

Electrical and Computer Engineering Education in the 21st Century: Issues, Perspectives and Challenges

L. SEVGİ

*Doğuş University Department of Electronics and Communication Engineering
Acıbadem, Kadıköy, 34722 İstanbul-TURKEY
e-mail: lsevgi@dogus.edu.tr*

Preface

The initiation of the study of this special issue went back to the first quarter of 2004 and was conceived by Prof. Kemal Leblebicioğlu, the editor-in-chief. It is, therefore, a product of nearly two years of intensive collaborative labor. I've been attending international panels/discussions on "how teaching engineering can be improved" in this *information century* with breathtaking progresses in science and technology for sometime [1-4], and have witnessed national and international efforts here and there in universities, in educational and research institutes, governmental agencies, etc. Prof. Leopold B. Felsen and I had an introductory paper [1] on this topic in another special issue of ELEKTRİK published in 2002 [2]. Problems and challenges related to EMC (Electromagnetic Compatibility) and BEM (Bio-Electromagnetic) engineering are outlined in the IEEE paper [3] prepared by me which was published both in 2003 and 2004. Finally, challenges of establishing an intelligent balance between real and virtual engineering labs discussed by me and Prof. Cem Gökner was also published in another IEEE paper [4].

Engineering is *the art of applying scientific and mathematical principles, experience, judgment, and common sense to make things that benefit people*. The four key words in engineering education (EE) are *mathematics, physics, experience* and *practice*. Engineering is based on *practice* minimums of which should be gained in labs during the university education. However, the cost and comprehensiveness of the lab equipment today becomes higher and higher. On the other hand, a regular PC may be turned into a virtual lab with the addition of a card or two. Consequentially, engineering faculties are constantly faced with the dilemma of establishing a balance between virtual and real labs, so as to optimize cost problems, while graduating sophisticated engineers with enough practice [4].

Development of novel computer technologies, interactive multimedia programming languages, and the World Wide Web make it possible to simulate almost all of the engineering problems on a computer. On the other hand, technical challenges in engineering today, posed by system complexities, require a range of multi-disciplinary, physics-based, problem-matched analytical and computational skills that are not adequately covered in conventional curricula. Physics-based modeling, observation-based parameterization, computer-based simulations, experimentation via real and virtual labs, model validation and data verification through canonical tests/comparisons are the key issues of current engineering education [3].

Engineering education problems in, for example, USA, Japan, Turkey, EU, etc., are quite different.

They differ even inside the EU, for example in Greece and in Netherlands. The demand from industry, market, and preferences of engineering students are inhomogeneous and this makes it very complex to rebuild a dynamic EE curricula. The generic question is *how, with what* and *how much* an engineer is going to be equipped during the four-year engineering education?

I've known university professors, who have written papers (even books) on some topics, for example, on radars, antennas, discrete Fourier transforms, etc., based on theoretical investigations but have never practiced on. How do you think a professor can teach engineering effectively without having engineering experience? Is it possible to be a good pilot without flying, a good surgeon without operating on a patient? There is nothing to discuss if your answer is "YES".

The fundamental problem in modern engineering education is that we have two types of engineering educators; *nearly four out of five who tell how to perform* (unfortunately, who are also in charge of the administration) and *one out of five who perform* (unfortunately, who do not have any power in the administration). The funniest thing for me is that these efforts mostly come from people who have only interested in teaching, but never in engineering. My philosophy is simple and clear;

People who do not care about the Earth and the Universe (the physics of the problem), the theories (mathematics behind physics) and the practice at the same time can not teach engineering effectively.

With all these in mind, I have been speculating about engineering education in science and technology corners/columns of newspapers, technical journals, conferences, panels, etc., for many years [5-8]. The last one was the international Colloquium on "Electrical, Computer and Power Engineering Education and Training" ("ELCOMPEET") which took place in Iraklio, Crete on November 11-12, 2004 [6]. The 10-member Panel of experts from 8 countries chaired by the Secretary-General of the International Council for Electric Power Systems (CIGRE), discussed problems related to engineering education, with the focus on *power engineering*. Focal aim in this Colloquium was the comparative study of the various approaches to matters of Education, Training and Certification, as well as the practice in different countries (mainly Europe and America). Therefore, I believe this special issue is very timely. I also believe that the topic is very important and has a high archival potential. There are numerous valuable contributions from all around the world. The content is divided into two parts: The first part contains papers that deal with philosophical issues in engineering education; current issues and problems, challenges, etc. A few technical papers are given in the second part.

