2006-56: A NEW APPROACH TO TEACHING INTRODUCTION TO ELECTRICAL ENGINEERING AT THE UNITED STATES COAST GUARD ACADEMY

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A NEW APPROACH TO TEACHING INTRODUCTION TO ELECTRICAL ENGINEERING AT THE UNITED STATES COAST GUARD ACADEMY

Abstract

"*Introduction to Electrical Engineering*" has been a required course for non-engineering majors at the United States Coast Guard Academy for over thirty-five years. The course's purpose has been to provide non-engineering majors a basic knowledge of electrical engineering. A cornerstone of this knowledge was an understanding of electrical circuits and electromechanical machines.

As advances have made technology more prevalent, the course added topics (e.g., electronic navigation, computers) to maintain its relevancy. In the twelve years since the last significant change, the pervasiveness of technology in society has increased dramatically. Additionally, student and Coast Guard fleet feedback indicated that the course needed a significant overhaul.

During the summer of 2004, the authors rewrote the course, creating a new course that focuses on technology's impact on society. By removing circuits and machines, the course now covers a broader range of electrical engineering fields such as image and signal processing, data compression, electronic navigation, communications, and computer networks and security. The course examines current trends; with a focus on how the Coast Guard and Homeland Security use technology and discusses the ethical issues that arise with the potential misuse of technology.

The authors developed several innovative lesson plans, laboratories and even a series of debates to improve the students' understanding of technological trade-offs, while developing their critical thinking, writing and oral presentation skills. With these skills, the students will be able to make more informed decisions on how to appropriately apply technology.

Now in its third semester, the course has obtained overwhelmingly positive feedback. This paper will review the impetus for the change, an overview of the new course material, a summary of the students' feedback and the assessment methods. It will discuss the lesson plans, laboratory exercises and projects developed to teach this material.

Introduction

Upon graduation from the United States Coast Guard Academy (USCGA), each graduate receives a commission as an Ensign in the Coast Guard and a Bachelors of Science in one of eight fields, four engineering majors: Civil; Electrical; Mechanical; Naval Architecture and Marine Engineering; and four non-engineering majors: Operations Research and Computer Analysis; Marine and Environmental Science; Management and Government.

"Introduction to Electrical Engineering" (IEE) has been a required course for non-engineers at the Academy for over thirty-five years. The course provided the Academy's four non-engineering majors with a basic knowledge of electrical engineering, enabling them to function in a technological environment. The course is usually offered both fall and spring semesters with

an average enrollment of 70 students and, partially due to its Physic II prerequisite, is taken during the junior or senior year. The cornerstone of this course had always been an understanding of electrical circuits and electromechanical machinery.

Over its existence, the course added modules (e.g., electronic navigation, computers) to cover technological advancements and their increasing importance. Although this evolutionary approach was part of a continuing effort to improve the course, it resulted in a course with discrete sections with little connection between them. The outputs of the assessment tools (End-of-Course Reviews, Departmental Reviews and Program Reviews) highlighted the lack of cohesion in the course. The student, faculty and constituent feedback indicated that the course needed significant updating.

The original course design, the impetus for change, the specifics of those changes and the data collected to date in support of those changes will be discussed below. The extensive course changes include innovative lesson plans, laboratories and ethical and technological debates in an effort to improve the students' understanding of the course materials.

Old Course

The course's unofficial nickname, "Baby Wires," provided an excellent summation of the course's content for much of its existence. IEE was primarily a calculus-based overview of electrical circuits, three-phase power and electromechanical machines. Despite the less rigorous presentation, it was not significantly different from the material covered in the electrical circuit and electromagnetic courses taken by the engineering majors.

Over the years, several modules on electronic navigation, communications systems, computer networks and the Internet had been added in attempts to keep abreast of the latest technology. Five hands-on labs covering electrical circuits, signal processing, fiber optics and motors & generators reinforced topics covered in class. To support writing across the curriculum and the need for well spoken officers, a research assignment on a current technology coupled with a formal paper and classroom presentation, were also required. Since circuits and machines had been the primary focus for so long no matter what other material was added, these topics remained. With each additional topic, there was less time to cover the material. The result was a cursory presentation of many topics. Appendix A includes an overview of the course lesson plans prior to the change.

A result of trying to cover more topics in less detail was that although excellent books could be found covering individual topics, or even several topics, no one text book could be found for the course. The Electrical and Computer Engineering (E&CE) section resorted to contacting a publisher and putting together a paperback book with parts of different text books in order to get the material in a single, affordable book for the students. This presented its own problems such as no table of contents or a valid index.

By the time the authors were assigned to teach the course, the course had lost its original focus. Countless incremental changes had been made over several years by different course coordinators in an attempt to maintain relevancy.

A common suggestion was to develop our own textbook was unappealing as few faculty members had the time to undertake what was obviously going to be a difficult task. This was exacerbated as most faculty preferred to spend their time preparing for and teaching the Electrical Engineering students. Also, most Electrical and Computer Engineering (E&CE) faculty members are rotating military who are assigned as teachers for four years prior to moving on to other Coast Guard jobs. Therefore, instructors rarely taught the IEE course for more than one or two semesters.

