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A Breadth First Course in Electrical and Computer Engineering

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A Breadth First Introductory Course in Electrical and Computer Engineering

Abstract

As technology continues to advance and competition within the global economy becomes fierce, it is increasingly important that engineering students can not only select the proper equations, perform the correct computations/simulations and build circuits correctly, but also possess an appreciation for the variety of knowledge areas within their field of study. In an effort to better prepare electrical and computer engineering students, the Electrical and Computer Engineering (ECE) Department at the United States Air Force Academy created a breadth-first introductory course to give students this view as a starting point in their education. A thorough review of the curriculum revealed primary knowledge areas that the students need early in their education in order to better prepare them for the depth of a rigorous ECE curriculum. This knowledge includes, but is not limited to, Radio Frequency (RF) communications, RADAR and electronic warfare, analog circuits including power generation and distribution and digital circuits and systems. These topics were selected due to their extensive use in senior capstone projects and needs the industry of the program constituents?

The solution proposed here is to create a breadth-first introductory course to motivate and inspire the students to dig deeper into topics they will see later in the curriculum. Through early exposure to a broad set of knowledge and simulation/laboratory techniques, students can begin to develop intellectual curiosity and intuition about how electrical and computer systems work and, in the process, see the fun and excitement in electrical and computer engineering.

This paper delves into the development of the course, from the determination of the goals through the implementation of the course structure and teaching philosophy. The paper concludes with an analysis of student feedback.

1.0 Introduction

A lesser known corollary to Murphy's Law for Engineers states "If it isn't broken, it doesn't have enough features yet." There is a bit of truth in this humorous insight into the psyche of the Engineer. Engineers are always searching for better implementations and better solutions. The same is true for engineering faculty and the delivery of an engineering curriculum. While a given curriculum may serve the current population well, a better solution most assuredly exists. In a continuous search for the better solution, engineering faculty follow the engineering process to develop new and better ways to deliver program and best serve the constituents. The following describes the development and implementation of ECE 210 *Principles of Air Force Electronic Systems*, a breadth-first introductory course in Electrical and Computer Engineering at the US Air Force Academy (AFA).

1.1 Motivations for Change and Motivation for Students

An early indicator that a curriculum adjustment was needed came from discussions with students at events specifically designed for soliciting feedback on their curriculum. These discussions indicated that students choose either an Electrical Engineering (EE) or Computer Engineering (CpE) major without having a good definition of either one. Even more concerning, junior-level ECE majors were unable to provide a reasonable explanation of how the two majors differed and were unaware of broad EE depth areas such as power systems and communications theory. This lack of knowledge among students halfway through their degree was identified as an institutional problem. Constituent feedback expresses a strong need for EEs in these areas.

Over the last decade, the ECE department has seen a shift from a majority of EE students to a majority of CpE majors. A review of the programs of record revealed that the CpE programs introduced majors to depth areas earlier than the EE program because of the need for significantly more mathematical prerequisite classes before more advanced EE topics. While the institution's constituents valued graduates from both programs, this shift was the first of many indicators that perhaps a curriculum change was in order. An introductory course with a large amount of breadth would introduce EE and CpE topics earlier in the students' course of study, enabling them to make a more well-informed choice of major.

An effort to attract more students into the EE program was a "soda straw" solution to a larger issue: How can we better fit the student to the major? Figure 1 below, reprinted from Matusovich, et. al. [1] shows a simplified view of Eccles expectancy-value theory [2]. The course described in this work aims to help students answer a question similar to the question on the right, "Do I want to earn an Electrical or Computer Engineering degree?" There are three answers to this question:

1) I choose Electrical Engineering.
2) I choose Computer Engineering.
3) I choose something else.

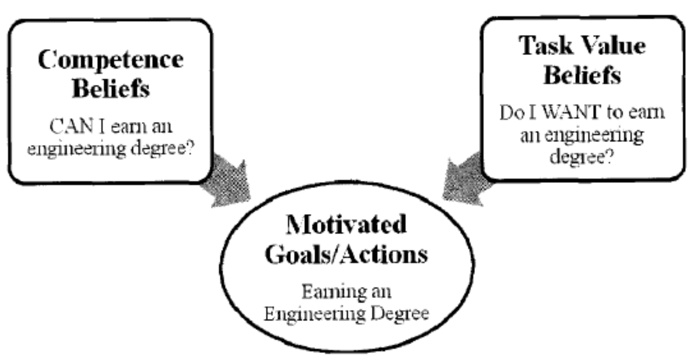

Figure 1: Simplified view of Eccles' expectancy-value theory showing the relationship between competence and value beliefs and the motivated action of earning an engineering degree [1].