Papers

Part 1 starts with the introductory paper by the well-known scientist, a giant in electromagnetics, Leopold B. Felsen from Boston University, Dept. of Aerospace & Mechanical Engineering and Dept. of Electrical & Computer Engineering (part-time), also University Professor Emeritus, Polytechnic University, Brooklyn, USA. Prof. Felsen attempts to highlight various aspects on EE teaching analysis to a computer-weaned generation. He points out that a major challenge is to persuade EE students to become exposed to electrodynamics. Also, he summarizes his 50-year of international experience and collaboration with his colleagues from variety of different countries with a set of interesting.

The second paper entitled "Electronic Publishing for Engineering Education" belongs to Prof. Donald G. DUDLEY from Electromagnetics Laboratory of the Department of Electrical and Computer Engineering, the University of Arizona, USA. Prof. Dudley, being the editor of the IEEE Antennas and Propagation Society Classical Series, has long been involved in IEEE publishing, therefore must have a lot to say on

electronic publishing. The third paper discusses innumeracy and public understanding of science. Prof. Levent Sevgi from Doğuş University, Dept. of Electronics and Communication Engineering, Istanbul, presents a paper entitled “Speaking with Numbers: Public Understanding of science”.

Then comes another interesting paper, written by Prof. Cynthia Furse and her colleagues Professors April Kedrowicz, Sundry Watanabe, and Damon Hall of Center for Engineering Leadership (CLEAR) and Center of Excellence for Smart Sensors of the Department of Electrical and Computer Engineering, in University of Utah, USA. Their title is “Infusing Technical Communication and Teamwork within the ECE Curriculum” where they discuss a unique approach to infusing formal training and practice in oral and written communication and team work development in the Department of Electrical and Computer Engineering (ECE) of their University. They aim to infuse writing, speaking, and teamwork experiences throughout the ECE curriculum as alternatives and reinforcements to the standard “lecture” pedagogy; in other words not simply “writing experiences,” but rather an alternative method to teach engineering concepts.

The title of the paper by Prof. James M. Conrad of the Department of Electrical and Computer Engineering, University of North Carolina - Charlotte, USA is “Software and Hardware Tools for Teaching Communications Concepts and Introducing Students to Low-Power Wireless Communications”. Prof. Conrad states that engineers who have knowledge of embedded systems and wireless communications will be in high demand, but students can not learn about these technologies during hands-on lab exercises because there are only a few affordable environments available for classroom use. Therefore, together with his colleagues he provide students with hands-on lab exercises which represent some areas of communications and wireless communications used in industry. The next step suggested is a follow-on Wireless Enabled Embedded Systems course.

A highly effective education project has been carried out by Dokuz Eylül University in İzmir. Prof. Cüneyt Güzelış, Dean of Engineering Faculty, discusses their years of experience in the paper entitled “A Problem Based Learning Experience in an Engineering Faculty”. Similar discussion is presented by Prof. Menas Kafatos, Dean of School of Computational Sciences (SCS) and director of Center for Earth Observing & Space Research in George Mason University, USA. The paper “Computational Sciences: At the Intersection of Science and Engineering - Case Study for Academic & Research Programs” prepared by him and his colleagues Professors Peter Becker and Zafer Boybeyi contains details of their discussions.

Professors Johan Smit, Peter Morshuis and Edward Gulski, from Delft University of Technology, The Netherlands, in their paper entitled “Readjusting the current trend in Electrical Power Engineering” outlines basic problems in power engineering education, and point out ways of solutions. In his short letter entitled “An International Dialogue on Electrical Engineering Education” Professor Thales M. Papazoglou, *Chairman – ELCOMPEET’04, from the Technological Edal Institute of Crete*, summarizes the international Colloquium on Electrical, Computer and Power Engineering Education and Training (ELCOMPEET) which took place in Iraklio, Crete on November 11-12, 2004. Professors Riadh W. Y. HABASH, Christine SUUR-TAAM, Mustapha C. E. YAGOUB, Karima KARA, and Ghanim IBRAHIM from Faculty of Engineering and Faculty of Education, University of Ottawa, Canada, highlights teaching/learning problems in engineering education from a wider perspective in their paper entitled “Online Learning Resource for Smooth Transition from High School to Engineering Education”.

