

Seminar-Based Electromagnetics Education

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Abstract - In this paper, an innovative student seminar-based classroom practice is reported. The instructional process was illustrated by student-oriented theoretical inquiry of interested topics combined with traditional and emerging applications. Specifically, under the careful guidance of the instructor, every student or student group chose an EM topic of their interest and presented to the class; while other students or student groups were encouraged to pose questions and probe details that should be defended by the presenter. The class has been involved in various EM topics that allowed them to better grasp the significance of EM theory and gain physical insight into what could otherwise be a sea of mathematical manipulations. The student performance as a presenter and an interrogator was evaluated by both the instructor and the peer students. Other practical issues are discussed in the paper. Qualitative analysis showed that the seminar-based instruction enhanced the students' interests in EM education, fostered their problem solving skills, and improved the learning experience.

Keywords: Electromagnetics education, seminar, teaching method, Electronics Engineering Technology (EET).

1 INTRODUCTION

The importance of electromagnetic (EM) waves and fields problems can never be exaggerated. These problems arise in diverse areas such as radar systems, antennas, communication systems, electrical machines and apparatus, PCB, RFIC, RFID, Bluetooth, and other mobile techniques. However, because of its nature of abstract math and physics, electromagnetics is generally very challenging and demanding, even for well-motivated students majoring in electrical engineering (EE) that have a fair amount of preparation in the required math and physics courses. Electromagnetics education is always a difficult task in engineering and engineering technology curriculum. There are a great many of pedagogic practices in EM education, most of which can be classified into one of the three: traditional classroom lectures, hands-on experiments and projects, and simulation and multimedia tutorial software packages. While classroom lectures are still the main stream practice, simulation and visualization tools, including some popular commercial Computer Aided EM software and those produced in house by various university faculty have been employed for efficient electromagnetics education [1, 2].

Among the great many of reports in literature on electromagnetics education, most of them are for undergraduate and graduate level students in EE program [3, 4]. Few have focused on electromagnetics education of EET students. Electromagnetics is not considered a typical EET course. Because engineering technology students prefer hands-on skills, EET curricula focus on more practical applications and technical information instead of theoretical views.

“Graduates of four-year Engineering Technology programs may get jobs similar to those obtained by graduates with a bachelor’s degree in engineering [5],” this is because in a four-year EET program, as students progress through the curriculum, the mathematics and physics courses, as well as previous engineering technology courses, allow EET students to reach and cover many advanced electrical and electronics courses. Examples of these courses include electromagnetics, which is generally considered one of the electrical

engineering topics.

2 ELECTROMAGNETICS EDUCATION IN EET PROGRAM

Electronics engineering technology is the profession in which knowledge of mathematics and natural sciences gained by higher education, experience, and practice is devoted primarily to the implementation and extension of existing technology. EET education focuses primarily on the applied aspects of science and engineering aimed at preparing graduates for practice in the technological spectrum closest to produce improvement, manufacturing, and engineering operational functions. High-level mathematics is not required, and thus electromagnetics courses are generally electives in EET programs. For example, our traditional EET curriculum does not require mathematics skills beyond Calculus II and ordinary differential equations, and therefore we did not offer electromagnetics courses.

However, the recent merging of EET program into the School of Computing demonstrates a commitment to further a research-based graduate and undergraduate curriculum. This change is a response to the booming research and economic activities of the local area. Institutions and industrial companies that are located nearby require a large computational workforce with higher education. Among the examples are Stennis Space Center and Raytheon Inc. Field engineers, testing engineer, and application engineers graduated from our program have requested that electromagnetics courses be offered in EET curriculum for the benefit of potential jobs in wireless communications, and microwave measurement.

Our two-year experience shows that the greatest challenge facing the educators in EET program is to motivate undergraduate students who do not have higher-level mathematics to enjoy the learning experience of electromagnetics. Such students may pursue graduate education or take jobs in the EM related fields in the future. In EET program, technical courses are generally taught in a fashion that incorporates mathematics, science described as in [6, 7], and discussion of practical applications in addition to theory has been found to be helpful.

Our previous experience has found a unique way of enhancing interest in electromagnetics among EET students successfully by integrating EM topics into traditional non-EM courses [7, 8]. We have already taken the first step to enhance the interest in electromagnetics among EET students by intentionally introducing electromagnetics concepts into traditional EET courses such as *Electrical Power* [7], *Communication Systems*, and even introduction level *Circuit Analysis* [9]. Instead of a mere coverage of technical details, mathematics and electromagnetics of an appropriate level are introduced behind the technology phenomena. The students can easily understand the technical information, and more importantly, the student's interests in electromagnetics are greatly increased. Since 2005 our program has been offering two courses in electromagnetics to both undergraduate and graduate students; one is *Electromagnetic Fields and Waves*, and the other is *Antennas and Wireless Propagation*.

3 SEMINAR-BASED ELECTROMAGNETIC EDUCATION

3.1 Motivation

When we first offered course *Electromagnetic Fields and Waves*, we used the traditional instructor-lecture-and-student-listen form to deliver the topics. We found that both the students and the instructor suffered from the experience: a fast pace left the student in bewilderment of mathematical formulations and abstract theories; however, a slow pace would not guarantee the whole syllabus fulfilled. At last our students were

totally lost in the abstract mathematical equations and showed no more interest in electromagnetics. The outcome was not satisfactory.

Recently we have been adopting the proposed student-oriented, seminar-based teaching method. In this practice, students are the major characters and are kept active during the learning process, while the instructor's role is to help and guide students by clarifying the difficulties they may encounter.

The main purpose of the proposed teaching method is to keep the students' interests during the whole learning process and to provide sufficient introduction knowledge for their future and even life-long learning. At the same time, students obtain training for possible academic research or professional career.