Many institutions have gone through curriculum updates to improve learning early in the curriculum [3] [4] [5]. The first step in revising any program is to take close look at the current curriculum model. To that end, ECE department faculty performed a rigorous curriculum review in 2011. As part of this review, information on programs and introductory courses was collected from seven comparable institutions. Table 1 summarizes the findings. Many ECE programs have an introductory course in EE or ECE tailored to meet the needs of the particular program. Many programs use a common topic such as robotics to introduce the students to electrical and computer engineering knowledge areas including programming, sensors, and analog-to-digital conversion. Only Purdue, Columbia and Illinois cover more than one or two knowledge areas and can be considered broad in scope.

Table 1: Introductory courses from comparable institutions.

Institution	Course(s)	Topics
Rose-Hulman IT	ECE 160	System engineering, teamwork, engineering design, autonomous robotics
Georgia Tech	ECE 2030 Intro to Computer Engineering	Gates, K-maps, FSM, flip-flops, memory, control
Georgia Tech	ECE 2025 Intro to Signal Processing	MATLAB, continuous and discrete frequency and time domains
Columbia University	ELEN E1201 Introduction to Electrical Engineering	Broad coverage of many EE topics.
University of Illinois	ECE 110 Intro to ECE	Circuits, transistors, gates, A-to-D
University of Illinois	ECE 190 Intro to Computing.	Digital logic, assembly, C programming
Purdue University	ECE 9000: intro to ECE	History, overview of areas, analytic tools
Carnegie-Mellon University	ECE 18-100: Intro to ECE,	Circuits, K-maps, flip/flops, sequential logic and FSM.
Carnegie-Mellon University	ECE 18-202: Math Foundations of EE	MATLAB, complex analysis, complex differentiation
Virginia Tech	ECE 1574 OO Engineering Problem solving with C++	Programming
Oregon State [3], not part of original review	ECE 111, Introduction to Electrical and Computer Engineering I	Use of micro-controller systems to build Robots

Other information gathered as part of the review included student feedback and program assessment data. For example, students entering their senior year exhibited poor lab skills. This information lead the ECE department to set a goal of providing hands-on early and often in the curriculum. The next section describes this goal and others that drove the development the introductory course, ECE 210 at the US Air Force Academy.

2.0 Determining Goals for Curricular Changes

Based on the findings presented a key recommendation from the 2011 Curriculum review was to develop an introductory course with the following strategic goals:

The course must

1. Be fun (an oftentimes forgotten but important part of helping students to answer "Do I WANT an engineering degree?")
2. Provide an overview of EE and CpE
3. Provide knowledge and experiences currently not offered in the program
4. Provide breadth before depth
5. Provide extensive hands-on experiences
6. Introduce software and test equipment

Goals 2, 3 and 4 seek to build intuition and curiosity in the students by providing a broad overview of EE and CpE. These three goals work together to pique the students' interest enough to continue in the major. Conversations with advanced students in the major indicate that a few were frustrated by the lack of detail in the first course. Their comments indicate a hunger that will be fed as they move through the rest of the major.

Another strong motivator for students choosing engineering as a career path is self-efficacy or the belief in one's ability to perform a task within a specific domain. If a student believes she or he will succeed, then success is more likely. Jones and others [7] have shown there is a strong link between self-efficacy and persistence. While personal performance certainly influences this area, time spent with faculty contributes greatly to self-efficacy.

The course presented here moves toward giving students confidence to solve problems they have not seen before by re-connecting them with applications learned earlier and providing a significant amount of faculty interaction during class, via the "flipped classroom" [8] [9] [10]. For example, the final project requires students to read datasheets and implement hardware and software given the information they find. Labs and projects from earlier in the semester require the use of datasheets. Other techniques and the overall teaching philosophy applied in the course are described next.