Prof. Levent Sevgi from Doğuş University, Dept. of Electronics and Communication Engineering, Istanbul, presents highly interesting virtual tools that can be used in EE. His paper is entitled “Virtual Tools/Labs in Electrical Engineering Education”. In the following paper entitled “A Labview-based Virtual Instrument for Engineering Education: A Numerical Fourier Transform Tool” prepared by Prof. Sevgi and

Ç. Uluşık a LabView-based virtual fast Fourier transformation tool is introduced. The reader may download the virtual FFT tool and train themselves on various numerical problems related to this transform, such as aliasing, spectral leakage, etc.

Prof. Karl F. Warnick, from Department of Electrical and Computer Engineering, Brigham Young University, USA, and, Prof. Peter Russer of Institute for High Frequency Engineering, Munich Technical University, Germany, present a joint paper entitled “Two, Three and Four-Dimensional Electromagnetics Using Differential Forms” where they discuss circuit approach in solving EM problems. The paper entitled “Complex Analysis of the Lossy-Transmission Line Theory: A Generalized Smith Chart” is by the Professors E. Gago-Ribas, C. Dehesa-Martinez, M. J. Gonzalez-Morales from Oviedo University in Spain. The final paper “Secure Digital Communication using Chaotic Symbolic Dynamics” is written by Professors Ajeesh P. Kurian and Sadasivan Puthusserypady, from University of Singapore.

I wouldn't conclude before saluting Prof. Ernst Lueneburg who died in Aug. 25, 2004, at the age of 72. We are grateful for his many contributions in electromagnetics and for the professional legacy he left behind in all around the world. He had been very much willing to contribute to this special issue. Here is what I received from him, before he died, in April 24, 2004 in respond to my general invitation announcement:

”Dear Levent Bey,

Thank you very much for inviting me to contribute to the proposed international issue of ELEKTRIK. I am very interested to prepare a paper either by myself or in collaboration with another colleague but have not yet decided about the specific topic and title.

With best regards,

Ernst Lueneburg”

Although he couldn't make it, I hope he has a kind of İnternet access on the “other side” now, may reach this special issue under TUBITAK site, and likes the content of the issue.

September 2005

Kadıköy - İstanbul

References

- [1] L. B. Felsen, L. Sevgi, ”Electromagnetic Engineering in the 21st Century: Challenges and Perspectives”, (introductory paper) Special issue of ELEKTRIK, Turk J Elec Engin, Vol. 10, No.2, pp.131-145, Feb 2002.
- [2] L. Sevgi (guest editor), Special issue on ”Complex Electromagnetic Problems & Numerical Simulation Approaches”, Turk J Elec Engin, Vol. 10, No.2, Feb 2002.
- [3] L. Sevgi, ”EMC and BEM Engineering Education: Physics based Modeling, Hands-on Training and Challenges”, IEEE Antennas and Propagation Magazine, Vol. 45, No.2, pp.114-119, April 2003, (republished in Vol. 46, No.2, pp. 140-145, April 2004).
- [4] L. Sevgi, C. Gökna, ”How to Establish an Intelligent Balance Between Numerical and Physical Experimentation”, IEEE Potentials Magazine, pp. 40-43, Oct/Nov 2004.
- [5] L. Sevgi , ”Challenging EM Problems and Numerical Simulation Approaches”, Electromagnetics in a Complex World: Challenges and Perspectives, I.M. Pinto, V. Galdi, L. B. Felsen (Eds), Springer Proceedings in Physics, SPP 96, pp. 41-58, 2003.

- [6] L. Sevgi, "Electrical Engineering in the 21st Century: Problems and Challenges", ELCOMPEET, Current Trends in Electrical, Computer and Power Engineering Education and Training, Nov 11-13, 2004, Heraklion, Crete, Greece.
- [7] L. Sevgi, "Modeling and Simulation Studies for Wireless Propagation: Perspectives and Challenges", (4-hr short course), URSI National Meeting, Bilkent University, Sep 2004.
- [8] L. Sevgi, "Modeling and Simulation Strategies in EMC Engineering: Problems and Challenges", (Two-hour tutorial) EMC 2005 6th International Symposium on EMC and EM Ecology, St Petersburg, Russia, June 21-24, 2005.