Multimedia Approaches to Teach Engineering to Non Engineers

Robert J. Voigt, Patricia F. Warren, Charles B. Cameron, Anne Madsen, Eric Twite
U.S. Naval Academy

Abstract

This paper addresses some of the challenges of teaching electrical engineering to humanities majors in a demanding academic environment. We focus on the use of multimedia tools in the classroom in order to “engage the students.” The challenges we face in teaching this type of course to non-engineering students are many and varied. The circumstances are such that the students are enrolled in the course as a core requirement, thus, while they are motivated to pass, they may not be motivated to excel. Students may not have a strong math or physics background to rely upon; therefore, we are restricted from using higher mathematics to convey electrical engineering principles more precisely described by such methods. In this institution, we are faced with an intense demand for the student’s time in academic, athletic and military obligations. This is not unlike any collegiate environment where there are time demands on students beyond the control of the teachers. A common example is part-time or full-time students who must hold jobs to pay for their education. Thus, we must convey as much information as the students can comprehend while realizing that the load for this course represents only a small portion of the demand for their time. Efficiency in the classroom is essential. Relying on multimedia presentation, both in and out of the classroom, is appropriate for reaching students who appear largely to be visual learners. Doing so makes the material interesting and understandable to this audience. In this paper, we focus on a subset of ideas and methods we have used and we try to quantify their results. We illustrate the importance of cooperative and collaborative learning in this environment and show how we have approached the problem. We also will describe some of the tools we have developed which can be applied across disciplines other than engineering and can provide these tools to interested parties via a Web-based server.

I. Background

The goal of the Naval Academy is to prepare an individual, militarily, academically and morally, so that they will have an effective foundation with which to execute their duty and lead the servicemen and women entrusted to them. Because the Navy and Marine Corps of today is technologically pervasive, all students are required, regardless of their major, to take courses which expose them to the engineering disciplines that they will ultimately encounter during their service in the fleet. This requires students to take courses in electrical, mechanical and systems engineering. For any educator, this would present a unique professional challenge as approximately 40% of a graduating class are not engineering, math or science majors; they none-the-less must exhibit a mastery of these subjects in order to graduate. The abilities and affinities of these midshipmen lie in the realm of humanities and social science; they do not have the rigorous math background required for a typical engineering approach to technical subjects. In addition, these students may be less motivated to conquer the material, due to the extremely "foreign" nature of the subject. The multitude of additional demands, military obligations, athletic participation and leadership responsibilities also compete for the midshipmen's time, thus providing a diversion of their academic focus of effort. Thus, we need to reach a less motivated portion of the student body, who lack the proper background, and we need to accomplish this in the midst of an extremely demanding schedule.

Although the Naval Academy is a unique academic environment and yet with all of its differences, there are many similarities to other universities. While the specific types of demands on the student's time are unique, the fact that there are a lot of demands is not. In addition, we are faced with a number of different learning styles in the classroom. Multimedia tends to address the visual sensing learner over the verbal intuitive one, but we feel that the use of multimedia allows us to address a wider variety of learning styles than traditional classroom methods.

The course we describe focuses on problem solving techniques for basic electrical engineering, it meets 3 times a week for fifty minutes. The material was reinforced with mandatory, graded daily homework assignments and supplemented with weekly 2-hour laboratories which demonstrated the concepts being taught in the classroom. To better reach the students, we augmented these traditional teaching methods with extensive use of multimedia in the classroom. Each classroom is equipped with a multimedia personal computer (PC) connected to a "Smartboard", a device that serves both as both a large screen display and as an interactive touch screen. The display is driven by a projection system connected to the PC. Utilizing one of four different colors, the Smartboard also permits us to "draw" interactively, in color, atop the projected presentation, acting as a virtual chalkboard. Each of the PC's is also connected to the campus network and the Internet, providing access to multimedia teaching tools which are being developed at other institutions. The PC's are equipped with Windows software and applications software including Microsoft PowerPoint, MATLAB, PSpice and Netscape for Internet access.