Goals 1 and 5 are connected in that hands-on learning is more fun. However, the expectations for this new course were high: to provide knowledge on a broad set of electrical and computer engineering principles while allowing students to gain hands-on experience, which will likely motivate further learning. Since this is an introductory course, students would need supervision and support during their labs. With each class being 53 minutes long and the need for lab activities during that time, there was not much time left to provide a full lecture on the topic of the day. This need led to a flipped classroom approach.

The flipped classroom approach requires the student to learn the new material in the course before each class via instructor-generated reading or electronic media and to complete the homework assignment. Class time can then be used to practice/discuss/reinforce the material with the professor [9]. Generally, the first 10 minutes of the class is dedicated to answering questions about the reading assignment and homework. The remainder of the class is structured differently depending on the topic and task of the day.

The flipped classroom structure allows the students to not only learn new material introduced in the course but also to apply the knowledge and learn hands-on techniques with guidance from a professor within a short period of time. This philosophy seems to appeal to students. In a recent survey of 19 course graduates, 32% said that they would learn more if a lecture was provided in class with a lab completed outside of class (see Figure 2). In contrast, 63% liked the flipped classroom approach.

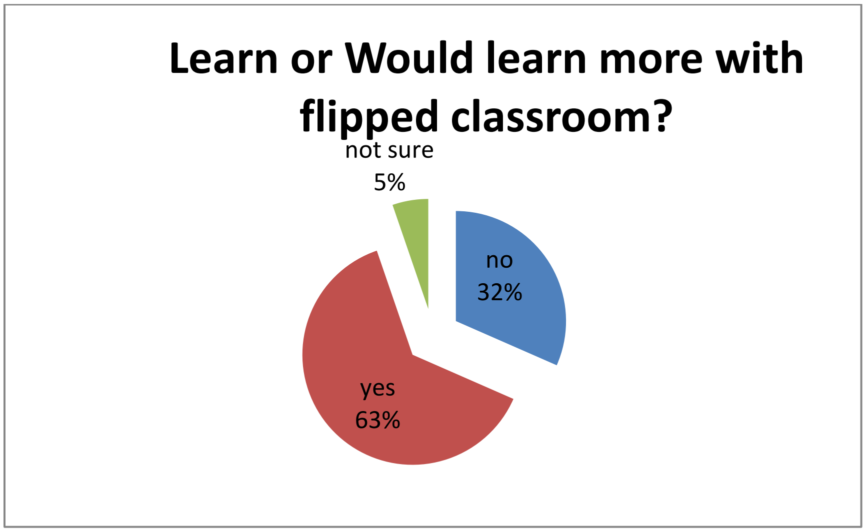

Figure 2: Flipped classroom student preference

Statistics from graded exams and questionnaires also showed that students in the flipped classroom performed well on the exams and enjoyed the course. During the first offering of the course in Fall 2012 (lesson 13/40), students were allowed the opportunity to provide anonymous feedback. Of the 33 students, 20 volunteered their thoughts in the extra comments section. Of the 20 students, 14 expressed that they thought the course was "awesome," "fun," "great," "engaging," "interesting," "cool" or "enjoyable." The data collected so far show that the flipped-classroom approach has been a success in this class.

Goal 6 mean~~s~~ creating activities that put instrumentation into the students' hands. Care must be taken when giving inexperienced students projects involving industrial-grade equipment. They need exposure to the tools but should not be "over exposed." Many tools are complex and can provide or perform detailed analysis ~~at~~ with the click of a button. Because analysis and simulation tools are easy to use, students are able to work with realistic systems without the pain and frustration of manually solving systems of equations or differential equations. Simulation tools such as National Instruments' Multisim relieve the user of the burden of setting up the mathematical models. Heavy use of such powerful technology can supplant the intuition that comes from working with the mathematical model, and/or the physical model can be lost. The laboratory remains the place where this intuition can still be developed [10]. Development of intuition is important in today's engineering programs because in recent years there are few students who have tinkered with electronic and mechanical systems [11]. Hands-on work using industrial grade tools is highly motivational and connects coursework with the real world[12][13].

3.0 Course Structure and Implementation

With a set of goals established, we could build the course. The new course is executed in 40 lessons of 53 minutes. The 40 lessons are divided into four blocks of instruction covering four broad topics: RF communications, RADAR and electronic warfare, analog circuits including power generation and distribution, and digital circuits and systems. These topics areas were chosen because the graduates of our institution will be expected to understand basic principles of these systems widely used within the defense industry. An example of a basic principle of one system: A RADAR user must understand that a pulse is transmitted, a reflection is received and the distance to the shiny object is derived from the time it took for the echo to return. All department faculty vetted the topics and principles.