3.2 Procedure

Topics Included in the Seminar

Being a prerequisite of some courses in electrical engineering, the course *Electromagnetic Fields and Waves* is an introduction EM course. An excellent collection of topics benefits students in their future development both in academic fields and in industry. Examples of these fields include biomedical engineering and biotech, physics based signal processing and imaging, computer chip design and circuits, electronic systems, photonics and laser engineering, wireless communications and propagation, MEMS and microwave engineering, Radar engineering, RCS analysis and design, antenna analysis and design, EMI/EMC analysis, and remote sensing. In our EET program, the course covers the following topics:

- Fundamental mathematics: analysis methods that are necessary in EM study;
- Static electric fields: basic understanding of electric phenomenon;
- Solution of electrostatic problems: introduction of computational electromagnetics, and commercial EM software simulation;
- Steady electric currents;
- Static magnetic fields;
- Time-varying electromagnetic fields: key components of electrodynamics;
- Plane electromagnetic waves: fundamental to communications;
- Antennas and radiation: one of the most important EM applications.

Student Presentation

The introduction of the course is essential in fostering the students' good attitude towards the course. The mathematical fundamentals provide solid analysis skills necessary to electromagnetics education. Both topics should be covered by the instructor. The students are given the list of the major course topics and are required to choose one in which he or she is mostly interested. He or she is the so-called "presenter" of the topic. The presenter is responsible for the preparation of the lecture, including theory statement,

mathematical derivations, and most importantly, real-life applications of the theories. The presenter acts as an instructor lecturing to the class with slides of good quality. The presenter needs to be well prepared because he needs to defend any possible questions that may be raised by other students.

Student Evaluation

After each class, students are asked to evaluate the performance of the presenter. The presenter is evaluated based on if he or she (1) has a good preparation on today's presentation; (2) has shown a good understanding of theories; (3) has presented a good knowledge of applications; (4) has explained theory clearly (5) has interpreted examples clearly.

To guarantee a satisfactory learning outcome of other students (so-called audience), they also need to be measured. Each student is evaluated by every other student, the main criteria being if he/she (1) has raised meaningful questions; (2) has actively participated the discussion.

3.3 Outcomes and Student Comments

In the proposed teaching process, the students have been encouraged and indeed have shown the maximum activeness in the learning process. A survey has been carried out to evaluate the teaching outcome. It has shown that the students think that the seminar-based teaching method has better outcomes than the traditional classroom lecture. Here are some of the student reflections.

- “By this way of teaching the presenter and the listeners both are gaining more knowledge than when the lecture teaches in class, because the presenter who presents the seminar will get the total basic idea about the topic, in the same way the all presenters get the same way.”
- “I am gaining a lot of knowledge as well as self confidence about the subject.”
- “The method of approach toward the subject is very good and has an immense value on our coursework as it signifies the importance of being self confident and showing good interest towards the subject. I personally appreciate the instructor for making this innovative idea happen which would be going to yield good results for us in our coursework.”
- “I like this process. In this way the student knows what to prepare and present and will have good knowledge on the topic after presentation. In addition to this since there is a discussion of questions time at the end of the presentation, audience doubts will be cleared. ”
- “This method makes class real interesting because each student will strive hard to learn their topic and present well. Lastly, everyone tries their best to score well in their presentation. ”
- “This mode of teaching provides us the following: individual talent is exposed; every one involvement is achieved; no lazy business; new aspect on topics and interesting topics are highlighted; traditional instructional teaching—student listening is avoided. ”

There are also concerns from the students that may used to guide future teaching of the course. Below are some suggestions.

- “More and more applications are needed, so that students can understand the topics clearly and easily.”
- “Only the instructor should explain the topics. Only he must complete the whole topic.”
- “Students’ active participation is required, and audience attention is also required to get best performance from presenter.”
- “The slides are to be designed with good information and illustrations rather than plain slides with topic headings; slides should be brief rather than complex information and numerous slides; the presenter should list important points in the slides and should explain them in detail all the time of presentation.”
- “Dress code can be introduced for presenter only.”
- “Students need to use the resources properly.”
- “Students prefer individual presentation. They think individual presentation has better outcomes than group presentation.”

4 CONCLUSION

A new practice in teaching *Electromagnetic Fields and Waves* to electronics engineering technology students is presented. This seminar-based teaching method is student-oriented in the sense that with the instructor’s help and supervision, each major topic of the course is covered by a student presenter. The presenter is responsible in every aspect of the teaching, from theory explanation, mathematical derivation, to applications of the theory. The presenter also needs to defend questions raised by other students. This method keeps all students active during each and all lectures because their grades are evaluated by their performance both as a presenter and as an audience. A student survey has been carried out and has shown that the outcome from this method is more satisfactory than the traditional classroom lecture method. In the seminar-based method, students try their best to bridge theories and technologies efficiently. This process helps students understand the abstract theories easily. Students have also gained self confidence and have improved interest in electromagnetics.

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Biography

Zhaoxian Zhou received the B. Eng. from the University of Science and Technology of China in 1991; M. Eng. from the National University of Singapore in 1999 and the PhD degree from the University of New Mexico in 2005. All degrees are in Electrical Engineering. From 1991 to 1997, he was an Electrical Engineer in China Research Institute of Radiowave Propagation. In the fall of 2005, he joined the School of Computing, the University of Southern Mississippi as an assistant professor. His research interests include electromagnetics, radiowave propagation, high performance computing and numerical analysis. His teaching interests include communications, electromagnetics, antennas and propagation, electric power, and signal processing. He is a senior member of IEEE and a member of ASEE.