Decision to Change

During the spring of 2004 "End-of-Course Review," a normal part of the assessment process, the course's direction was discussed. The E&CE section discussed the "health" of the course, using the two major assessment instruments available: feedback from students and the feedback from the Coast Guard fleet (our customer) on what electrical engineering topics new Ensigns must understand during the course of their duties.

At the end of each semester, students are asked to fill out an anonymous on-line survey that covers five broad categories using a scale from 1 to 5, with 5 being the highest. Appendix B shows the results of the course surveys for the 11 semesters prior to the course change (fall 1999 through spring 2004) with 620 responses. It was clear that these numbers were lower than desired. Specifically, the low responses to questions on how well the students understood the material and the material's relevancy demonstrated that the course could be improved.

The student comments that accompanied the survey were even more telling as they continually questioned the need for non-engineers to learn the intricacies of electromechanical machines and electrical circuits. The following are examples of some typical comments:

> "This class was very difficult for me because I am a government major. I still don't see the point of having to take this course. I don't want to be an engineer, so how will this be helpful to me in the future??" – Fall 2002
>
> "The textbook was horrible. It was confusing, unorganized, and difficult to understand." – Spring 2003
>
> "IEE was an exceptionally hard class for non-engineering majors. It was quite a bit harder than IEEs offered at comparable engineering schools. This course needs an overhaul and needs to be tuned to the students that will be taking it." – Spring 2004

The students' attitude towards the course and by extension, their attitude toward the EE major, was very poor. Ironically, the IEE course's poor reputation was causing a large portion of the student body to speak ill of the whole engineering department. This negative attitude made it more difficult to attract and retain engineering students.

Another concern was the needs of the Coast Guard, which employs 100% of our graduates. Due to the sea-faring nature of our service, it was felt that Coast Guard Ensigns should have an understanding of the technical principles of radio navigation and communications systems. More than that, we decided that any college graduate should have some basic understanding of technology to improve their performance and help them to make more informed decisions about technology.

As the deliberations about the necessity of certain topics continued, it became obvious that minor tweaks would not be sufficient to correct the problems in the course. It was determined that significant changes were needed. During the End of Course Review the Engineering Department Head, started a discussion about cell phones and GPS tracking. This led to the authors envisioning a course that would teach the students about the technology that has a daily impact on their lives. The course would be more of an overview of computer and electrical technology course rather than the meticulous circuit analysis course it had been.

Changes Made

Given the E&CE section's approval, the authors looked at the desired outcomes of the course and commenced upon a complete re-write. As this is one of the two engineering courses used to justify the Bachelor of Science Degree, there was a fundamental requirement to maintain a rigorous technical approach. We started from scratch and discussed topics to include and the level of understanding desired for this course.

We believe that a basic understanding of electrical engineering properties is important. However, many of the typical EE topics, circuit analysis and electromechanical theory, were already covered in our calculus based Physics II course. Although the IEE course did provide a practical and thorough treatment of these topics, we could not articulate a reason why non-engineers would need such an in-depth discussion of these topics.

A module on electronic navigation was included based upon the Academy's requirement to graduate Coast Guard officers with a "liking for the sea and its lore." Approximately eighty percent of academy graduates go immediately to serve on board a Coast Guard cutter. The dependence of these ships and their law enforcement duties on GPS, DGPS, WAAS, LORAN and other electronic navigation systems dictate that the ship's operators must have a complete understanding of the abilities and limitations of these navigation systems.

The cutters' remote working environment and the need to communicate long distances with other vessels and shore units also necessitates discussions of communication systems. The explosion of digital communications typified with the switching to digital in the TV realm, sky rocketing use of digital cell phones, E911, wireless networks, Voice Over Internet Protocol, etc., are indicative of the growing importance of communication systems in everyday life.

Two modules on computer networks and the Internet were developed along with modules covering image processing, information theory, and technology in society. These topics were selected based upon our opinion that these topics provide the best education of how dramatically technology impacts today's society. Just like society at large, the Coast Guard is relying more

heavily on these technologies in an effort to reduce costs, while improving efficiency and effectiveness.

The authors concluded that after discussing all of the potential uses of these technological advancements, a discussion of both engineering tradeoffs and how to appropriately apply that technology was necessary. We conceived a 'moral and ethical dilemmas' module for this purpose. Additionally, the authors felt these discussions of engineering tradeoffs brought up in this manner accomplished the Academy's shared learning outcome of critical thinking. The recent disclosure of Government monitoring of international phone conversations in the US without approval of the courts, demonstrates that these lessons on the ethical use of technology are indeed essential.

Engineers are familiar with tradeoffs (e.g., horsepower vs. fuel economy), and we wanted to relay the decision process to the non-engineers taking the course. Ethical tradeoffs not only require understanding of the materials presented, but also bring a more humanistic approach to the course and hopefully pique interest of the non-engineers.

With this new concept of a course, a thorough search of applicable text books was commenced. The authors decided upon the textbook "Information Technology: Inside and Outside" by David Cyganski, John Orr and with Richard F. Vaz. This was the best of many that the authors found that discussed the topics desired, including a detailed coverage of communications and electronic positioning (specifically GPS). The authors believe strongly that these topics are important for our students, but are also important for students everywhere.