The graded work consists of 15 labs, four projects, four exams and 21 homework assignments to provide practice solving problems. The relatively high amount of graded material paired with a limited amount of classroom time necessitated a unique lesson structure as compared with a typical ECE course. This need is predicated on the assumption that it is simply not possible to both lecture on the material and allow students enough time to properly accomplish each assignment while having access to their instructor. This is the flipped-classroom approach described earlier. As shown in Table 2, each lesson plan falls into one of four categories: lectures (10 lessons), labs (15 lessons), projects (11 lessons) and exams (four lessons). Lecture periods actually have very little lecture time from the instructor, but instead include live demonstrations and students working problems at the board or on the computer.

During lab days, the instructor generally expands the discussion of the topic in the reading material to tie the material to the real world through a demonstration or examples. The students use the remaining time to complete the lab work with instructor supervision. Most students are able to finish the lab work during class. Students are able to complete most labs outside of class using their personal computers and materials provided. During project days, teams of two use class time to work on their block projects. Professors provide guidance, and peer instruction is also encouraged. On exam days, 30 minutes are dedicated to the exam with the remaining time available for students to work on block projects. During the remaining 10 days of the semester, the class time may consist of viewing live demonstrations or videos, listening to an external speaker, programming, simulation or practicing mathematical problems. A sample schedule follows in Table 2 on the next page.

There are four blocks of material each capped by a project and an exam. Students are given two full class periods to work on block projects. Each block project was created to allow students to demonstrate the most important concepts presented during the course of the block and to ensure that high-level concepts were being adequately absorbed. The fourth and final block project is a culminating experience and therefore four full periods are devoted to work on the class's final project, required in lieu of a final exam. To complete the final project, students must use the inexpensive and easy to use Arduino microprocessor. After this experience, students may buy one of their own and tinker outside of class. Overall, 11 lessons are fully devoted to project lessons and four are exam/project lessons. Once the course outline, teaching philosophy and content were determined, resources needed to be garnered to support the content of the course.

Table 2: Course schedule

Lesson	Topics	Category
1	Course Overview & Policies / Intro to MATLAB	Lecture
2	Filters	Lab
3	Amplitude Modulation	Lab
4	Demodulation	Lab
5	Antennas (Monopole, Dipole, Parabolic, Phased Array)	Lecture
6	Radio Receiver Design Project	Project
7	Radio Receiver Design Project	Project
8	Exam #1	Exam
9	FRIIS/Line of Sight/Introduce dB	Lab
10	RADAR	Lab
11	RADAR	Lab
12	GPS	Lecture
13	Electronic Warfare	Lecture
14	Electronic Warfare	Lecture
15	RADAR Selection Project	Project
16	RADAR Selection Project	Project
17	Exam #2	Exam
18	Circuit Analysis	Lab
19	Circuit Protection	Lecture
20	Instrumentation Systems	Lab
21	Op Amps, and Op Amp Implementations	Lab
22	AC Power	Lab
23	AC/DC Conversion	Lab
24	Power Distribution	Lab
25	Power Transmission	Lecture
26	Solar Energy Project	Project
27	Solar Energy Project	Project
28	Exam #3	Exam
29	Analog-to-Digital Conversion	Lecture
30	Digital-to-Analog Conversion	Lecture
31	Intro to Arduino Programming	Lecture
32	Programming	Lab
33	Programming	Lab
34	Digital Communication	Lab
35	Exam #4	Exam
36	Final Project Time[1]	Project
37	Final Project Time	Project
38	Final Project Time	Project
39	Final Project Time	Project
40	Final Project Demonstration	Project

[1] Students can select from the following projects: weather station, wireless communication using infrared, rangefinder or room mapper using MATLAB. With instructor approval, they also have the option to create their own designs.

3.1 Resources Required

As a breadth-first course, ECE 210 incorporates various high-level topics from the electrical and computer engineering disciplines. Most of the resources required to implement the class are easily found within department supply closets. Ubiquitous consumable items required include resistors, capacitors, diodes, protoboards and op-amps. Common signal generation/measurement equipment such as function generators and oscilloscopes were also used during the course and are likely readily available in various forms in any ECE department.

