Guest Editorial

As PROFESSIONALS of the IEEE-SMC community, we all are or have been involved, directly or indirectly, with education: as (former) teachers, or as (former) students. The design, management and evolution of our educational system is of utmost importance to the future generations of engineers and scientists. At the same time, it provides a variety of challenges.

Among the key challenges pointed out by the UNESCO declaration on worldwide education [1] are innovation, interdisciplinarity, transdisciplinarity, cooperation with the labor world, and adaptation of quality in relation to the variety of cultures. In addition, the challenge is not only to transmit what science and technology is and allow, but also to prepare students to the increasing complexity of our world, and exploit the opportunities offered by recent developments in information and communication technology. New forms of educational practice have to be developed to allow for more open experiences, to introduce a reflexive attitude within the practice of teaching, and to prepare for distant and individual-centered education.

These challenges relate to Systems Engineering in two ways. First, the design, management and adaptation of educational systems, from the level of overall system functionality, structure and organization down to the level of operational teaching forms and supporting tools, is a complex task to which systems engineering may have much to contribute. Second, educational requirements of interdisciplinarity and problem solving across a range of disciplines point to an increasing need to include systems engineering knowledge and abilities to a larger extent in our education, options varying from inclusion of systems thinking in existing curricula to the further development of separate curricula in systems engineering.

After in particular Andrew P. Sage had regularly published about education in IEEE publications [2]–[10], an upsurge of interest in educational issues occurred at the 1994 IEEE SMC International conference held in San Antonio. A panel session generated a sort of informal task force on issues in systems engineering education. Several professionals of higher education coming from various countries and various educational systems felt the necessity to share and communicate experiences. As a result, special sessions devoted to systems engineering education within further IEEE-SMC international conferences of Vancouver, Beijing, and Orlando were organized. The different aspects of the exchanges produced within this informal group can be found in the proceedings of those conferences [11]–[26].

Directly involved in this group, we thought it was worthwhile to attempt a first synthesis, consolidation and dissemination of experiences and views. The papers in this special issue resulted from an open call. Most, however, were contributed from the group that had been active in the SMC conferences. After a selection and review process, seven contributions resulted that may be grouped in three categories:

First, the two contributions by Sage, and by Asbjornsen and Hammann, discuss a number of general aspects of systems engineering and their educational consequences. Both relate to the need for integration of systems engineering as a practical activity and systems engineering as a conceptual structure embedded in system theory. While Sage primarily reflects on the general aspects, Asbjornsen and Hammann elaborate in particular on integration of systems engineering within more specialized educational programs in different fields of engineering education.

Second, three contributions provide views and report on experiences with respect to particular aspects of systems engineering education. They originate from the European curricula of Ecole Centrale de Lille in France and Delft University of Technology, in the Netherlands. Bigand, Craye, and Deshayes describe the idea's underlying project courses as a crucial component in systems engineering education. In particular, they concentrate on the management and evaluation of project courses, and come up with a number of practical suggestions based on extensive experience. Next, Van Peppen and Van der Ploeg discuss the more general issue of quality control and management at course and curriculum level. They present a conceptual design of a stakeholder-based quality management system, and report on the experiences with this system in the context of the Delft curriculum in Systems Engineering, Policy Analysis and Management. The third contribution is this category discusses the application of systems design principles to the (re)design of the Delft curriculum. In addition to an elaboration of the design principles, Bots and Thissen stress the multi-actor nature of the curriculum design process, and report on successes but also on problems encountered and lessons learned from this perspective.

The final two contributions return to the more general issues of curriculum content and future developments. Brown and Scherer analyze the core content of a variety of US curricula granting degrees in systems engineering. Using cluster analysis techniques they find three major orientations: industrial engineering, system analysis (and design), and control systems, being itself subdivided toward either general methods or toward applications in specific engineering fields like electrical engineering. They conclude that there is no clear agreed upon core curriculum of Systems Engineering as a discipline, and that different views persist with respect to the preferred curriculum structure. Options vary from undergraduate, like any other engineering field, to graduate and doctorate level, as a systemic extension of a well established engineering field. In addition, they point to the importance of the integration of information technology and system analysis and design. In the last contribution, Tien carries us then to the possibilities and challenges of a more radical restructuring of education delivery in relation to the development of information and communications technology. Do we have to prepare for an individual centered approach that would allow any one to access educational materials or multimedia courseware at any time and from anywhere,

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which would radically change the character of both the teaching profession and the university? How can we prepare for such a challenge?

A spectrum of a systems engineering curricula for the twenty-first century can implicitly be extracted from the different contributions. It varies in structure from a traditional engineering based curriculum with a system-oriented approach integrated in it, via a graduate specialization in systems engineering to independent undergraduate curricula primarily concentrating on systems engineering from the first year on. It varies in content across orientations to control engineering, industrial engineering, generic system design and strong inter-linkage with information technology, and from a focus on analytic and design tools and techniques to a broader approach including ample attention to the multi-actor context of systems design, and to policy and management issues associated with this. Each of these is associated with their own challenges, various of which are pointed out and elaborated in the papers contributed to this issue. Beyond this, much is still to be learned about how the different forms of systems engineering education would fit the different needs of society.

Yet other challenges could be pointed out, not discussed here. For example, evaluation of students, interdisciplinary research, international exchange of students, and multicultural comparisons are all very relevant.

We hope that our modest attempt at a first synthesis will stimulate interest and reactions, and will be followed by more interaction and learning on (systems engineering) education during the twenty-first century. The topic is of utmost importance to both the IEEE-SMC community and society as a whole.

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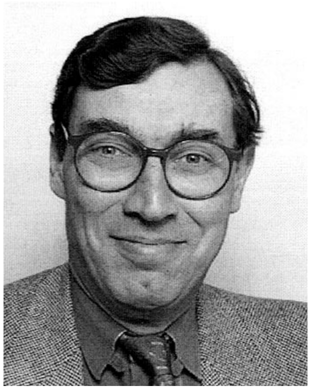

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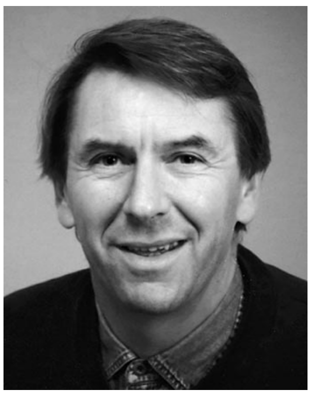

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