Because of technology's rapid advancement, we supplemented the text book with current events articles, examples of which can be found in the bibliography. Some of these readings were Coast Guard material on electronic navigation fundamentals or industry tutorials. Other topics such as computer viruses, information security and ethical issues are pulled from various sources, especially as they make the news.

The book provided four natural lesson groupings – introduction, image processing, signal processing, and networks. These groupings were used as break points to inject our applications and ethical discussions, which we called 'Using Technology' and 'Big Brother'.

The 'Using Technology' lessons discussed applications of the material in that lesson grouping which were currently being employed in society or the Coast Guard. For example, the image processing section ends with a lesson on the state of facial recognition and the possible uses in points of entry into the U.S. The signal processing section ended with lessons on Enhanced-911 and Geographic Information Systems, tying into the GPS section and finally, the computer networks section included discussions on cyber terrorism and network security.

The 'Big Brother' lessons were classroom discussions on what can happen when technology is abused. This included applying technology in unexpected ways or in ways that the legal system simply has not caught up with. Usually current events provided a relevancy to the course that is missing from many introductory courses. Classroom discussions were held on privacy rights and

video surveillance, tracking GPS equipped cell-phones and how the government or businesses monitor individual's Internet use.

The four natural breaks also provided convenient exam scheduling and helped in the development of labs to further solidify the lessons discussed in the class lectures. The image-processing lab covers such topics as digital images, facial recognition, image compression and steganography. Comparing signal bandwidth, basic filter design, voice manipulation and recognition are covered in the signal-processing lab. A hands-on demonstration was developed for the electronic navigation lab to demonstrate the relative accuracies of GPS, WAAS and DGPS, while also demonstrating the impact on positioning of satellite masking, multipath and spoofing. Packet sniffing, data security and wireless networks are developed in the networking lab.

In place of a fifth lab, the authors attempted to incorporate the strengths of the non-technical students with the course objectives. Student debates with current relevance effectively demonstrated technological applications, engineering trade-offs, and ethical issues created by the rapid advancement of technology. The debates allowed for more active participation of all group members than the project presentations and papers had done previously, while retaining the course's technological emphasis with the addition of a critical thinking component.

To ensure proper preparations and that the students' debates were sufficiently technologically oriented, a talking points paper is required one week before the debate. The Director of the Student Writing and Reading Center as well as Morals and Ethics instructors were consulted to assist in developing a guide for the students for proper framing and format of the talking points, as well as the rules of order for the debate itself.

A modified parliament debating style and specific time limits set for the pro and con sides were codified. Their "duties" in the debate were identified as opening, rebuttal and closing arguments. A question and answer section, to both involve the other students in the audience and allow the instructors to ask pressing questions to the debaters, was inserted. Technology based topics were provided to the students based on conceived problems not yet faced, but looming on the horizon; issues in the news; issues facing the Coast Guard on a daily basis and issues being discussed in the current module in the class lectures.

When presented with the course's new outline, the other E&CE section members enthusiastically agreed with the course's new direction. The course changes were submitted to the Academy's Curriculum committee and then the Academic Council who both approved the changes beginning the fall semester of 2004. To reflect the course's new direction, in the fall of 2005 the course name was changed to "Introduction to Electrical and Computer Engineering" (IECE). Appendix C includes an overview of the new course's lesson plans.

Feedback

During the three semesters since the change, seven instructors have taught the course (the authors have taught and served as course coordinators since the inception). Teaching engaged students has been more enjoyable, and the changes have the additional effect of raising the

enthusiasm of the instructors. Coupled with the teaching of practical applications of current technologies, the instructors' interest remains high.

The feedback from the students seemed to indicate significant positive results. Appendix D shows the results of the End Of Course Surveys completed after the course's change, from fall 2004 through fall 2005. This represents the average responses of 187 students. Below are somewhat typical comments that we received. While not all comments are positive, the sampling below represents a significant shift from the previous edition of the course.

> "This class was awesome. This has been one of the few classes that I have left every lecture feeling that I learned something every single time." – Fall 04

> "I apply or think about the material learned in class everyday, from how my cell phone works to the https when I do my online banking." – Fall 04

> "The information really will contribute to my ability to aid in technical issues in the Coast Guard and life in general. Also, we discussed many ethical issues concerning computer use and internet use." – Spring 05

Statistical Analysis of Cadet Feedback

A more rigorous examination of the results was conducted to see if the course changes were actually manifesting in the knowledge, retention and applicability of the course, or if rose-colored lens were simply being applied to the data. The authors sought the aid the Academy's Institutional Research to assist in a detailed analysis of the data (Appendix E is a description of the methodology used in the analysis.). The average ratings for each section (1, 3 and 4) were greater after the course revision and this improvement was statistically significant at the 99 percent confidence level. This also indicates statistically significant improvement in the course's overall rating.

Table 1 shows the questions that were found to have statistically significant increases in average response ratings.