Potentially limited resources include software licenses for MATLAB, myDAQ Virtual Instruments, solar panels, power resistors, rechargeable lithium-ion batteries and Arduino kits and shields. The authors' institution maintains the licensing agreement for MATLAB and National Instruments' myDAQ modules were borrowed temporarily from circuit sequence courses occurring later in the curriculum. MATLAB and the myDAQ modules are available-at reasonable prices for students and are very useful throughout most ECE curricula.

Solar panels and lithium-ion batteries, which required the most lead time and were the most expensive, had to be purchased for the solar energy lab. Solar panels could cost as much as $1,000. As a result, students were able to use the panels only during class time.

Perhaps the most challenging equipment acquisition was for the five different Arduino projects at the end of the semester. Calculating the number of generic kits to purchase was straight-forward (one per student; whereas trying to determine how many shields and accessories to purchase for specific projects would require guessing how many of each project to support. This meant limiting the number of each type of project and that not all students could have their first choice of project. Some institutions may choose to operate under a model where the students purchase their own parts; thus, they become the driver and have increased freedom. Because the students may order the wrong parts or have trouble getting parts, the authors chose to provide prepackaged projects. After the planning was completed and the necessary parts ordered, the course was implemented with the first class of students in the Fall of 2012.

4.0 Assessment Data and Analysis

We have undertaken assessment of the course implementation to determine how well the goals have been met. This list summarizes the various methods we used to gauge the effectiveness of the course and to solicit inputs we could use to improve the course.

1. Online midterm and end-of-course anonymous feedback
2. Hardcopy surveys administered intermittently throughout the course
3. Hardcopy surveys administered to students a full academic year after taking the course

During each administration of the course, we heavily encouraged student feedback. All feedback was anonymous. In Fall 2012, there were common trends in the Lesson 13/40 feedback: the class was fun and engaging, and the readings were easy to understand; however, students wanted more help learning MATLAB, more in-class time to finish labs, explanations of labs during class, and practice problems tying together all material from a block of instruction. The structure of the course was tweaked during this first course offering based on continuous student feedback. At the end of the semester, students provided feedback via the institution-wide online feedback mechanism.

4.1 Measuring Student Satisfaction

Overall, students in the fall of 2012 rated the course a 4.97 on a 1-6 scale (1-Very Poor, 2- Poor, 3-Fair, 4-Good, 5-Very Good, 6-Excellent), which was slightly higher than the course average across the institution (4.75) and the course average within the Engineering Division (4.69). Students had both positive and negative feedback, as shown in Table 3.

Table 3: Fall 2012, Online Eend-of-Ccourse Sstudent Ffeedback

Positive Feedback	Negative Feedback
The course provided a great foundation.	The course was advertised as an easy and fun course; while it was fun, it was not easy.
Enjoyed of all the hands-on experiences (e.g., labs).	The labs need to be explained and linked to the reading BEFORE in-class lab time.
	More lab time needs to be provided in class.
	The homework needs to be graded by effort, not correctness.
	The difficulty, low instruction, and high expectations of Block 4

All negative feedback was addressed before the offering in the following spring semester. Many of the EE students had no previous programming experience, unlike the CpE students who take an introductory programming class during the same semester. An extra lesson of instruction on programming for the Arduino better prepared the EE students execute their final projects. To provide the extra lesson, a field trip was eliminated from the course.

Anecdotal student feedback indicated that, without a proper introduction to the lab, students had a hard time understanding the “big picture.” Students said they needed a strong understanding of the learning goals before diving into the details of the lab and getting lost. Adding extra time to review the lab goals alleviated this problem.

At the end of the Spring semester, students once again provided feedback via the institution-wide online feedback mechanism. Overall, students rated the course a 5.18 on a 1-6 scale (1-Very Poor, 2- Poor, 3-Fair, 4-Good, 5-Very Good, 6-Excellent), which was slightly higher than the course average across the institution (4.76) and the course average within the Engineering Division (5.15). Students again had both positive and negative feedback, as shown in Table 4. In general, the students had a positive experience and seemed to enjoy the course as a whole.