II. Day to Day Operation

While we may facetiously categorize the students of today as the "Nintendo generation," the reality is that we are instructing a generation of students more familiar with and interested in high resolution, three dimensional, rendered graphics than ever before. This technology has been used in research as a visualization tool but for this generation of students, it has predominately been used as a vehicle to entertain. Recognizing that when learning is presented as an entertaining activity, students are more likely to enjoy it and stay "tuned in", we decided to capitalize on their familiarity with this technology and developed multimedia presentations to keep their attention. The use of multimedia, which we define as almost anything on a computer that integrates graphics, sound and animation, seems like a logical choice to keep their attention. Our objective was to have the midshipmen learn the material; we felt that the more interested we kept them, the more likely they are to learn and retain the information we want them to know.

We built the course presentation materials as a series of PowerPoint slides supplemented by other embedded media, much of which we could access directly from the presentation without a great deal of classroom disruption. We have found that even the limited animation capabilities of

PowerPoint can be extremely beneficial to get a point across to the students. For example, a simple use of objects appearing on a slide was used to help reinforce the concept of vector addition and the construction and relationships of the impedance triangle. In addition, the use of embedded links in the presentation allowed for a single "click" access to either a website or to another file displaying an animation on the screen to the class.

While it struck a responsive chord with the students, there were mixed reactions from the teachers. Initially, one teacher stated that he felt like a trained monkey, tethered to the Smartboard, unable to stray too far away, as it is necessary to touch the board to advance the slides. To resolve this problem, we are providing laser remote controls to advance the PowerPoint slides. In the meantime, we have found that the less written information per slide, the less we are tied to the board. This allows for the more traditional approach of using the chalkboard to supplement the slides and gives the individual teachers the freedom to embellish or augment as they see fit.

III. Movies and Animations

Abstract concepts can often be illustrated more easily than they can be explained, especially if the concept is mathematically challenging for the student to visualize or their mathematical background precludes adequate derivation of a concept. There are many topics in electrical engineering which lend themselves to illustrative explanations, particularly the large class of physical quantities that vary periodically with time. Although these ideas can be rigorously described through equations and complex variables, it becomes increasingly difficult to accomplish this task the further one moves away from rigorous mathematical derivation. Moreover, while topics such as alternating current, phasors and complex numbers can be described with two-dimensional diagrams on a chalkboard, representation of the time-varying dimension is difficult to grasp, especially for the visual learner. In order accomplish our learning objectives, we chose a combination of tools to help us describe these phenomena.

As a comparative example of the strength of animation, we show the sinusoid and phasor relationship. Starting with a MATLAB program, we provide a static description of a sinusoid as a complex vector in the phase domain. We describe the sinusoid generally as $v(t) = A \sin(2pft+f)$ and its corresponding vector as $A\angle f$. Setting $2pft$ equal to q , we display these graphically in figure 1. To the uninitiated eye of the student, the time varying component is not well represented by either of these graphs.

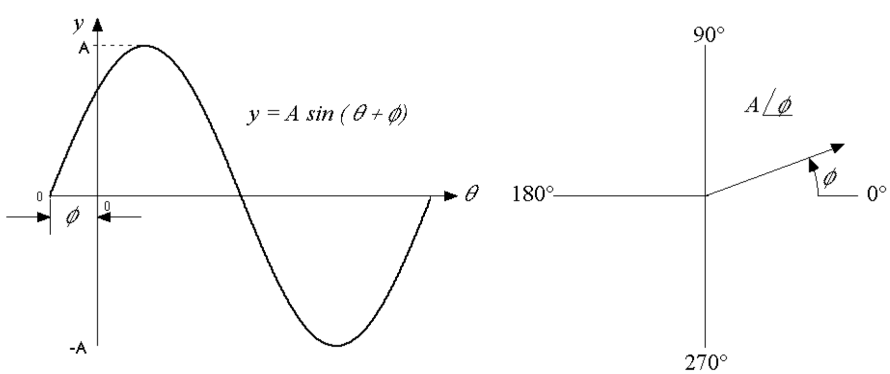

Figure 1. Two representations of a time-varying signal

The phasor, a vector quantity with a magnitude and a phase angle, is a useful way of graphically representing the sine wave. However, the physical relationship between the two can be better described by the rotating phasor whose angular velocity is directly proportional to the frequency component of the sine wave. Using the movie command in MATLAB, we were able to plot the rotating phasor and show its corresponding location on a sine wave with the same magnitude and frequency. Figure 2 shows two "snapshots" of the screen from the movies. Aside from the obvious benefit of allowing the students to visually confirm the relationship between the two representations, we were able to show the effect of frequency using the same technique on sine waves having three different frequencies.

