Educating Future Technical Leaders

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I. A Call of Systems-Thinking Engineers

After decades of development work and technological achievements, numerous technical products in a mature form have now been presented to the world. At the same time, world trade increases over expanding areas in an unprecedented rate. Signals are given that a vast majority of tomorrow's engineers will do technical service work rather than research and development of new products. Partly as a consequence of this situation, many of to-day's engineering educators concern about replacing a "curriculum-based" study with a learning program based on "systems-thinking".

"Systems-thinking", it may be asked – what is new about that, haven't engineers always been thinking in terms of systems like control systems, traffic management, and so on?

Yes, of course they have, and the "hard" results are found everywhere. However, the new paradigm (way of thinking and acting) asks for an extension of the engineer's systematic way of problem solving into new and more general fields of interest. Then a question arises: how can this challenge be handled by engineering educators without sacrificing the profile of the engineer? Not surprisingly, this issue has for a long time been discussed by engineering educators.

Some educators, for instance Ertas et al. [1], have begun using the term "transdiscipline". This concept should mean that course content is not the issue. In stead, the choice of learning process is the key element. Such approach could, applied to the undergraduate level in particular, maybe, yield interesting results. Even if the noun "transdiscipline" is not being used, the conceptual thinking is supported by others, for instance Moore and Voltmer [2], who are calling for an engineering education renaissance. to

II. Engineering Made Invisible?

Thus, some authors seem to agree that it will be necessary to replace the present "curriculum-thinking" paradigm with a more holistic approach. Such thinking could mean that present-day's fairly large number of mutually nearly independent courses ought to be substituted by a few sequences of broad-scoped courses. Examples of such "courses" [1] are design, process, systems, and metrics. Together should these four elements form an entire educational program.

Design, process, systems, and metrics – one may wonder: where is the engineering part of it? A closer look at these four "courses" may indicate an answer.

III. A New Engineering Education Curriculum

To educate engineers to serve businesses competing in a global market a transdisciplinary educational program [1] may be constructed in accordance with Table 1. The table intends to show a general relationship in thinking and culture (design, process) between *all* disciplines. The table indicates that there should be no significant difference between principles and learning methods applied to, for instance, the education of priests, lawyers, economists, medical personnel, and engineers. Only the content of Systems and Metrics will differ from one profession to another, and even here, there will be some overlap.

IV. A Common Denominator: Training Leaders of Tomorrow

A closer look at Table 1 shows that the *content* of the Design and Process rows describes tools to be used by any leader at any level in any organization. A pedagogical program should, ideally, provide universal training in the application of those tools under real-life, though fairly protected conditions. Thus, it can be claimed, that a transdisciplinary educational program is, by nature, a way of training leaders. An internationally oriented company of to-day is handling a multitude of different tasks. To contribute efficiently in making the company competitive, a technical education at college level should clearly be considered a training of leaders with a particular insight of technology and engineering culture.

V. IEEE Education Society Facing the Challenge

Recently, IEEE Technical Activities Board (TAB) in 13 points reviewed IEEE's 39 societies. These points included, among others, mission statements, core values, and society interaction. As one society's objectives and fields of interest rarely can be "clean" with respect to others, several overlaps were noted. However, Education Society was different. Says the TAB Society Review Committee: "Vetting this Field of Interest (FOI) against all the other IEEE FOI's available showed an *explicit* overlap with only one: the FOI of the Engineering Management Society."

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TABLE I
KEY ELEMENTS OF TRANSDISCIPLINARY THINKING AND STRUCTURE

Scope	Sequence	Elements
All disciplines	Design	*Fundamental nature of design abstractions as a key engineering tool*: Problem description, organization of resources, synthesis of ideas, construction, testing, evaluation
	Process	*Key concepts and techniques in dealing with process development and management:* Necessary methodology by which a task or set of tasks is carried out. Processes can be electrical, chemical, mechanical, political, social, etc.
Engineering fundamentals	Systems	*The philosophy of integrated systems with emphasis on the interplay between tools and techniques of different disciplines:* Technical content, delivered according to principles given by Design and Systems
	Metrics	*The development of concepts of engineering measurement as well as quality assurance:* Technical content, delivered according to principles given by Design and Systems

TABLE II
A COMPARISON OF OBJECTIVES/MISSION STATEMENTS AND FIELDS OF INTERESTS

	Education Society (ES)	**Engineering Management Society (EMS)**
Objectives Mission Statement	The objectives of the Education Society shall be scientific, literary, and educational in character. The Society shall strive for the advancement of the theory and practice of electrical and computer engineering and of the allied arts and sciences, and the maintenance of a high professional standing among its members and affiliates.	The IEEE Engineering Management Society (EMS) directs its efforts toward advancing the practice of engineering and technology management as a professional discipline, encouraging theory development for managing organizations with a high engineering or technical content, and promoting management transitioning and high professional standards among its members.
Field of Interest	The Education Society's field of interest shall be: 1. Educational Methods. 2. Educational Technology. 3. Instructional Materials. 4. History of Science and Technology. 5. Educational and Professional Development Programs within Electrical Engineering, Computer Engineering, and allied disciplines.	The Engineering Management Society's interest include but are not limited to: 1. Technology policy development. 2. Assessment and transfer. 3. Issues related to research, development, design, evaluation, production, and operations. 4. Innovation and entrepreneurship. 5. Program and project management. 6. Strategic management and strategic planning. 7. Education and training related to engineering and technology management 8. Transitioning to management. 9. The socioeconomic impact of engineering and technology management.

A comparison of objectives/mission statements and FOI's between the two societies is given in Table 2.

VI. THE "*EXPLICIT* OVERLAP": TRAINING TECHNICALLY LITERATE LEADERS OF TOMORROW

From an educational "systems-thinking" point of view as presented in Table 1, a look at Table 2 should make it clear that this "*explicit* overlap" really exists. First, the ES Objectives and EMS Mission Statement express a common goal from different points of view. While ES focuses on tools to reach educational goals, EMS describes some goals which are overlapping ES goals in a holistic perspective. Second, ES FOI numbers 1 and 5 in particular, cover all elements listed by EMS.

Moreover, if the teacher organizes the learning program well, Table 2 even applies to the students' learning situation. Namely, in addition to learning the fundamentals students are trained, from a holistic point of view, to master new technology, adjust to new situations nationally and internationally, and efficiently cope with workplace reorganizations. Given a learning situation where students must take responsibility for organizing and documenting their learning progress, an environment for education of technically literate leaders has been organized.

VII. Broad-Scoped Thinking and Cooperation is the Key

Apparently, in a perspective of educating future technical leaders, the two Societies stand united in their visions. Supporting the development of transdisciplinary learning programs may help visions come true.

References

[1] Atila Ertas, Timothy Maxwell, Vicki P. Rainey, and Murat M. Tanik, “Transformation of higher Education: The Transdisciplinary App¬roach in Engineering”, IEEE Transactions on Education, Vol. 46, No 2, May 2003, pp. 289-295.

[2] Daniel J. Moore and David R. Voltmer, “Cur¬ri¬culum for an Engineering Renaissance”, IEEE Transactions on Education, Vol. 46, No 4, November 2003, pp. 452-455.