Table 4: Spring 2013, Online end-of-course Sstudent feedback

Positive Feedback	Negative Feedback
Interesting readings	More lab time needed in class
Real-life application of the course	Provide more Arduino and Lab experiences
The course was set up well and the course load was fair	
Continue the emphasis on MATLAB	
Enjoyed of all the hands on experiences (e.g., labs)	

4.2 Measuring Goal Achievement

In addition to course improvement, we needed to assess how well the course was meeting our goals. Although hardcopy surveys are no longer administered during the course's execution, the online feedback (midterm and end-of-course) continues to provide, for the instructors, valuable insight into the good, the bad and the ugly that are not always visible from the instructor's perspective.

Once again, the initial goals were to provide a course that must:

1. Be fun
2. Provide an overview of EE and CpE
3. Provide knowledge and experiences currently not offered in the program
4. Provide breadth before depth
5. Provide extensive hands-on experiences
6. Introduce software and test equipment to be used in future courses

In general, electrical and computer engineers enjoy the work in their chosen profession. Most relish opportunities to program a microcontroller and design/build/test circuits: the "fun" part of engineering. Early in the course, some students discovered that they really do not like math or the work that electrical and computer engineers perform and that these majors would not be a good fit for them.

In order to meet goals 3, 4 and 5, many subjects/experiences were identified as items to include in the course. These include, but are not limited to:

- Soldering
- Antennas
- Electromagnetic wave propagation
- Circuit protection
- Electrical busses
- Solar energy
- Encryption
- Electronic warfare
- Fiber optics/waveguides
- Wire gauges
- Instrumentation
- AC/DC conversion
- Digital bandwidth/throughput
- Electric motors

Again, these topics were chosen because of their importance in Air Force Systems. To become electrical/computer engineers or pilots in the US Air Force, the students need to have a basic familiarity with these systems. Also, the extensive hands-on experiences and early introduction to test equipment will allow students to focus more on new material in their future courses and spend less time learning new pieces of equipment or new application software.

To gauge the longer-term effects of the course on students in the EE/CpE programs, hardcopy surveys were administered a full academic year after taking the course to 75% of our EE/CpE juniors. The surveys are available in Appendices A and B. Additionally, hardcopy surveys were also provided to students who did not take the new course (45% of EE/CpE seniors). All juniors took the course during their sophomore year. The seniors had not had the opportunity to take the course by the time of our survey. The results showed that goals 3, 4 and 5 of the course were met.

Survey responses reveal that both juniors and seniors are more comfortable troubleshooting hardware than software. Because they have more experience, seniors reported being slightly more comfortable reverse engineering than juniors. Figure 3 shows that juniors reported feeling more comfortable than seniors using test equipment and breadboards. Approximately 95% of juniors felt comfortable using test equipment and breadboards, compared to 77% of seniors. This supports the course's goals 5 and 6, relating to hands-on experiences and use of equipment. This is surprising not only because of the number of years each group has been studying engineering but also because the seniors have an average GPA of 3.40, while the juniors have an average GPA of 3.15; the seniors, in general, exhibit a higher aptitude than the juniors.

