ISRES Publishing

The Eurasia Proceedings of Educational & Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2015

Volume 2, Pages 226-230

ICEMST 2015: International Conference on Education in Mathematics, Science & Technology

IMPROVING THE EFFECTIVENESS OF ELECTROMAGNETIC THEORY EDUCATION BY INCREASING THE LEARNING MOTIVATION

Şule Berna AYAN
Department of Biomedical Engineering, Faculty of Engineering, Başkent University

Mehmet YÜKSEKKAYA
Department of Biomedical Engineering, Faculty of Engineering and Department of Biomedical Equipment Technology, Vocational School of Technology, Başkent University

ABSTRACT: Electromagnetic theory course is currently taught in many institutions and in many disciplines. However, this course usually has difficulties in capturing the glance of students especially for undergrads in disciplines which are not focused on concentrated mathematics education. The common reasons are that the course has mostly theoretical concepts, it needs a well mathematics background and it usually does not have any practical application. Since active and experimental education is usually more attractive to the undergrads in engineering, theoretical courses are difficult for them especially for biomedical engineering undergrads. For this reason an electromagnetic theory course with its laboratory and a project work is developed to increase the motivation of the students and it is planning to be taught for sophomores in Başkent University Biomedical Engineering Program.

In order to make the course more attractive firstly, a survey has been completed for different electromagnetic course taught worldwide and syllabus has been updated. Secondly, visual and practical teaching materials are searched for the electromagnetic concepts and they are classified. Thirdly, laboratory experiments are organized and test devices and materials are ordered. Finally, a plan for teaching electromagnetic theory is advised.

This paper explains the walkthrough to make the electromagnetic course more attractive to the students. In the paper the methodology for efficient and attractive learning and syllabus design are discussed.

Keywords: Electromagnetic theory, learning motivation, electromagnetic laboratory, active learning.

INTRODUCTION

Circa 1870, extraordinary equations were formulated called Maxwell's Equations. They represent a fundamental unification of electric and magnetic fields. Engineers and scientists worldwide use these equations on their works or studies (Taflove, 2002).

In our department of biomedical engineering curriculum, we also give a place to this course because mainly the department has bioelectrical based lessons. Biomedical engineering involves human physiology and also electricity. Therefore we need to learn electromagnetic to combine these different fields.

It is generally admitted that electromagnetic theory (EM) is one of the most difficult courses to teach in engineering curriculums. Especially for our students unlike other courses such as physiology for engineers, microprocessors or linear system, EM requires a lot of mathematical tools. The course consists heavily vector mathematics and closed-form field solutions are only available for symmetric, idealized geometries. This inclines to make most students assume EM as too abstract when it is actually based on experimental results. Except for the ones who are mathematically tended, engineering undergraduates usually feel uncomfortable with EM and beware of it (Beker, Bailey, & Cokkinides, 1998).

- Selection and peer-review under responsibility of the Organizing Committee of the conference

*Corresponding author: Şule Berna AYAN- icemstoffice@gmail.com

The traditional way of introducing EM is to concentrate on theory and to omit even simple EM applications, but applications can be used as a vehicle to explain fundamental theoretical concepts. Due to this fact we are developing new course outline for Introduction to Electromagnetic Course for Başkent University, Biomedical Engineering Students.

We researched popular courses in the world, mostly EM courses supported with complex virtual experiments to capture the students' attraction, but it is required numerical calculation knowledge and also programming experience. On the other hand, lecture hours are not even enough to teach EM concepts. For this reason, in our course outline we prefer basic but real applications and some simple virtual experiments using MATLAB. We add some experiments in our syllabus and we aim learning electromagnetic theory while having fun for students because students tend to become best motivated to learn something when they can see its relevance (Durney, 1973; Belcher & Dori, 2005).

For capturing the glance of students we moved on step by step. In the first step, a research was completed for different electromagnetic course taught worldwide and our syllabus was updated. Then, laboratory experiments are organized and necessary devices and materials was obtained. Finally, some recommendations were given for teaching plan.

METHODS

Syllabus

According to researches, electromagnetism is taught in many universities worldwide in different departments. Generally, the lecture is given by faculty of physics or faculty of engineering. On the other hand, they have some differences in their syllabus. Although some of the courses have laboratory sessions, the others do not (Table 1). This table is obtained in order to compare the lecture and laboratory hours for different programs.

