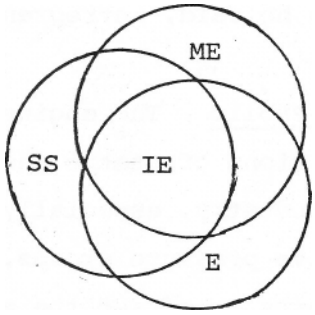
7. Teaching non-technical subjects to engineers A paper by d'Agostino et al of the University of Naples gave detailed information on the non-technical content of engineering courses in 18 Universities in Italy. Most of the Universities provide some lectures on the general or theoretical aspects of economics and law. It was commonly found that students were mainly interested in technical subjects and that teachers seconded for these subjects from outside the engineering faculties lost no time in going back to their own faculty. The authors thought that with the need for more effective management of technology and for engineers to play a crucial role at decision levels in organisations, there should be a radical change in approach to teaching non-technical subjects.

Two Universities - Udine and Calabria - show strong signs of such change. Their teaching is of a much more applied nature - for example at Calabria the courses provided include:

History of Towns and Town Planning
History of Science and Technology
Urban and Rural Sociology
Regional Planning

S.D. Koyluoglu of the Middle East Technical University in Turkey described a course on financial operations and project control for undergraduate engineers. Much of Turkish industry comprises small to medium sized engineering companies which could not afford to employ experienced or trained managers who are in very short supply. Consequently, engineers are required to carry out managerial functions for which, however, they are ill-prepared. The course arose out of surveys of the needs of industry. There was some comment in discussion, including remarks by myself and R.J. Wheeler of Lanchester Polytechnic based on our respective papers, that at the undergraduate stage engineers should be educated to understand management rather than be trained to be managers (other than of themselves), and that it was desirable to bring out the non-quantitative aspects of management (e.g. human relationships). It was noted that the request for inclusion of the quantitative (engineering-like) financial and project control course came from engineers in industry who were themselves struggling to be managers.

Industrial Engineering (1E) at Basle was described as a combination of mechanical engineering (ME), social science (SS) and economics (E) related as shown in the diagram.



In each discipline, learning objectives are stated and these are based on skills and abilities, not knowledge. For example, one of the learning objectives specified for a factory planning exercise was "interpret company politics."

The courses emphasise the innovative and entrepreneurial aspects of engineering and aim to avoid the damage caused by the "work with hands in industry/work with heads in college" characteristic of many sandwich courses.

8. Creativity, Innovation and Entrepreneurship There was a great deal of interest in the innovative aspects of engineering and the creation of new engineering enterprises. This is to be the theme of the 1982 S.E.F.I. Conference in Delft. There was a call for engineering schools to set up innovation units and one such was described by C. Karlsson of Chalmers University of Technology, Sweden. Students, teachers and researchers interact in a combined product development and innovation/management centre. A course has been provided on how to come through with a new idea and there were 100 applications for 30 places. Many of those accepted left before the end to set

up their own businesses but continued to use the lecturers as consultants. With the aid of Government money a "research park" is being set up and, to facilitate the application of the results of research, special courses will be provided on entrepreneurship, setting up a business and innovation.

There was frequent reference to the role of engineers as entrepreneurs. S. Watson of EEC (responsible for education for entrepreneurial activities) said that an entrepreneur is often regarded as an ignorant hero who becomes less effective the more he learns. We need to devote more attention to developing in engineers the skills of being an entrepreneur. He thought that we needed to develop both opportunity recognition and information handling skills to make good entrepreneurs. The products of business schools were essentially academics who become corporation managers and such managers are not, he said, entrepreneurs.

9. The Public The engineering profession appears to be preoccupied with questions of status and prestige. Low status affects recruitment to industry, especially into those branches which have spawned reactive pressure groups. A. Michel of Belgonucleaire spoke of efforts to offset the anti-nuclear lobby. There have been difficulties in communicating with the public because, he said, engineers think rationally, whereas there is a great deal of irrationality in society and also because an engineer is not very capable of thinking himself wrong: He reported failure in an attempt to overcome the problem for industry generally - an idea that apprentices/trainees should show visitors (including schoolchildren) around industrial enterprises was put to 70 companies and only 4 showed sympathy. In general discussion, I suggested that engineers should become directly involved in society, a point which was brought out in the final summing up session.

10. Politics In the discussion on status it was said that engineers are ineffective as tools of social change and that change could only be brought about by political action. One contributor said that engineers can be given an insight into politics, for example by including political issues in a History of Technology course. It was reported that in Belfast, engineers were provided with a course for enhancing social and political awareness. One unidentified U.K. contributor with responsibility for teaching non-engineering subjects, argued along the lines that the U.K. is run by civil servants who are trained in the humanities, that such training does not affect the humanity of a person, the inhuman closing down of small schools and community hospitals is due to the civil servants and until we get rid of these there will be no worthwhile political changes made. Looking at politics the other way round P. Laffitte, President of the Conference des Grandes Ecoles, thought that politicians should realise that the future of everybody is being formed in the engineering schools.

11. Continuing Engineering Education The growing importance of continuing engineering education was emphasised on a number of occasions during the conference. Interest was world-wide - for

example one participant from Mexico was Head of a Continuing Education Division of a College of Engineering while another from Greece was Director of a Continuing Education Centre. Another manifestation of interest was the agreement of the S.E.F.I. General Assembly (which was held during the Conference) to set up a Working Group on Continuing Engineering Education, which will have amongst its functions the working towards a Conference on the topic in Paris in 1983. I am a member of the Working Group and a co-ordinator of the U.K. contribution to its deliberations. The extent to which management studies should feature in continuing engineering education is still an open question - I am trying to obtain clarification on this point by means of a questionnaire to be sent to U.K. members of S.E.F.I. (and possibly members in other European countries).

12. Developing Countries The problems of engineering education in or for developing countries was considered in one of the sessions. In the summing up, differences in approach were described - some insisted on in-country training while others thought equally strongly that training should be in highly industrialised countries. It was said that in developing countries, research to back up teaching is not always necessary - such research favours sophisticated knowledge for which there is no need. There was a call for greater exchange of engineering teachers between developed and developing countries, as part of the continuing education of the teacher-engineer.

13. Glimpses of the Future There was a great deal of comment about the future particularly in a closing address by M. Elmandjara, President of the World Future Studies Federation. Points made include:

- a changeover from a "limit to growth" to a "no limits
- engineers will need to be energy orientated
- innovative rather than maintenance learning will be required
- a major basis of decisions will be "vulnerability to change" and "flexibility"
- engineers (and others) should be trained for the society in which they will be living
- the know-how approach (which is the major preoccupation of engineering schools) will change to a know-why approach.

14. Management Studies There was a great deal of antagonism towards management studies units together with repeated comments that the teaching of management must be carried out by engineers because they are the only teachers with credibility in the eyes of the engineering students. On the other hand some contributors recognised the problems arising from teaching management as a 'hard' subject akin to engineering and the possible damage caused by the engineering content to dissimilar attributes required for management (both referred to in my paper). Karlsson of Sweden spoke of the deforming effects on students of the typical engineering course, which made them unfit for management and described a new arrangement designed to overcome this basic problem, in which natural science, technology, social science and projects are integrated from the start of a four-year course.

15. Acknowledgement I would like to express my warm appreciation to N.W. Metropolitan Regional Association for Management Development for the Bursary enabling me to attend the Conference and to the secretarial staff of Birklands for their patience and skill in typing the Conference paper and this report.

H.V. Beck
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