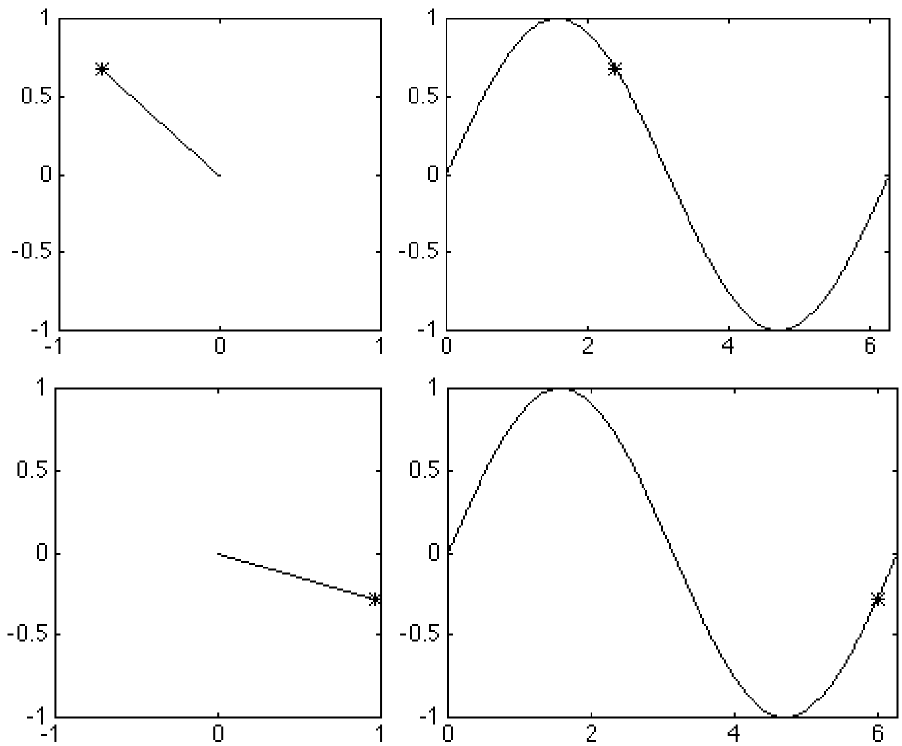

Figure 2. Screen shots of movie showing phasor sine wave relationship

This particular demonstration was also made available on the Web and even though the movies are fairly large, they are easily accessible from the classroom with a direct Internet connection.

In addition to the MATLAB generated movies, several basic concepts were captured from an educational video series and again used in the classroom to emphasize the concept being taught. Of these, the more useful videos turned out to be those which described the electromagnetic phenomena of induction and magnetic fields. These concepts are usually explained with the benefit of Maxwell's equations and a more rigorous analysis of field and wave theory. This was an infeasible method to teach humanities majors since the mathematics would quickly become too difficult for them to comprehend. The students' reaction to these videos varied but the general consensus was that they helped to demonstrate a theoretical concept which was not clearly understood.

IV. The World Wide Web

One of the benefits of having a large screen on an inter-networked computer in the classroom is that the entire World Wide Web is available. In our studies of how to bring more multimedia into the classroom, we searched the Web extensively to see what others had done. We focused on multimedia presentations, which we classified as any dynamic presentation, i.e., animation, movie or interactive demonstration. One of the more interesting applications which we did use and was received favorably by the students was the “Voltage Circuit Simulator” from the University of Oregon. We discovered that not many people are making their resources available on the Web. There is a great deal of information available on the Web which is essentially static and therefore not considered to be multimedia.

V. Dynamic Simulations

We had access to two simulation packages, PSpice and MATLAB, in the classroom. Of these two, MATLAB lent itself better to the creation of a dynamic, user interface for graphing and simulating circuits while PSpice was better for displaying the actual circuit components. Classroom time is a premium and the ability to demonstrate a concept, such as filter design, required a quick and easy access to the variables. Using sliding controls to vary the values of resistance, capacitance and inductance, we could interactively display the effect of changing component values on a filter. A screen shot of the tool is shown below in figure 3 for a series-resonant band pass filter.