Table 1. Syllabuses of the Universities Investigated

University	Department	Course Name	Lectures	Laboratory	Credits
Başkent, Ankara, TURKEY	Biomedical Engineering	Electromagnetic Theory	3 sessions / week	1 session / week	3
MIT, MA, USA	Physics	Physics II: Electricity and Magnetism	4 sessions / week	1 session / week	12
Utah, UT, USA	Electrical and Computer Engineering	Introduction to Electromagnetics	3 sessions / week	3 sessions / 8 weeks	
Colorado, Boulder, CO,USA	Electrical, Computer, and Energy Engineering	Electromagnetic Fields and Waves	2 sessions / week	X	3
Houston, TX, USA	Electrical and Computer Engineering	Applied Electricity and Magnetism	2 sessions / week	X	3
California Santa Cruz, CA, USA	Electrical Engineering	Electromagnetic Fields and Waves	2 sessions / week	1 session (2 hours) / week	5+2 (LAB)
Lamar, TX, USA	Electrical Engineering	Electromagnetics I	3 sessions / week	X	3
Queen Mary, London, UK	School of Physics and Astronomy	Electric and Magnetic Fields	3 sessions / week	X	15
Penn State Harrisburg, PA, USA	Science, Engineering, and Technology	General Physics II: Electricity & Magnetism		1 session / week	
Michigan Tech, MI, USA	Physics	Physics II - Electricity & Magnetism	3 sessions / week	X	3

When the details of lecture plan is examined, in faculty of physics, the syllabus is mostly intended to fields and charges. However, electromagnetic waves are selected more in engineering faculties. The course contents were listed and compared (Table 2). Massachusetts Institute of Technology, University of Colorado, Lamar University, Penn State University and Michigan Technological University have courses which are included all topics in our syllabus. At these universities, electromagnetism courses are taught in department of physics and/or faculty of engineering.

Table 2. Course Contents of the Universities Investigated

Topics \ Universities	Başkent, Ankara, TURKEY	MIT, MA, USA	Utah, UT, USA	Colorado, Boulder, CO,USA	Houston, TX, USA	California Santa Cruz, TX, USA	Lamar, TX,USA	Queen Mary, London, UK	Penn State Harrisburg, PA,USA	Michigan Tech, MI, USA
Vector Calculation	□	□	X	□	□	□	□	□	□	□
Static Electric	□	□	□	□	□	□	□	X	□	□
Gauss' Law	□	□	X	□	□	X	□	□	□	□
Conductor, Capacitor	□	□	X	□	□	X	□	□	□	□
Magnetic Fields	□	□	□	□	□	□	□	□	□	□
Faraday's Law	□	□	X	□	X	X	□	□	□	□
Maxwell Equations	□	□	□	□	□	□	□	□	□	□
Electromagnetic Waves	X	□	□	□	X	□	□	□	□	□

In the laboratory sessions of these courses (Table 1), there are some visual and multimedia teaching methods. There is a method at the Massachusetts Institute of Technology (MIT). The Technology-Enabled Active Learning (TEAL) Project involves media-rich software for simulation and visualization in freshman physics carried out in a specially redesigned classroom to facilitate group interaction (Belcher & Dori, 2005).

There is also another multimedia method. The Computer Applications for Electromagnetic Education (CAEME) Center developed software books in electromagnetics, and produced CD ROMs for teaching and learning electromagnetics. Available CD ROMs include video clips, and extensive assets of innovative multimedia modules including virtual labs and instruments, simulation software, and virtual participation in practical applications. Several IEEE and non-IEEE societies participated in this effort including the IEEE Microwave Theory and Techniques Society, Electromagnetic Compatibility Society and the Applied Electromagnetic Society (ACES) (Iskander, 2014).

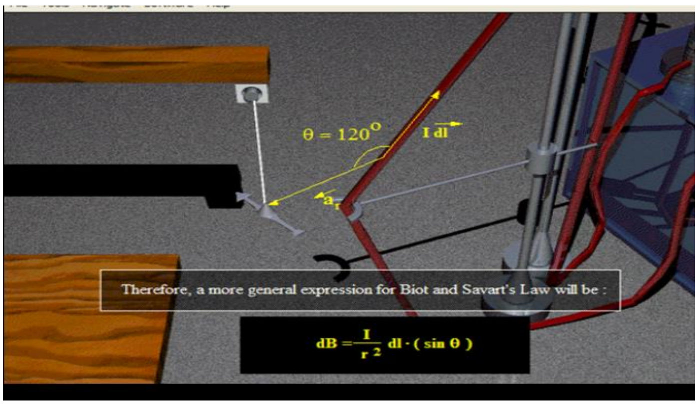

Figure 1. Virtual experiment illustrating Biot-Savart Law (Iskander, 2014).