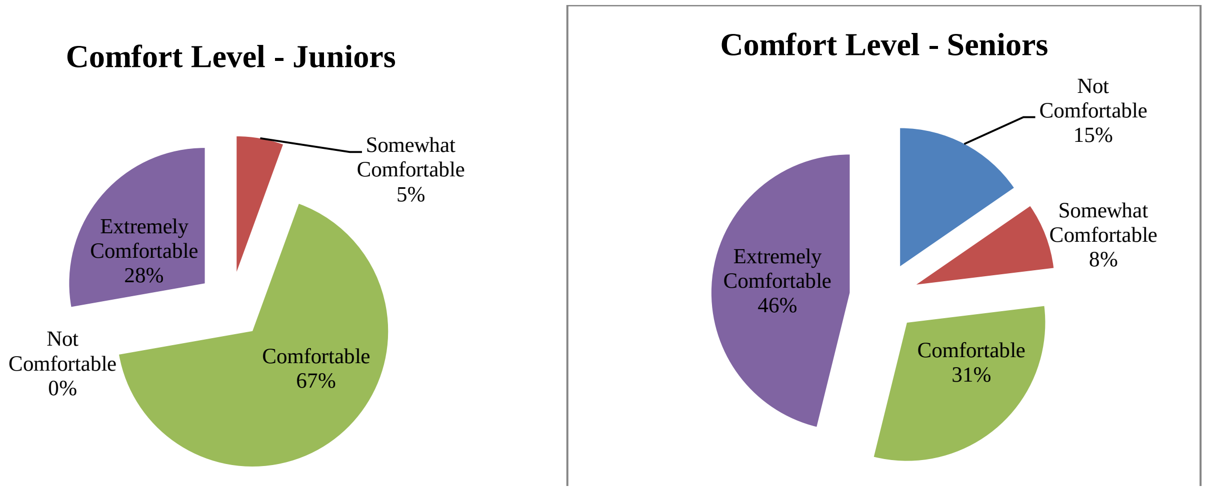

Figure 3: Test equipment/breadboard usage – juniors-to-seniors comparison

The survey also captured the following data from students that took the course:

1. 75% claimed the course motivated to further explore ECE.
2. 90% said the course is a good overview of ECE.
3. 72% claimed the course solidified their choice of major.

Not only did the course solidify those students' selection of ECE majors, but it also helped identify students who eventually changed majors. In the course, the individual is responsible for keeping up with the material and practicing mathematical problems outside of class. Looking at the performances on the graded exams, which tested the results of their efforts, and through one-on-one counseling, most students who changed majors did so by the end of the semester. This is an indication that goals 1 through 4 were being met for the students who stayed and that the expectation that the goals would better prepare students for their choice of major. The sentences in this paragraph do not seem to go together. Maybe move some of them?

As shown in Figure 3, 63% of those who continued as ECE students said that they learned more with the flipped classroom approach to the course, showing an appreciation for the individual work outside of class and the lab in class. Continuing the use of the flipped classroom is an obviously good choice.

5.0 Conclusion

In summary, the need to provide a 30,000 foot view of ECE via broad topics and applications, to better develop lab skills of our students~~,~~ and to help match a student to the ECE major drove the implementation of a new kind of introductory course. The initial reaction from students is very favorable. From our findings, this new course provides breadth, builds confidence and intuition, introduces standard ECE tools and fundamental ECE principles and ignites curiosity in students.

Generally, students found the course not easy, but fun. It helped solidify their choice of major and motivated them to learn more depth. Also, the students seem to be more comfortable with hands-on tasks, which can be expected to manifest in better lab skills by the time they become seniors. Finally, due to time constraints, the hands-on theme of this introductory course would not be achievable if it were not for the flipped classroom approach. Although an introductory hands-on ECE course is nothing new, the breadth of material paired with the (adjective) teaching approach of this course makes it unique amongst other institution offerings. Since the course is still in its infancy, long-term success cannot yet be measured; meanwhile, the course will continue to be assessed by instructors as students complete the program. The resulting assessment data will be used to continuously improve the course.

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APPENDIX A: ECE 210 SURVEY – JUNIORS

Circle your answer or provide a short answer.

1. **Computer Engineering Student** or **Electrical Engineering Student**.

2. ECE 210 was created to offer our majors the same material covered in ECE 315 [ed. ECE course for non-majors], and fill in the learning gaps of USAFA ECE graduates. Do you feel that this material is important? **Yes** **No**

ECE 210 Course Topics

Freq Domain	Friis Equation	Wire Gauges	Arduino
LPF, HPF, BPF Filters	RADAR	Slow Blow vs. Fast Blow fuses	A/D Conversion
AM Modulation	EW	circuit breakers	D/A Conversion
1st order RC Filters	Jamming	reverse engineering	Bandwidth
Envelope Detectors	GPS	Wheatstone bridges	Throughput
Synchronous Detectors	dB	Strain Gauge	kB, MB, GB
Monopole Antennas	Line-of-Sight	op amps	Programming
Dipole Antennas	Surface Waves/Sky Waves	Instrumentation Sys	ROT13 Encryption
Parabolic Dishes	Duty Cycle	transducers	MATLAB "functions"
Diodes	MATLAB	AC Power (RMS)	Integrating sensors
Capacitors	MultiSim	Electrical Busses	DC Motors
Resistors	Fiber Optics	AC/DC Conversion	PCM modulation
DMM	Waveguides	Power Transmission	MyDAQ
O-Scope	Breadboards/wiring	Solar Energy	MultiSim
Function Generator	Intro to MATLAB (publish)	zener diodes	
Function Multiplier	1st order RC filter (active)	soldering	

3. Has ECE 210 provided a better understanding of the following topics in your 3rd year courses? * Do not answer if you took ECE 210 and ECE 332 the same semester.