Table 1 – End-Of-Course Survey Questions with Statistically Significant Increases in Average Responses

Section 1 -COURSE FEEDBACK
Q1. I understood the learning objectives of the course.
Q2. The homework assignments could reasonably be completed within the time allotted.
Q3. Homework did not exceed, on the average, the two hours per one-hour lecture guideline.
Q6. I believe the course material will benefit me during my career.
Q8. Emphasis was placed on the quality of material, not on the quantity (ie. material was not just rushed through to get it done).
Q9. Lessons were well organized and presented in a comprehensive manner.
Section 3 – FEEDBACK ON TEXT
Q1. Information I needed for this course was readily available.
Q3. The text contained sufficient example problems.
Q4. The textbook was easy to read.
Section 4 – SELF-ASSESSMENT
Q1. By studying for this course, a student could get a good grade.
Q2. My level of understanding of the material that was presented during this class has increased dramatically.
Q5. I will be able to use the concepts presented in the class in my career.
Q6. I understand the majority of the material presented in class.
Q7. I can apply the material presented in class to real-life situations.

Question 4 of Section 4 ('The course received the majority of my effort this semester') was found to have statistically significant decreases in average response ratings. A lower average response for this question can be interpreted as a significant positive result in that students on average seem to understand more of the material. This interpretation can be inferred by the higher average responses to Section 1 questions 1, 2, 8, and 9; all significant Section 3 questions; Section 4 questions 2 and 6; and Section 6 questions 2, 9, 10, and 11.

All remaining questions that are not included in Table 1 showed no statistical change in the average response. As these questions deal with fairness of grading and level of effort required in the course this indicates the course was still academically challenging and that the positive feedback was not due to grade inflation. This supposition is supported by the course GPAs. Before the change the average course GPA was 80.4%; since the change the average course GPA is 80.7%.

From this analysis, the IEE course revisions seem to have produced statistically significant beneficial results in all areas examined.

The analysis is incomplete as we have not yet measured the retention and application of the knowledge in the Coast Guard fleet. As the first graduates of this new course have only been serving in the Coast Guard for 7 months, we have yet to gather enough meaningful data. The intent is to work with Institutional Research to determine appropriate questions and means of gathering the data. This information will be provided back to the E&CE section in the yearly End-of-Course assessments meeting to provide the best possible product to our constituents.

Conclusions

As discussed, the authors created a new "*Introduction to Electrical and Computer Engineering"* course that focuses on technology and its impact on society. By removing circuits and machines, we were able to focus on a broader range of electrical engineering fields, which will allow the students to make better decision when dealing with technology.

Initially the circuit analysis was removed, with the understanding that these topics were covered in the required Physics II course. We have now concluded that the new material is more valuable in students' everyday lives and for their job performance than knowledge of either basic circuit analysis or hysteresis effects.

The innovative approaches, including the debates, lessons not typically seen in a technology course (Big Brother, ethics, etc.) and hands-on labs give a relevancy that we feel is missing in many standard introductory courses. The topics covered (networks, signal processing, image processing, etc.) require higher-level understanding of engineering topics, yet they provide the students with something vital that they were missing in a 'baby wires' class: interest.

A statistical analysis of data collected indicate that the students are more involved, feel that the course is more relevant, yet are no less academically challenged than before. With better attitudes toward the course and open minds, more true learning and understanding is taking place. Actual impact on the students' performance after graduation has not been measured as the students have only recently entered the workforce. The E&CE section plans on conducting further analysis to ensure the course meets both the students' and the Coast Guard's needs.

Because all of the Academy's graduates go to one employer – the US Coast Guard – it is possible to tailor the course to meet very specific customer needs. We know the types of jobs they will be doing and the type of technology they will be using – as the authors were recently doing the same types of jobs and will be returning to the Coast Guard fleet very shortly. However, the information in this course is relevant to any broad based introduction to electrical, computer and engineering technologies course. The authors strongly believe that the topics presented in our new "Introduction to Electrical and Computer Engineering" are not only important for Coast Guard Academy students, but for students everywhere.

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The authors would also like to thank the other members of the USCG Academy's Electrical and Computer Engineering section, specifically the other IECE instructors who have helped to shape the course – Prof. Michael McKaughan, LT Todd Moyer, LT Michael Teixeira and LCDR Dan Pickles.

Bibliography

The following list is an example of the references or assigned readings that have been used during the class:

Text book

D. Cyganski, J. Orr, and R. F. Vaz, *Information Technology: Inside and Outside*. Upper Saddle River, NJ: Prentice Hall, 2001.

Using Technology 1: Facial Recognition & Homeland Security

K. L. Kroeker, *"Graphics and Security: Exploring Visual Biometrics*", IEEE Computer Graphics and Applications, vol. 22, no. 4, pp. 16-21, Jul/Aug, 2002

K. Reed, "Eye scans get frequent fliers' ayes", Boston Globe, 10 Aug 2004

Communications

"Introduction to HF Radio Propagation", Australian Space and Weather Agency Website, IPS - Radio and Space Services, Sydney, Australia, available from http://www.ips.gov.au/Category/Educational/Other%20Topics/Radio%20Communication/Intro%20to%20HF%20Radio.pdf. (accessed 27 February 2006).

Radionavigation

Trimble Navigation Ltd GPS Tutorial, Trimble Navigation Ltd. Website, available from http://www.trimble.com/gps/index.html, (accessed 27 February 2006).

Using Technology 2: Geographic Information Systems and Enhanced-911

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Computer Ethics

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Disclaimer: The above are examples of the articles the authors have used to assist in teaching the course material. Their inclusion is for information purposes only and is not meant as an endorsement of any of the companies or opinions expressed.