Moreover, MATLAB is a choice to make electromagnetic simulations. MATLAB is an object oriented programming language. Signals, waves or some circuit combinations can be simulated with MATLAB. On the other hand, all of these methods require some programming skills and background information about these programs' toolboxes.

The last visual method is an application is called PhET Simulations. This application includes more simple examples and more understandable than the other methods to help students engage in science and mathematics through inquiry, PhET simulations are developed using the following design principles:

- Encourage scientific inquiry
- Provide interactivity
- Make the invisible visible
- Show visual mental models
- Include multiple representations (e.g., object motion, graphs, numbers, etc.)
- Use real-world connections
- Give users implicit guidance (e.g., by limiting controls) in productive exploration
- Create a simulation that can be flexibly used in many educational situations

We also incorporated this application into our experiments. If there is a match between our experiments and the PhET Simulations, after finishing the real experiments, the students check the test results by doing the simulations.

Experiments

In our electromagnetic theory course there are some real and visual applications in laboratory sessions. Although the sophomores do not have the knowledge about MATLAB, we counted a MATLAB simulation in our experiments. This application added to introduce MATLAB to students. Because, there will be many courses which are connected with MATLAB simulations on terms ahead.

Faraday Ice Pail experiment is done to show the electrification of the conductive materials. The mechanism was named "Faraday Ice Pail" by Michael Faraday, because he used an ice bucket as the conductive metal in the experiment. To perform this experiment, one metal bucket, one metal ball which is connected a plastic stick and one electroscope are used (Bueche, 1988).

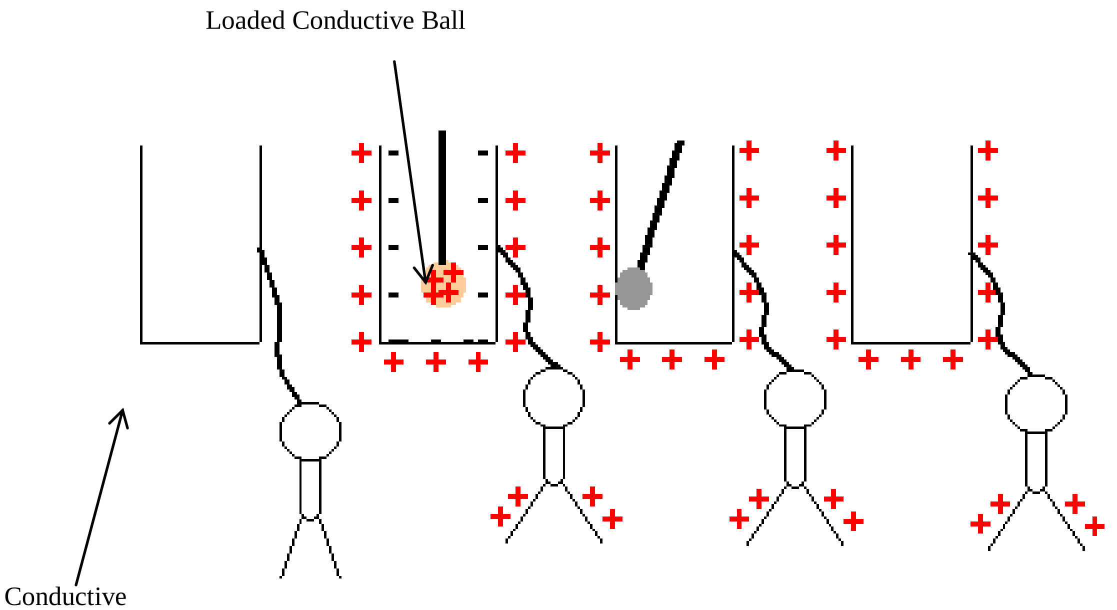

Figure 2. Faraday Ice Pail Experiment (Bueche, 1988)

Induction Experiments for Faraday is done to figure out the aim and applications of Faraday's Law. Also learn how make an electromagnet. One coil, one iron stick, one conducting wire, two bar magnet and one ampere meter are used for this experiment.