	Circle your choice		
MATLAB	Yes	No	N/A
MultiSim*	Yes	No	N/A
Power	Yes	No	N/A
Troubleshooting	Yes	No	N/A
Programming	Yes	No	N/A
Circuit Building	Yes	No	N/A
Test Equipment	Yes	No	N/A

4. Did ECE 210 provide a good overview of Electrical/Computer Engineering? **Yes** **No**

5. Did ECE 210 (big picture course) motivate you to learn more depth in the various topics? **Yes** **No**

6. Would you have learned more with a lecture in class and a lab work outside of class? **Yes** **No**

7. Did ECE 210 prepare you for any other courses?

   Yes **No** (If yes, please check the applicable course below.)

   - ☐ ECE 332 ☐ ECE 321
   - ☐ ECE 281 ☐ ECE 333
   - ☐ ECE 382 ☐ ECE 343
   - ☐ Engr 311 ☐ ECE 499

8. In two or three sentences, describe how you would differentiate between Electrical Engineering and Computer Engineering.
   ____
   ____
   ____

9. Did ECE 210 help solidify your choice of major? **Yes** **No**

10. Do you feel comfortable troubleshooting an ECE problem with hardware?
    Not Comfortable Somewhat Comfortable Comfortable Extremely Comfortable

11. Do you feel comfortable troubleshooting an ECE problem with software?
    Not Comfortable Somewhat Comfortable Comfortable Extremely Comfortable

12. Do you feel comfortable with reverse engineering?
    Not Comfortable Somewhat Comfortable Comfortable Extremely Comfortable

13. Do you feel comfortable using test equipment and breadboards?
    Not Comfortable Somewhat Comfortable Comfortable Extremely Comfortable

14. Please provide any additional comments that you want us to know on this topic.

APPENDIX B: ECE 210 SURVEY – SENIORS

Circle your answer or provide a short answer.

1. **Computer Engineering Student** or **Electrical Engineering Student**.

2. ECE 210 was created to offer our majors the same material covered in ECE 315 [ed. ECE course for non-majors]. Would you have liked to have taken this course? **Yes** **No**

ECE 210 Course Topics

Freq Domain	Friis Equation	Wire Gauges	Arduino
LPF, HPF, BPF Filters	RADAR	Slow Blow vs. Fast Blow fuses	A/D Conversion
AM Modulation	EW	circuit breakers	D/A Conversion
1st order RC Filters	Jamming	reverse engineering	Bandwidth
Envelope Detectors	GPS	Wheatstone bridges	Throughput
Synchronous Detectors	dB	Strain Gauge	kB, MB, GB
Monopole Antennas	Line-of-Sight	op amps	Programming
Dipole Antennas	Surface Waves/Sky Waves	Instrumentation Sys	ROT13 Encryption
Parabolic Dishes	Duty Cycle	transducers	MATLAB "functions"
Diodes	MATLAB	AC Power (RMS)	Integrating sensors
Capacitors	MultiSim	Electrical Busses	DC Motors
Resistors	Fiber Optics	AC/DC Conversion	PCM modulation
DMM	Waveguides	Power Transmission	MyDAQ
O-Scope	Breadboards/wiring	Solar Energy	MultiSim
Function Generator	Intro to MATLAB (publish)	zener diodes	
Function Multiplier	1st order RC filter (active)	soldering	

3. Do you feel comfortable troubleshooting an ECE problem with hardware?
Not Comfortable Somewhat Comfortable Comfortable Extremely Comfortable

4. Do you feel comfortable troubleshooting an ECE problem with software?
Not Comfortable Somewhat Comfortable Comfortable Extremely Comfortable

5. Do you feel comfortable with reverse engineering?
Not Comfortable Somewhat Comfortable Comfortable Extremely Comfortable

6. Do you feel comfortable using test equipment and breadboards?
Not Comfortable Somewhat Comfortable Comfortable Extremely Comfortable

7. Please provide any additional comments that you want us to know on this topic.