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Enhancing Student Learning Using Simulation Programs and Scientific Visualization

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Abstract

A new approach in teaching electromagnetics using multi-media simulation programs was implemented to enhance student learning and hence increase student retention. The fundamental nature of Electromagnetics makes its understanding a necessity in order to comprehend all the other Electrical Engineering topics. The basic Electromagnetics theory and its engineering applications material are all based on highly mathematical equations. Students had difficulty understanding and/or visualizing its abstract topics. This course is presently taught using the latest class technologies and its contents are available on the Internet for out of class access.

I. Background

Electromagnetics, the oldest and most fundamental branch of electrical engineering, is basic to everything electric and magnetic. Because of its fundamental nature, understanding Electromagnetics is essential in most areas of electrical and computer engineering. The study of waves and wave propagation, for example, is necessary in the analysis and design of power lines, communication links, optical fibers, high-speed digital electronics, satellite communications, and many other emerging technologies. At South Dakota State University, this material is covered by the undergraduate required four-credit course: Electromagnetics (EE 385).

II. Motivation (Problem)

The challenge for educators in the Electromagnetics field is to maintain student interest in this difficult and highly abstract subject. Students usually hate the material covered in this course for lack of understanding and visualization.

III. Approach (Method)

Research has proven that student interest, involvement, and retention are greatest when material is studied in a practical framework with hands-on experiences [1], and [2]. One such approach is the use of virtual reality

through simulation and multimedia software to bring the student's learning experiences to life.

The strategy then was to redesign the Electromagnetics course to integrate simulation software and computer-based visualization to render the abstract concepts of electricity and magnetism into a more intuitive form. In addition, the use of multimedia software, computer generated class presentations, digitized videos and other computer technologies would be incorporated in the redesigned course. Virtual laboratories, which focus on basic theories, would allow students to experiment and discover the fundamental relationships between electricity and magnetism. This presents an alternative to experimental laboratories that are prohibitively expensive to develop. Students' conducting key experiments in the field enhances their learning through active participation. Interactive games and quizzes would also be included for review and self-evaluation.

IV. Software Tools

After investigating different software packages, a compiled software packages integrated together by the Center of Computer Applications in Electromagnetics Education (CAEME) at the University of Utah was chosen. To accomplish its main goal: to stimulate and accelerate the use of computers and software tools in electromagnetics education, the center packaged many tools into what they called: The CAEME software package. It consists of two volumes. The first one is comprised of a collection of sixteen software packages, covering basic topics included in the electromagnetics course.

Eighteen additional simulation packages and four multimedia interactive lessons in electromagnetics have been compiled in the second volume. The software included in the second volume is equipped with state-of-the-art graphics that will help students learn while having fun. Many of these packages deal with the design and simulation of electromagnetics systems such as transmission lines, wave-guides, optical fibers, and antennas. Furthermore, software used to solve electromagnetics problems using numerical techniques is also included.

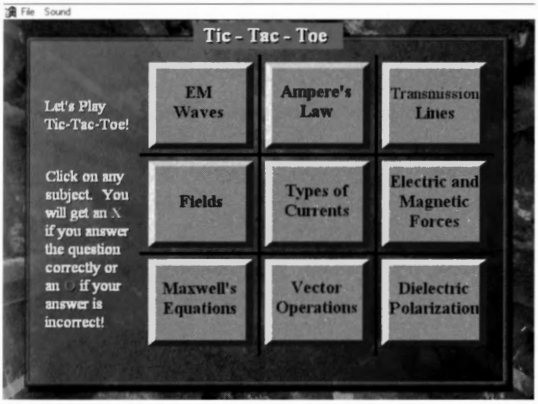
V. Methodology

The delivery of the course material moved from a complete lecture format to a technology-base delivery format. A combination of power point presentations and blackboard demonstrations is used to cover the different parts of a section. Then, the CAEME software is used to address the same topics through computer tutorials, simulations, video clips and computer-enhanced visual aids. To reinforce the students' understanding, the software is also used to present solved examples. Finally, students are challenged to answer questions through interactive games for self-evaluation. For example, a Tic-Tac-Toe game gives students nine categories to choose from, as shown in Figure1. By clicking on a button, students are given random questions and

given an "X" or an "O" for a correct or a wrong answer respectively. Students need three "X"s in a row, column, or diagonally to win. Depending on whether a student wins or loses, the software plays appropriate music.

The active learning approach is also extended to outside the classroom by making the software available to students. Through a user-friendly computer interface, students can answer questions and go through a number of exercises by taking quizzes and playing games designed to test the students' knowledge. Scattered throughout the application, these quizzes are quite challenging requiring access to a calculator, pencil and paper to solve equations. The software package keeps students' scores and provides feedback when needed. Students taking the redesigned course presently are attracted to this software application due to the high level of interactivity it offers.

FIGURE 1



Software Screen Showing the Tic-Tac-Toe game and its Topics.

VI. Methodology Assessment

Although no formal or qualitative assessment was done after teaching Electromagnetics with the new method, typical student evaluations show good qualitative results. Some of these comments are quoted below:

- "The simulation computer tool provided a graphical representation of these invisible quantities to promote the learning of the topics."
- "It [software tool] helps paint a picture that equations just can't illustrate."
- "The questions on both the Quiz and the Tic-Tac-Toe game [of the multi-media software] were educational as well as challenging."
- "This [software tool] helped give a better understanding of topics discussed in class."
- "I will leave the course with that visual reminder that will help with my understanding of the material."

VII. Conclusion

The Electromagnetics course is still taught at SDSU using the software tool CAEME that includes multi-media presentations, simulation, and assessment tools. Integration of use of technology in the instruction of this highly abstract subject enhances student comprehension and learning hence leads to higher undergraduate student retention. Furthermore, by understanding the basic phenomena of Electromagnetics, students become more successful in learning the more advanced courses and subjects in Electrical Engineering which leads them to be more nationally and internationally competitive in the real world job market.

REFERENCES

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BIOGRAPHIES

Dr. Madeleine Andrawis is a Professor in the Department of Electrical Engineering and Computer Science at South Dakota State University since January 1992. She has been the Teaching Learning Center coordinator from July 2002 till present.

Dr. Andrawis was a NASA Faculty Fellow for the summers of 1994 and 1995 at Langley Research Center in Virginia; 1997 at Goddard Space Flight Center in Maryland; 1998 and 1999 at EROS Data Center in South Dakota.

Dr. Andrawis is very interested in the scholarship of teaching and learning. She has won two Governor's Faculty Awards for Teaching with Technology in 2000 and 2001 and Governor Rounds Faculty Award in 2003. She has redesigned many of her courses to integrate the latest technologies and enhance student learning.

Dr. Andrawis has reviewed books in the area of Electromagnetics and VLSI Circuit Design. She has published in refereed journals and presented in many professional conferences.