

Electromagnetic Theory Teaching: Focussing Beyond Applications

By

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Abstract: This presentation considers the challenges facing electromagnetic education. While practical utility is generally and rightly cited as to why the subject is important and is required to be learnt, given the declining core jobs in several parts of the world, the presentation examines if the relevance of electromagnetic theory in education significantly extends beyond applications. The answer seems to be yes, given that the development of the theory contains approaches that exemplify attributes such as creativity, diversity and life-long learning. These aspects are illustrated with examples drawn from EM theory. The presentation concludes with the thought that delivering EM theory with a focus on **both** applications and attributes is worth a try.

Keywords: Creativity, Diversity, Education, Electromagnetic education, Electromagnetic units, Innovation, Maxwell's displacement current

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Krishnasamy T. Selvan obtained his BE (Hons), MS and PhD degrees respectively from Madurai Kamaraj University (1987), Birla Institute of Technology and Science (1996) and Jadavpur University (2002). He also obtained a PGCHE in Higher Education from University of Nottingham in 2007.

Selvan has been a Professor in the Department of Electronics and Communication Engineering, SSN College of Engineering, India, since June 2012. From early 2005 to mid-2012, he was with the Department of Electrical and Electronic Engineering, University of Nottingham Malaysia Campus. He also held the positions of the Assistant Director of Teaching and Learning for the Faculty of Engineering and the Deputy Director of Studies of the Department of Electrical and Electronic Engineering.

From early 1988 to early 2005, Selvan was with SAMEER – Centre for Electromagnetics, Chennai, India. During 1994–1997, he was the Principal Investigator of a collaborative research programme that SAMEER had with the National Institute of Standards and Technology, USA. Later he was the Project Manager/Leader of some successfully completed antenna development projects.

Selvan's professional interests include electromagnetics, antenna metrology, horn antennas, printed antennas, and electromagnetic education. In these areas, he has authored or coauthored a number of journal and conference papers. Selvan was on the editorial boards of the International Journal of RF and Microwave Computer-Aided Engineering and the International Journal on Antennas and Propagation. He has been a reviewer for major journals including the IEEE Transactions on Antennas and Propagation. He was technical programme committee co-chair for the IEEE Applied Electromagnetics Conference held in Kolkata in December 2011, and Student Paper Contest co-chair for IEEE AEMC 2013 to be held in Bhubaneswar. He was Publications Chair for the IEEE MTT-S International Microwave and RF Symposium (IMaRC) held in Bangalore in December 2014. He co-organized sessions on EM/microwave education during IMaRC 2014 and International Symposium on Antennas and Propagation, Kochi, 2014.

Selvan founded the Madras Chapter of the IEEE Antennas and Propagation Society (AP-S) in 2013. He is a member of the Education Committee of the IEEE Antennas and Propagation Society. He is an IEEE AP-S Region 10 Distinguished Speaker for 2015-16.

Selvan is a senior member of the IEEE, a Fellow of the Higher Education Academy (UK), and a Life Member of the Society of EMC Engineers (India).

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She was the General Chair of the 2013 IEEE International Antennas and Propagation, URSI/USNC Symposium, and the Technical Program Chair for the conference in 1999. She was also the General Chair for the 1998 IEEE Region 3 Southeastcon conference. She was a member of the IEEE Antennas and Propagation ADCOM from 2000 -2003. She has served on the technical program committee for several IEEE AP- URSI/USNC conferences. She is the Chair of the Women in Engineering Committee for the Society. Dr. Wahid is a Senior Member of the IEEE and a member of the Eta Kappa Nu and the Tau Beta Pi Societies.

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Electromagnetic Theory
Teaching: Focussing beyond
Applications

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Presentation objectives

- Relevance of EM – as generally appreciated
- Student interest in the subject; possible reasons
 - The job scenario – India
 - The international engineering education scenario
 - Modern educational objectives
- Importance of making EM's relevance much wider
- Possible ideas for 'how to'
- Summary; challenges

EM and its relevance

- Foundation of all of electrical engineering
- Behind most modern electronic & communication applications
- And so important for electrical engineers

EM & student interest

- Declining interest widely acknowledged
- Reasons cited include
 - Abstract nature of the subject
 - Excessive math content
 - Inability to link theory with practice
- Suggestions in the literature to revive interest include
 - Use of animations/ visualizations
 - Emphasis on applications
 - Making the subject more lab-based
 - Making available quality learning material

Possible additional reasons

- All suggestions above emphasize practice and hence applications
 - They make the inherent assumption that all graduating electrical engineers are placed in EE companies
 - This may not be the case
 - Students' attitude to subjects that they deem not necessary for jobs
- Teacher *enthusiasm* matters:
 - “Some of my friends who had already taken this subject told me that EM will be boring and tiresome. But actually after being introduced to the subject, I found it interesting ...” – A student

International educational scenario

- Declining interest in engineering studies
- Changes taking place in engineering education
- ASME's *Vision 2030** recommends the following curriculum changes, among others:
 - greater cultivation of **innovation** and **creativity**;
 - increased emphasis on developing students' professional, **non-technical skills**;
 - encouraging greater **diversity** among students and faculty

* http://www.indiana.edu/~ciec/Proceedings_2013/CEED/CEED512_Kirkpatrick.pdf

Expectations from modern engineers

- Arora and Faraone [IEEE AP-S Mag., Oct. 2003]:
 - Integrity, honesty, creativity, lifelong learning
 - Ability to think critically and independently

Desired outcomes of university education

- Scholarship
- Global citizenship
- Life-long learning

[S. C. Barrie, “A research-based approach to generic graduate attributes policy,” *Higher Education Research & Development*, vol. 23, no. 3, Aug. 2004]

- All the above, of course, in addition to knowledge and skills
- Can EM have a role *also* in this scheme of things?

Widening EM's relevance

- EM's relevance extends beyond its far-reaching applications
- When considered in context, EM can also be a helpful subject in respect of developing the *overall* attributes of engineering students
- The following attributes are some of them:
 - Creativity
 - Intellectual/scientific spirit
 - Diversity
 - Life-long learning and openness

Creativity

- No short-cuts to teaching creativity!
- Discussions on how great scientists went about their research pursuit could throw some hints
- Displacement current, for example, an excellent illustration, if considered in context (Selvan, 2009)
- Tried the approach, with positive **perception** (Selvan and Rengarajan, 2010)

Intellectual spirit

- Learning in context and its advantages
- Science is a **process** and not an event
- Abstractions and science

Diversity

- Diversity in work environment
- How do we discuss desirability of diversity?
- Several aspects in EM present diversity both as inevitable and desirable:
 - Dimensions
 - Gauges
 - EM vectors
- Fundamentals of electromagnetic units and constants
- Idea can be extended

Life-long learning & openness

- Importance of being open to ideas and of being a life-long learner in modern settings
- How scientific process as whole embodies this quality
- EM, an excellent domain to discuss this
- Recent debates on fields and particles

Summarizing...

- The importance of EM – applications
- The importance of EM – generic attributes
- EM, if delivered in context and with enthusiasm, can have much wider relevance and possibly better reception

The challenges

- Skill development can be assessed
- Generic attributes are hard (or impossible?) to measure
- Nevertheless important
- Therefore:

Delivering EM with focus on both **applications** and **attributes** is worth a try