Experiment and Simulation Driven Green Electromagnetics (ESDGEM)

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Introduction and Objectives

Discipline: Electrical & Computer Engineering

Level: Undergraduate

Course: Electromagnetics (I and II)

Objectives:

1. Stimulating students' interest in applying what they learn not only in my class but also other classes and extracurricular activities,
2. Going after for what has nAot been covered in books/classes, connecting the bridges between different courses and real life, and
3. Creating awareness for green engineering.

Outcomes:

Engineers

a) with more ability of applying their knowledge and experience in real world engineering projects;

b) with improved skills to plan, construct, and manage engineering systems and devices;

c) who are aware of the environmental issues, recent technological trends, challenges, and needs.

Developmental History of Innovation

Steps taken for the implementation

1. Preparation of Electromagnetic Concepts Inventory [1],
2. Preparation of 14 experiment setups for in class demonstrations [2],
3. Preparation of +100 MATLAB subroutines for in class demonstrations, projects, and homework assignments,
4. Making movies to teach basics of computational methods to solve electromagnetic propagation and scattering problems, and
5. Designing simulation projects.

References:

[1] Notaros, B.M., "Concept inventory assessment instruments for electromagnetics education," Antennas and Propagation Society International Symposium, 2002. IEEE , vol.1, pp.684-687, 2002
doi: 10.1109/APS.2002.1016436

[2] Felder, R.N., and R. Brent, "Learning by Doing," Chem. Eng. Ed., vol. 37, no. 4, pp. 282–283, 2003.

Learning Activities and Materials

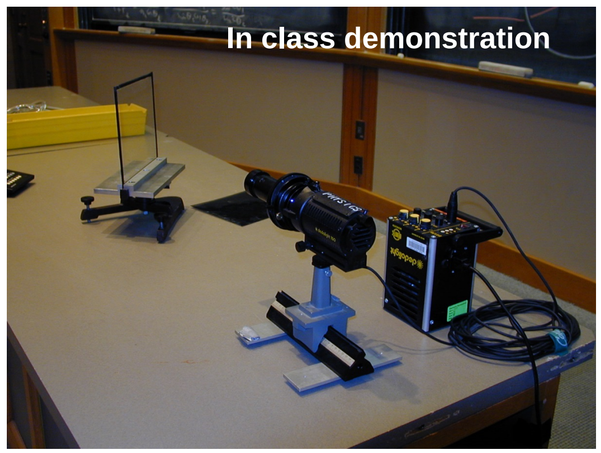
Rather than explaining everything with mathematical derivations first and then showing some applications, I make some demonstrations in the beginning of the lecture and lead my students to develop theory based on the questions they and I ask.

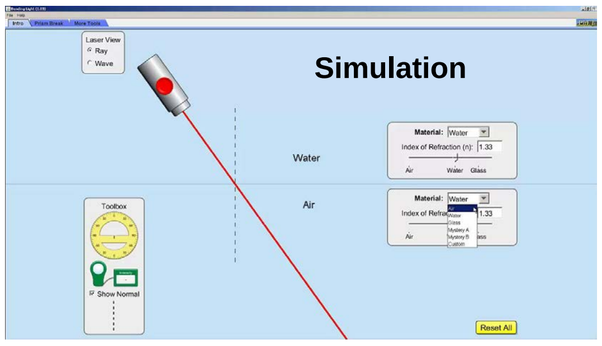
Example:

1. I make a demonstration of wave reflection/refraction/transmission using a very simple setup (with a laser pointer, large cup, water, protractor, and a ruler).
2. Based on our measurements, we try to reproduce the Snell's Law.
3. Then I help them to derive boundary conditions between two dielectric media.
4. In the last step, we try to demonstrate on computer what we observe in class through scientific programming.

Other important learning activities:

- scientific programming
- Pre-class assignments (in groups)





Execution

a) Electromagnetics Concept Inventory at the beginning and end of the semester

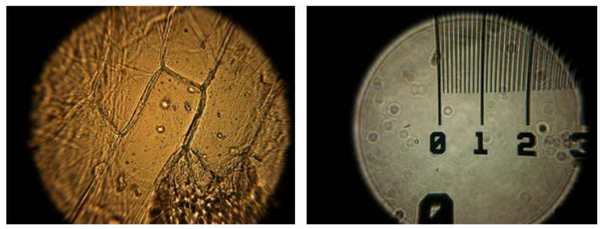
b) Effective use of the "Blackboard System", which is a tool that allows faculty to add resources for students to access online

c) Use of use clickers to collect and store my students' response to tens of questions I ask every lecture

d) Forming small groups of students to discuss environmental issues and design problems or to work on small projects I assign them to complete outside the classroom

Students working in my lab independently

Pictures taken by students with an iPhone



Major Issues to Resolve

A. Some students
   - o do not want to work in teams,
   - o do not complete their pre-class assignments,
   - o Influence others in a negative way, and
   - o might make inappropriate comments (e.g. racist) in class.

B. Funding to support independent studies.

C. Technology support to create movies, applets, and online learning tools.

Discussion

A. Generally, undergraduate electromagnetic courses are considered difficult to understand due to high level of mathematics utilized to explain electromagnetic waves and fields.
   i. In class demonstrations not only help students to understand the main concepts but also make the course more attractive. They easily get excited even with very simple experiments.
   ii. Simulations enhance their visualizations.
   iii. By solving Maxwell's equations or another electromagnetic related phenomenon through scientific computing prepares them for real world engineering design problems.

B. As engineering educators, we need to modify and enrich our education system to contribute to the building of a more sustainable, stable, and equitable world. Currently at the George Washington University, we are working on a new "Sustainability Program" by bringing together faculty members and courses in engineering, sustainability, appropriate technology and renewable energy.

C. The experience I have gained during this transformative work might be useful for FOEE symposium attendees who especially want to create an awareness of ecosystems, ecosystems services, and the preservation and restoration of natural capital.

D. As a junior faculty who believe in life-long learning, I am very excited to meet my peers from different disciplines to share ideas and explore interesting and effective innovations in teaching and learning, learn from research and best practice in education, and leave with a charter to bring about improvement at GW.

2013 Frontiers of Engineering Education
Irvine, California
October 27-30

Sponsored by:
The National Academy of Engineering and
John McDonnell and the McDonnell Family Foundation

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