Appendix A

Introduction to Electrical Engineering
Lesson Plan Overview – Prior to Fall 2004

Lesson Plan	Length
Module 1: Electric Circuit Theory	
Introduction	1 day
Resistance, Voltage and Current	1 day
Capacitance and Inductance	1 day
Sinusoidal Signals and Complex Numbers	2 days
Impedance	1 day
AC Circuit Analysis	1 day
Frequency Response	1 day
Power	1 day
Filters	1 day
Module 2: Power and Machinery	
Complex Power	1 day
Power Factor	1 day
Transformers and 3-Phase Power	1 day
Rotating Machinery Basics	1 day
AC Generators	2 days
Residential and Shipboard Wiring	1 day
Module 3: Communications	
Signals and Frequency	1 day
Communications Systems	4 days
Module 4: Computers and Networks	
Computer Systems and Networks	3 days
Module 5: Electronic Navigation Systems	
Electronic Navigation Systems Fundamentals	2 days
Global Positioning System	2 days
LORAN-C Navigation	2 days
RADAR	2 days
Antennas	2 days
Electromagnetic Propagation	2 days
Lab 1: Multimeters and Resistive Networks	
Lab 2: Circuit Problem Session	
Lab 3: Power Problem Session	
Lab 4: Paralleling Generators	
Lab 5: Frequency Spectrum	
Lab 6: Fiber Optics	

Appendix B

END OF COURSE SURVEY RESULTS: FALL 1999 – SPRING 2004

Section 1 -COURSE FEEDBACK	Mean	Std. Deviation	Std. Error Mean
Q1. I understood the learning objectives of the course.	3.6	0.84	0.03
Q2. The homework assignments could reasonably be completed within the time allotted.	3.9	0.82	0.03
Q3. Homework did not exceed, on the average, the two hours per one-hour lecture guideline.	4.0	0.84	0.03
Q4. Exams and quizzes were fair.	3.5	0.96	0.04
Q5.Grading was fair.	3.9	0.80	0.03
Q6. I believe the course material will benefit me during my career.	2.9	1.08	0.04
Q7. The course was academically challenging.	3.9	0.79	0.03
Q8. Emphasis was placed on the quality of material, not on the quantity (i.e., material was not just rushed through to get it done).	3.3	1.02	0.04
Q9. Lessons were well organized and presented in a comprehensive manner.	3.4	0.97	0.04
Section 3 – FEEDBACK ON TEXT	**Mean**	**Std. Deviation**	**Std. Error Mean**
Q1. Information I needed for this course was readily available.	3.3	0.99	0.04
Q2. The textbook was a major contributing factor to the success of the class.	2.3	1.05	0.04
Q3. The text contained sufficient example problems.	2.7	1.04	0.04
Q4. The textbook was easy to read.	2.3	1.07	0.04
Section 4 – SELF-ASSESSMENT	**Mean**	**Std. Deviation**	**Std. Error Mean**
Q1. By studying for this course, a student could get a good grade.	3.9	0.84	0.03
Q2. My level of understanding of the material that was presented during this class has increased dramatically.	3.4	0.91	0.04
Q3. I could have put more effort into this course.	3.5	0.99	0.04
Q4. The course received the majority of my effort this semester.	2.7	0.99	0.04
Q5. I will be able to use the concepts presented in the class in my career.	3.0	0.96	0.04
Q6. I understand the majority of the material presented in class.	3.3	0.94	0.04
Q7. I can apply the material presented in class to real-life situations.	3.0	0.99	0.04
Q8. I was academically challenged during this course.	3.8	0.89	0.04
SECTION OVERVIEWS	**Mean**	**Std. Deviation**	**Std. Error Mean**
Response Mean for Section 1 (Course Feedback)	3.6	0.57	0.02
Response Mean for Section 3 (Text Feedback)	2.7	0.82	0.03
Response Mean for Section 4 (Self Assessment)	3.3	0.53	0.02

NOTE: Section 2 is on Engineering Department Objectives and Section 5 provides feedback on the instructor's performance. As these are either not applicable for a course taken by non-engineers or are dependent upon individual instructors, this data was not considered during the evaluation.

Appendix C

Introduction to Electrical and Computer Engineering
Lesson plan overview - Fall 2004 to Present.

Lesson Plan	Length
Module 1 – Introduction	
Introduction	1 day
World Wide Web	2 days
Module 2 – Image Processing	
Digital Information	2 days
Digital Images	2 days
Computer Graphics	1 day
Compressing Information	2 days
Image Compression	2 days
Using Technology: Facial Recognition & Homeland Security	1 day
Big Brother 1: Video Surveillances	1 day
Module 3 – Signal Processing	
Audio Information	1 day
Audio Sampling	1 day
Digital Audio	1 day
Data Transmission	3 days
Radio Frequency	2 days
Electronic Navigation	2 days
Using Technology 2: GIS and E-911	1 day
Big Brother 2: Monitoring Movement	1 day
Module 4 - Networks	
Circuit and Packet-Based Network	1 day
Local Area Networks: Ethernet	1 day
Wide Area Networks: Internet	1 day
Wireless Networks	2 days
Internet Security	2 days
E-Commerce	2 days
Big Brother 3: Government and Commercial Monitoring of the Internet	1 day
Technology and Ethics	1 day
Voice Over IP	1 day
Lab 1: Image Processing	
Lab 2: Frequency Spectrum	
Lab 3: Electronic Navigation	
Lab 4: Computer Networks	
Lab 5: Debate – series of 3 spread throughout the semester	