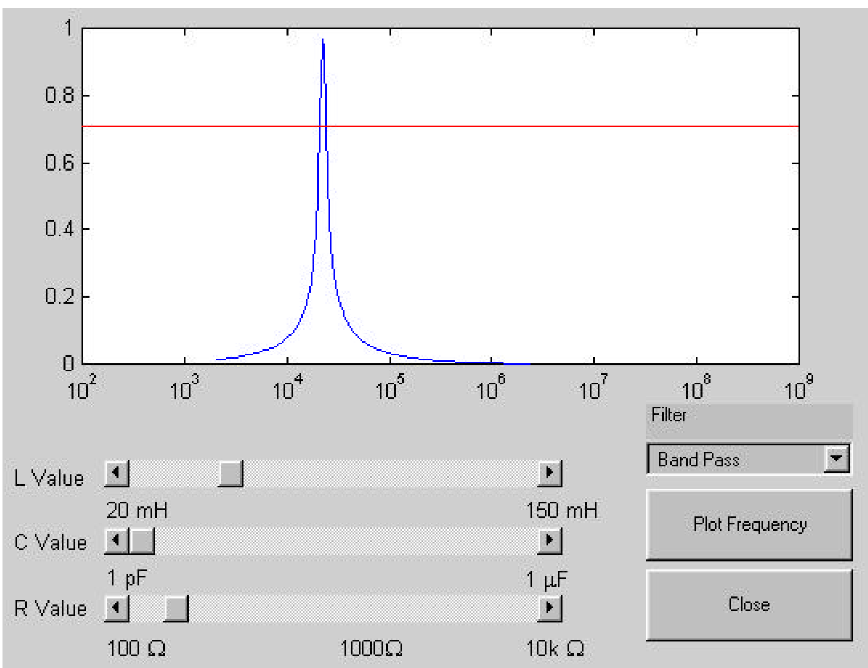

Figure 3. An interactive tool showing a band pass filter response

MATLAB's Graphical User Interface Design Environment (GUIDE) allowed for rapid prototyping of a user interface which could be displayed on the Smartboard. The touch screen capability of the Smartboard allowed the simulation controls to be changed easily in the classroom setting.

VI. Low Budget *Jeopardy!*

In our attempts to engage the students and bring more of a cooperative and collaborative environment into the classroom, we used an old game show idea in our classrooms and made it as "high tech" as our low budget would allow. To emphasize basic electrical engineering concepts and fundamentals, we developed a facsimile of the television game show *Jeopardy!*. It is a game show readily recognized by the students, one whose rules were already known. We incorporated some of the sound effects of the television game show, which were found on the Columbia Tri-Star home page; game slides were developed using PowerPoint, to simplify modification. This was not a daily exercise but one which we used every few weeks, usually in conjunction with a test review period. The students were grouped into teams of three or four and kept track of their own score. The "payoff" for the winning team typically involved receiving full credit for one of their weekly quizzes. This reward, in conjunction with the competitive nature of these midshipmen, ensured full participation by all students. The choice of PowerPoint for this application was not optimal since we could not interface directly with external hardware buzzers, for example. We are working on a stand-alone version, complete with hardware buzzers which will identify the team to first buzz in and lock out competitors. A screen shot of a sample answer and its question shown is depicted in figure 4 with a sample game board in figure 5. The touch screen capability of the Smartboard made playing the game easily executable and the students were able to clear the board on an average of fifteen to twenty minutes.

