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Overview

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THIS special issue of the *International Journal of Engineering Education* reflects the conviction that those concerned with engineering education should build a much more interactive international community. Engineering research has advanced by the close working relations which have developed between specialists in different countries. Similarly, engineering education can be enriched by active international relationships. Much can be learned from the experiences and insights of engineering educators from other countries.

The systems developed for the 'formation of engineers' in the industrialized countries have significant differences. Such systems are embedded in the country's overall educational and societal framework. While the characteristics of these frameworks differ, the systems for the formation of engineers have a common objective, that is, to produce individuals with the ability to effectively perform the increasingly demanding tasks confronting today's and tomorrow's engineers. The performance requirements for engineers are becoming globalized as engineering-intensive companies operate increasingly in a market-place not limited by national boundaries. Products and services are more and more designed, produced, and marketed on a global basis.

The formation process by which a young person develops the intellectual skills needed to pursue a career in engineering is complex. There are both the academic and on-the-job components. In the academic phase, the mastery of both analysis and synthesis techniques is built on a mathematical and scientific foundation. This part of the formation process provides the launching platform for future professional development.

The on-the-job phase of the formation process corresponds to the clinical part of the education of medical physicians. Individuals are confronted with the practical problem-solving which constitutes the actual practice of engineering. They must integrate knowledge, experience, and ideas to meet the objective of designing products, processes, or services. They learn how to meet the requirements of customers.

Engineering has been rightfully labelled a learning, as well as a learned profession. Both the knowledge-base and the many other factors influencing engineering practice are changing significantly. The additions to the knowledge-base are many and rapid. New requirements, such as those derived from the present-day demand for increased ecological sensitivity and sustainable development, are changing engineering practice. Increasingly such changes originate from international sources. Thus strong international links between those concerned with both engineering practice and the formation process are of evident value.

The authors of the papers in this special issue were all participants in a conference entitled 'Making an Engineer: Learning from International Comparisons' which was sponsored by the Engineering Foundation which has its headquarters in New York. The conference was held in Santa Barbara, California, 16–20 August 1992. The conference focused on the process of formation of engineers in a number of industrialized countries. Engineering educators, as well as industrially employed engineers presented papers and contributed ideas in the discussion periods.

Several national systems were described with their distinctive characteristics. For example, the German dual system of Technische Hochschulen and Fachhochschulen provides German Industrial companies with engineers with both theoretical and practical expertise. German companies in turn have organized their operations to use these capabilities. Major Japanese companies have developed very comprehensive in-house systems for developing both the technical and managerial skills of their incoming baccalaureate-degree engineers. The United States, Canada, and Israel have many similarities in their undergraduate emphasis on engineering sciences and their strong graduate research-oriented programs. The United Kingdom features both three-year as well as four-year curricula including both thick and thin 'sandwich' programs.

None of these national systems are static; each is undergoing change. The increasingly global nature of the engineering enterprise, the rapid changes in technology, the importance of non-technical issues in engineering practice are being responded to in differing ways. It is from the diversity of these systems and their on-going development that much

can be learnt. As companies 'reverse-engineer' the products of their competitors, so the formation-process community should study the experiences of their international colleagues. As the papers in this issue demonstrate, there are many similar problems, but there are diverse ways of meeting them.

The first block of papers focuses on characteristics and trends in the formation systems of a selected number of major industrialized countries. The Japanese academic system is presented in its historical context by Professor Sogo Okamura whose career has included being a faculty member at the University of Tokyo, a government administrator, and now President of Tokyo Denki University. The strong role of the industrial community in the formation process is accented by the paper by a mechanical engineer, Ryozo Ito of the Toyota Motor Corporation on the company's professional development system for engineers.

A strong contrast is provided by the next three papers which describe the German system. Here, the Fachhochschule perspective is given by Professor Rudolf Taurit, the Principal of the Fachhochschule in Lübeck, and the Technische Hochschule perspective is given in the paper by Professor R. W. Staufenbiel, Chair of Aerospace Engineering at the RWTH Aachen. An insightful industrial perspective is provided by Dr Kruno Hernaut of Siemens AG of Munich.

Systematic changes in US engineering education are described by Professor Joseph Bordogna of the University of Pennsylvania, who is currently the Assistant Director for Engineering of the US National Science Foundation. President Saul Fenster of the New Jersey Institute of Technology concentrates, in his paper, on the new directions at his institution, one of the growing technologically-oriented universities in the US.

There are both similarities and differences between the US and the Canadian system which Professor Gary Heinke, Dean of Engineering at the University of Toronto, describes in his paper. Another system which has strong ties to the US is Israel; Professor Zehev Tadmor, the President of the Technion, describes the new directions which are being explored.

However, there are substantial differences in the United Kingdom. These differences are highlighted by Dr V. David VandeLinde, the newly appointed Vice-Chancellor of the University of Bath, who had been for many years the Dean of Engineering at the Johns Hopkins University in the US. Some future directions are discussed by Professor John J. Sparkes of the Open University who has been active in the UK Engineering Professors' Conference.

A second block of papers views the formation process from the perspective of employers and students. Vice-Chairman Hans Decker of the Siemens Corporation in New York describes some aspects of engineering practice from a global employer's point of view. President Hermann Viets of the Milwaukee School of Engineering in the US describes a five-year program at the University of Rhode Island which provides undergraduates with an opportunity to gain a degree in engineering and German simultaneously, as well as work experience in a German company. Professor Arnold Allentuch describes the various programs available to students at the New Jersey Institute of Technology for international study and work.

Finally, there are two papers which permit direct comparisons of some of the characteristics of the formation process. One by Professor Henry A. McGee of Virginia Polytechnic Institute and State University, who is presently a National Science Foundation Division Director, directly compares chemical engineering education in Japan, Germany and the US on the basis of his personal observations. Finally, a paper by Barbara Hibino, a Ph.D. candidate at Stanford University, compares the education and training processes for engineers employed by two global automotive companies, Ford and Nissan. Her observations are based on interviews in plants in the US and Japan, as well as Mexico where each company has recently set up manufacturing facilities.

Unfortunately space limitations in this issue prevented the inclusion of all the papers presented at the conference. In particular, a provocative paper from a US industrial perspective by Dr Peter Cannon, Vice-Chairman of the Board of Engineering Education of the US National Academies' National Research Council, concerning the supply of engineering graduates in the US, had to be omitted. Also a paper by Profssor Fumio Kodama of Japan's National Institute of Science and Technology Policy relating to the supply of Japanese engineers could not be included.

Hopefully, the readers of these papers will arrive at the same conclusion that participants at the conference did; namely that there is a rich source of information and knowledge about the formation-of-engineers process available through the study of current programs and trends in other countries. Good engineering practice requires the systematic examination and use of extant information and experience. Further systematic efforts in this direction are clearly warranted.

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