Appendix D

END OF COURSE SURVEY RESULTS: FALL 2004 – FALL 2005

Section 1 -COURSE FEEDBACK	Mean	Std. Deviation	Std. Error Mean
Q1. I understood the learning objectives of the course.	3.7	0.84	0.06
Q2. The homework assignments could reasonably be completed within the time allotted.	4.2	0.72	0.05
Q3. Homework did not exceed, on the average, the two hours per one-hour lecture guideline.	4.2	0.78	0.06
Q4. Exams and quizzes were fair.	3.4	1.05	0.08
Q5.Grading was fair.	3.9	0.92	0.07
Q6. I believe the course material will benefit me during my career.	3.6	1.00	0.07
Q7. The course was academically challenging.	3.9	0.90	0.07
Q8. Emphasis was placed on the quality of material, not on the quantity (i.e., material was not just rushed through to get it done).	3.7	1.03	0.08
Q9. Lessons were well organized and presented in a comprehensive manner.	3.6	0.94	0.07
Section 3 – FEEDBACK ON TEXT	**Mean**	**Std. Deviation**	**Std. Error Mean**
Q1. Information I needed for this course was readily available.	3.9	0.89	0.06
Q2. The textbook was a major contributing factor to the success of the class.	3.1	1.13	0.08
Q3. The text contained sufficient example problems.	2.7	1.19	0.09
Q4. The textbook was easy to read.	3.4	1.16	0.08
Section 4 – SELF-ASSESSMENT	**Mean**	**Std. Deviation**	**Std. Error Mean**
Q1. By studying for this course, a student could get a good grade.	4.1	0.89	0.06
Q2. My level of understanding of the material that was presented during this class has increased dramatically.	3.9	0.97	0.07
Q3. I could have put more effort into this course.	3.6	1.01	0.07
Q4. The course received the majority of my effort this semester.	2.5	1.04	0.08
Q5. I will be able to use the concepts presented in the class in my career.	3.7	0.90	0.07
Q6. I understand the majority of the material presented in class.	3.8	0.85	0.06
Q7. I can apply the material presented in class to real-life situations.	3.8	0.94	0.07
Q8. I was academically challenged during this course.	3.8	0.89	0.04
SECTION OVERVIEWS	**Mean**	**Std. Deviation**	**Std. Error Mean**
Response Mean for Section 1 Feedback.	3.8	0.60	0.04
Response Mean for Section 3 Feedback.	3.3	0.86	0.06
Response Mean for Section 4 Feedback.	3.7	0.52	0.04

NOTE: Section 2 is on Engineering Department Objectives and Section 5 provides feedback on the instructor's performance. As these are either not applicable for a course taken by non-engineers or are dependent upon individual instructors, this data was not considered during the evaluation.

Appendix E

Statistical Analysis Methodology Notes

1. All statistical analysis was performed using SPSS software.

2. Since a 5-point Likert scale set of responses was the basis for this analysis, normality of data for statistical analysis was not expected. This was borne out during exploratory data analysis, explained below.

3. To obtain overall Section Means, each student's mean section score was computed individually, and the average of these mean scores is the overall section mean. This is mathematically equivalent to summing up all the individual responses within a section and dividing by both the number of questions in the section and the number of students.

4. Exploratory data analysis simply consisted of identifying the valid cases: in this set, identifying the median case, identifying any outliers, computing the first, second, third, and fourth centralized moments for the sample (mean, variance, skewness, and kurtosis), and plotting a histogram of the entire set of responses. This was completed on a question-by-question basis.

5. The authors recognize the argument that Likert scale responses can be considered ordinal data vice scale data, and choose to treat the responses as scale data for evaluation. Only the endpoints are specifically labeled (strongly disagree/agree or Didn't Contribute/Contributed Greatly), allowing students to choose their level of agreement and minimizing nonlinearity of responses.

6. The statistical T-test was chosen as a method of comparing responses before and after the IEE course revision due to its robust treatment of non-Normally distributed data.

7. To prepare the data for analysis, responses were separated into two groups: semesters prior to the course revision (Spring 1999 – Spring 2003) and semesters after the course revision (Fall 2004 – Fall 2005). Then each set was separately aggregated on both a question-by-question basis and a section-by-section basis.

8. The two groups of data were examined as shown in the Group Statistics sheet. Valid response counts, means, variances, and standard errors were computed for use in the T-test, again on both a question-by-question and a section-by-section basis.

9. While the T-test is robust with the Normality of data assumption, it is more sensitive to differences in variation between the comparison groups, and hence, the Levene's Test is used to evaluate equality of variance. If the test does not produce statistically significant results, equality of variances may be assumed and the T-test may proceed; in the event equality of variances may not be assumed, the appropriate statistical correction factor is applied to the T-test, accounting for the dissimilar variances. The appropriate tests were selected and are displayed on the T-tests sheet. The raw results are included for completeness.