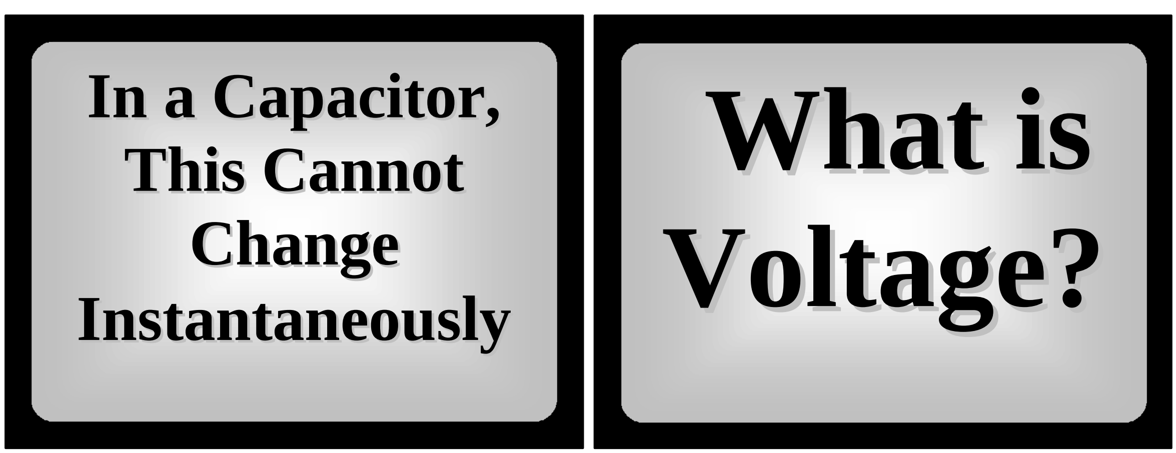

Figure 4. Sample *Jeopardy!* Question and Answer

We did not attempt to conduct a scientific study analyzing the effectiveness of utilizing this game; however, some observations may shed some light on the value of this type of teaching tool. As we stated before, we used this tool as a method of reviewing conceptual material prior to