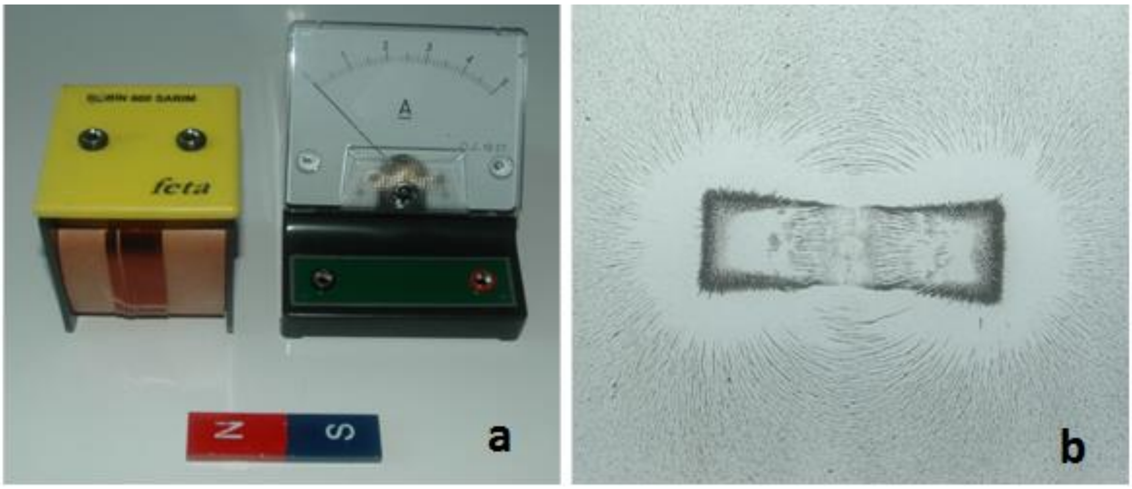

Figure 3 (a) Induction Experiments for Faraday (b) Magnetic Field Lines Experiment

Magnetic Field Lines is done to observe the magnetic field lines, the lines' behavior and direction. Required materials are one bar magnet, a white paper and iron fillings.

Magnetic Field in the Cause of Current experiment is performed to see the observation of the magnetic field created around the current-pass conductor and the moving of compass needles. Required materials are iron powder, circuit key, broadsheet-sized cardboard, batteries, wire, two compasses, magnet.

Besides the real experiments, we added a Matlab exercise to make students seem familiar about using Matlab and observe some electromagnetic fields in 2D and also 3D graphics (Arı & Özen, 2008).

Teaching Plan

In order to increasing the learning motivation, we advised some methods. First and foremost is laboratory session. In addition to experiments, assignments were planned for each topics and experiments. But above all, the first assignment is about TEAL. Afterwards, students have to research and observe each simulation on TEAL's website at the end of each topics. Furthermore, at the laboratory sessions, the matching simulations in PhET will be done and results will be compared with test results by students.

CONCLUSION & DISCUSSION

To sum up, to make the EMT more attractive, a progress was made. First of all, we updated our course contents and our schedule by doing a research about different electromagnetic course taught worldwide. Additionally, we included a laboratory session into our syllabus.

The electromagnetic course was just abstract before. However, after lecturing in this format, the students' results got better. Because now the lecture is more practical and it lets the students learn more clearly and easily. In that, students can visualize the abstract topics by doing experiments and simulations. Moreover, the experiments improve team working skills and active learning. Also, owing to projects, students have the chance to develop their presentation skills.

REFERENCES

Arı, N., & Özen, Ş. (2008). *Elektromanyetik Alanlar Teori ve Matlab Uygulamaları.* Palme Yayıncılık.

Beker, B., Bailey, D. W., & Cokkinides, G. J. (1998). An Application-Enhanced Approach to Introductory Electromagnetics. *IEEE TRANSACTIONS ON EDUCATION, 41*(1), 31-36.

Belcher, J., & Dori, Y. J. (2005). How Does Technology-Enabled Active Learning Affect Undergraduate Students' Understanding of Electromagnetism Concepts? *The Journals Of The Learning Science,14(2),* s. 243-279.

Bueche, F. J. (1988). Faraday Ice Pail Experiment. In F. J. Bueche, *Principles of Physics* (pp. 330-331). New York: Mcgraw-Hill College.

Durney, C. H. (1973). Principles of design and analysis of learning systems. *Eng. Educ., 63*, 406-409.

Iskander, M. F. (2014). Multimedia and Technology Based Electromagnetic Education. *978-1-4799-3540 IEEE*, s. 531-532.

Taflove, A. (2002). Why Study Electromagnetics: The First Unit in an Undergraduate Electromagnetic Course. *IEEE Antenna's and Propagation Magazine. Vol. 44. No. 2*, s. 132-139.