Appendix E
Raw Results for Statistical Analysis

Independent Samples T-Test														
		Levene's Test for Equality of Variances		t-test for Equality of Means										
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		Significance at $\alpha = 0.05$	99% Confidence Interval of the Difference		Significance at $\alpha = 0.01$
Section 1.									Lower	Upper		Lower	Upper	
course.	Equal variances assume	1.42899476	0.232280593	2.78770296	805	0.0054334	0.195437295	0.0701069	0.0578233	0.33305126	Significant	0.01442468	0.3764499	Significant
Q2. The homework assignments could reasonable be completed within the time allotted.	Equal variances assume	0.459930075	0.497851545	3.91031664	805	9.994E-05	0.260427807	0.0666002	0.1296973	0.39115833	Significant	0.08846943	0.4323862	Significant
Q3. Homework did not exceed, on the average, the two hours per one-hourlecture guideline.	Equal variances assume	1.175185009	0.278662983	2.6107487	805	0.0092025	0.180119027	0.0689913	0.0446949	0.31554316	Significant	0.00198683	0.3582512	Significant
Q4. Exams and quizzes were fair.	Equal variances assume	3.336809668	0.068116024	-1.21544919	805	0.2245512	-0.09926686	0.0816709	-0.25958	0.06104625	Insignificant	-0.31013715	0.1116034	Insignificant
Q5.Grading was fair.	Equal variances not assu	4.819833538	0.028418809	0.21147835	276.9345	0.8326696	0.015715025	0.0743103	-0.13057	0.16199989	Insignificant	-0.17702356	0.2084536	Insignificant
Q6. I believe the course material will benefit me during my career.	Equal variances assume	1.20515605	0.272621832	8.844709	805	5.731E-18	0.782542694	0.0884758	0.6088722	0.95621319	Significant	0.55410256	1.0109828	Significant
Q7. The course was academically challenging.	Equal variances assume	2.645424733	0.104239756	-0.45525401	805	0.6490493	-0.03114542	0.0684133	-0.165435	0.10314405	Insignificant	-0.20778512	0.1454943	Insignificant
Q8. Emphasis was placed on the quality of material, not on the quantity (ie. material was not just rushed through to get it done).	Equal variances assume	0.827363857	0.363308159	4.90337746	805	1.14E-06	0.418613076	0.0853724	0.2510343	0.58619185	Significant	0.19818578	0.6390404	Significant
Q9. Lessons were well organized and presented in a comprehensive manner.	Equal variances assume	0.418785358	0.517728235	3.01786792	805	0.0026258	0.241797481	0.080122	0.0845249	0.39907009	Significant	0.03492656	0.4486684	Significant
Section 3.														
Q1. Information I needed for this course was readily available.	Equal variances not assu	17.7828306	2.75708E-05	7.74640984	335.8985	1.129E-13	0.589649819	0.0761191	0.4399196	0.73938003	Significant	0.39245985	0.7868398	Significant
Q2. The textbook was a major contributing factor to the success of the class.	Equal variances assume	0.003804506	0.950832436	9.47133892	805	2.986E-20	0.842772124	0.0889813	0.6681094	1.01743489	Significant	0.61302679	1.0725175	Significant
Q3. The text contained sufficient example problems.	Equal variances not assu	6.183457246	0.013096651	0.03284072	277.599	0.9738252	0.00316543	0.0963874	-0.186578	0.19290843	Insignificant	-0.24683019	0.2531611	Insignificant
Q4. The textbook was easy to read.	Equal variances assume	1.320954287	0.250762215	11.2212583	805	2.994E-27	1.02170088	0.0910505	0.8429765	1.20042524	Significant	0.78661307	1.2567887	Significant
Section 4.														
Q1. By studying for this course, a student could get a good grade.	Equal variances assume	1.660145672	0.197953846	2.9117743	805	0.0036931	0.207547007	0.0712785	0.0676333	0.34746073	Significant	0.02350936	0.3915847	Significant
Q2. My level of understanding of the material that was presented during this class has increased dramatically.	Equal variances assume	0.347196516	0.555869738	5.67248407	805	1.963E-08	0.436260135	0.0769081	0.285296	0.58722427	Significant	0.23768716	0.6348331	Significant
Q3. I could have put more effort into this course.	Equal variances assume	0.144790952	0.703664243	1.19162081	805	0.2337612	0.098507849	0.0826671	-0.063761	0.26077638	Insignificant	-0.11493454	0.3119502	Insignificant
Q4. The course received the majority of my effort this semester.	Equal variances assume	1.116323624	0.29102842	-2.58608668	805	0.0098818	-0.21668104	0.0837872	-0.381148	-0.05221381	Significant	-0.43301552	-0.0003466	Significant
Q5. I will be able to use the concepts presented in the class in my career.	Equal variances assume	0.281906019	0.595601108	9.33580929	805	9.534E-20	0.733896843	0.078611	0.5795902	0.88820348	Significant	0.53092726	0.9368664	Significant
Q6. I understand the majority of the material presented in class.	Equal variances not assu	11.92451935	0.000582927	6.78428951	334.7131	5.305E-11	0.494583405	0.0729013	0.351181	0.63798582	Significant	0.30572554	0.6834413	Significant
Q7. I can apply the material presented in class to real-life situations.	Equal variances assume	1.191910239	0.275271215	9.87055183	805	9.063E-22	0.807823012	0.0818417	0.6471746	0.96847139	Significant	0.59651173	1.0191343	Significant
Q8. I was academically challenged during this course.	Equal variances assume	0.806390746	0.36945798	0.87581744	805	0.3813905	0.066482663	0.0759093	-0.082521	0.21548613	Insignificant	-0.12951132	0.2624766	Insignificant