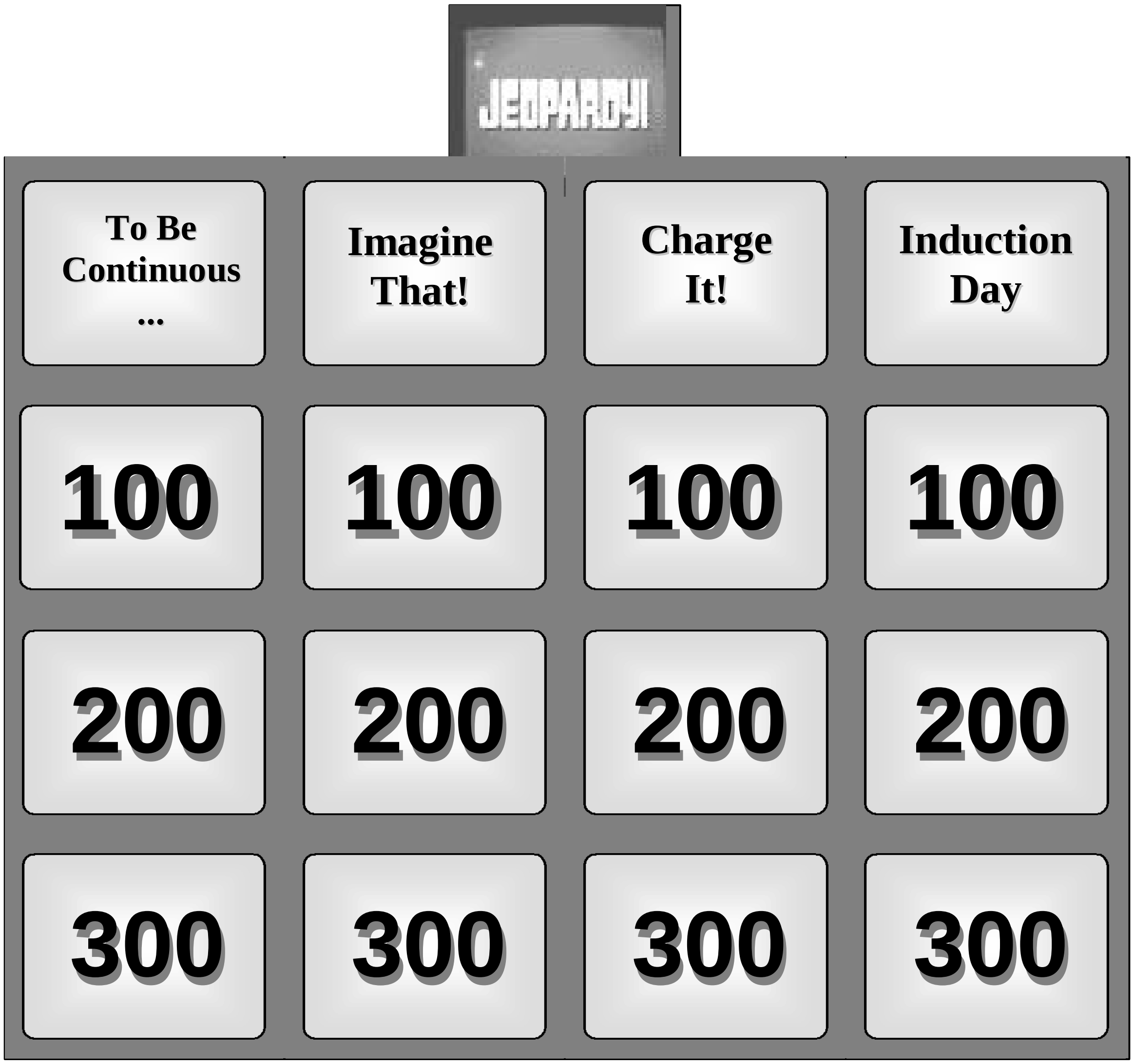

Figure 5. Sample Jeopardy! Game Board

each of the three regularly scheduled exams given over the course of a 16-week semester. There were 2 sections of students who were not able to play their usual round of *Jeopardy!* prior to the third exam. The average score on the conceptual, short answer portion of the test for these sections dropped by approximately 6 percentage points for both classes. We realize that there is no statistical significance to this singular data point, however, we would like to believe that the time spent playing the game resulted in a higher retention due to more student involvement in the learning process. We do believe that actively engaging the students, no matter what the methodology, will result in more material being absorbed and ultimately retained.

VII. Conclusions

While we would like to state unequivocally that each student gained a significantly greater amount of insight into electrical engineering due to our efforts to integrate multimedia into the classroom, we cannot justify this statement quantitatively. We do believe, based on feedback from the students and the performance indicators we use, quizzes, tests and homework, that the students appeared to develop a good understanding of what was being taught. We do not believe that we need to entertain the students in order to educate them, nor do we believe that the integration of multimedia “dumbs down” the curricula in any way. We simply seek to take advantage of all possible tools in order to reach the widest cross section of the learning styles present and to elevate the educational objective from simple knowledge to comprehension, application and analysis, as described by Bloom’s Taxonomy. It appears as though the goal of providing a solid foundation in electrical engineering was met through the use of multimedia teaching methods to enhance traditional methods was achieved.

Bibliography

1. Bloom, B. S. (1994) Taxonomy of Educational Objectives. 1. Cognitive Domain, New York: Longman.
2. R.M. Felder and R. Brent, Effective Teaching, North Carolina State University, 1998
3. URL: http://www.spe.sony.com/tv/shows/jeopardy/; Jeopardy! Game show home page.
4. URL: http://jersey.uoregon.edu/vlab/Voltage/index.html, Voltage Circuit Simulator

Biographies:

ROBERT VOIGT
CDR Robert J. Voigt USN is an assistant professor of Electrical Engineering at the U. S. Naval Academy in Annapolis Maryland. His research interests include real time, fault tolerant computer architecture and networking, particularly hierarchical multicast. He graduated from the Naval Academy in 1979 and received his MSEE in 1986 and his Ph.D. in 1996 both from the Naval Postgraduate School in Monterey, California.

PATRICIA F. WARREN
LtCol Patricia F. Warren USMC is an instructor of Electrical Engineering at the U. S. Naval Academy in Annapolis Maryland. She graduated from the University of California, Berkley in 1980 with a BS in Civil Engineering and received an MS in Applied Physics in 1998 from the Naval Postgraduate School in Monterey, California.

CHARLES B. CAMERON
CDR Charles B. Cameron USN is an assistant professor of Electrical Engineering at the U. S. Naval Academy in Annapolis, Maryland. His research interests include the measurement of the universal gravitational constant, fiber-optic interferometric sensors and fault-tolerant neural network control. He graduated from the University of Toronto (Trinity) in 1977 with a B.Sc., majoring in Computer Science. In 1989 he received his MSEE and Electrical Engineer's degrees and in 1991 his Ph.D., all from the Naval Postgraduate School in Monterey, California.

ANNE MADSEN
LT Anne Madsen USN is an instructor of Electrical Engineering at the U. S. Naval Academy in Annapolis Maryland. She graduated from the Naval Academy in 1990 and received an MS in Electrical Engineering in 1995 from the Naval Postgraduate School in Monterey, California.

ERIC TWITE
LCDR Eric Twite USN is an instructor of Electrical Engineering at the U. S. Naval Academy in Annapolis Maryland. His research interests are in controls and control systems. He graduated from the University of Southern California in 1983 with a BS in Industrial and Systems Engineering. He received an MS in Electrical Engineering in 1993 from the Naval Postgraduate School in Monterey, California.