Appendix E
Raw Results for Statistical Analysis

Independent Samples T-Test

		Levene's Test for Equality of Variances		t-test for Equality of Means									
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		Significance at $\alpha = 0.05$	99% Confidence Interval of the Difference		Significance at $\alpha = 0.01$
Section 6.									Lower	Upper		Lower	Upper	
Q1. The instructor was fair to all students.	Equal variances not ass	3.871502863	0.049455464	4.56710761	318.045	7.08E-06	0.288252544	0.0631149	0.1640771	0.41242801	Significant	0.12469813	0.451807	Significant
Q2. The instructor was helpful when students had difficulty.	Equal variances assume	0.068486303	0.793620549	6.01630465	805	2.707E-09	0.457952389	0.0761186	0.3085381	0.60736665	Significant	0.26141806	0.6544867	Significant
Q3. The instructor communicated effectively	Equal variances assume	3.784568899	0.052075022	5.73531783	805	1.377E-08	0.462057961	0.0805636	0.3039184	0.62019752	Significant	0.25404669	0.6700692	Significant
Q4. The instructor was enthusiastic	Equal variances not ass	11.30210411	0.000810716	9.96742768	365.0056	7.418E-21	0.704045196	0.0706346	0.5651434	0.84294703	Significant	0.52114641	0.886944	Significant
Q5. The instructor encouraged students to do their own learning.	Equal variances assume	0.983698776	0.321585364	7.55401457	805	1.147E-13	0.480886666	0.0636597	0.355928	0.60584536	Significant	0.31652035	0.645253	Significant
Q6. Material was presented in a well organized fashion.	Equal variances assume	0.322502356	0.57026604	2.53546589	805	0.0114179	0.214455753	0.0845824	0.0484277	0.38048381	Significant	-0.00393178	0.4328433	Insignificant
Q7. The instructor made effective use of visual aids.	Equal variances assume	0.149991202	0.698646135	2.531595	805	0.0115437	0.190676212	0.0753186	0.0428322	0.33852026	Significant	-0.0037927	0.3851451	Insignificant
Q8. The instructor used the board effectively.	Equal variances assume	3.818285681	0.051042006	4.57746347	805	5.45E-06	0.378859755	0.0827663	0.2163965	0.54132301	Significant	0.16516125	0.5925583	Significant
Q9. The instructor was concerned with my learning.	Equal variances assume	0.13573988	0.71265029	6.30567886	805	4.727E-10	0.492858375	0.078161	0.3394349	0.64628186	Significant	0.29105046	0.6946663	Significant
Q10. The instructor encouraged class particpation.	Equal variances not ass	8.628300897	0.003404239	9.83533491	321.7557	3.945E-20	0.737855787	0.0750209	0.5902623	0.88544924	Significant	0.54346195	0.9322496	Significant
Q11. The instructor motivated me to learn.	Equal variances assume	2.29047319	0.130562725	6.22339523	805	7.821E-10	0.515395894	0.0828159	0.3528354	0.67795643	Significant	0.30156942	0.7292224	Significant
matter.	Equal variances not ass	4.680195838	0.030805894	9.19220712	399.7813	2.136E-18	0.602001035	0.0654904	0.4732525	0.73074957	Significant	0.43249998	0.7715021	Significant
Q13. Assignments were graded and returned in a reasonable amount of time.	Equal variances not ass	13.11734913	0.0003109	0.61634028	266.0037	0.538197	0.048887356	0.0793188	-0.107285	0.20505985	Insignificant	-0.15690027	0.254675	Insignificant
Q14. The instructor praised accomplishments both in and out of class.	Equal variances assume	3.323342563	0.068674985	5.92117435	802	4.738E-09	0.460976434	0.0778522	0.3081583	0.61379456	Significant	0.25996413	0.6619887	Significant

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means									
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		Significance at $\alpha = 0.05$	99% Confidence Interval of the Difference		Significance at $\alpha = 0.01$
									Lower	Upper		Lower	Upper	
Response Mean for Section 1 Feedback.	Equal variances assume	0.000123087	0.991150848	4.52110607	805	7.076E-06	0.218248903	0.0482733	0.1234924	0.31300538	Significant	0.09360952	0.3428883	Significant
Response Mean for Section 3 Feedback.	Equal variances assume	0.175653312	0.675247446	8.91717641	805	3.166E-18	0.614322063	0.068892	0.4790929	0.74955121	Significant	0.43644635	0.7921978	Significant
Response Mean for Section 4 Feedback.	Equal variances assume	0.049356164	0.824243757	7.48485977	805	1.88E-13	0.328552484	0.0438956	0.2423891	0.41471585	Significant	0.21521619	0.4418888	Significant
Response Mean for Section 6 Feedback.	Equal variances assume	0.004403261	0.947110025	7.80463599	805	1.854E-14	0.430837142	0.0552027	0.3224789	0.53919541	Significant	0.28830645	0.5733678	Significant