The Development of a Combined Electrical and Computer Engineering (BSECE) Degree Program at Lafayette College

W. D. Jemison, J. F. Greco, W. A. Hornfeck, I. I. Jouny
Department of Electrical and Computer Engineering, Lafayette College

Abstract

Lafayette College has recently developed and approved a four year combined Bachelor of Science Degree in Electrical and Computer Engineering (BSECE). This new degree, the first of its kind at a small institution, will replace the College's Bachelor of Science in Electrical Engineering (BSEE) degree beginning with the class of 2003. This new BSECE degree program addresses the strong demand for computer engineering skills by students, employers, and graduate schools. This paper will discuss the motivation for making a change in the curriculum, describe the curriculum options identified including the advantages and disadvantages of each option, describe the chosen degree program and the plan for implementing it, and outline the challenges that are expected during the implementation.

I. Introduction

There are a number of developments, both external to and internal to Lafayette College, which drove the decision to develop and approve a four year combined BSECE degree [1]. First, there has been a rapid proliferation of technology in the form of computers and communication systems throughout society and in engineering in particular during the last decade. As a result, there has been an increased demand by employers and graduate schools for college graduates in general and engineers specifically to have a greater knowledge of computers and their utilization. In turn, Lafayette College has found an increased interest among engineering applicants for a well-defined computer engineering program. Lafayette College, located in Easton, Pennsylvania, is a small private college which offers undergraduate programs in engineering, natural sciences, social sciences, and the liberal arts. Though the school has offered a Bachelor of Science degree in Electrical Engineering since 1915, to date it has not offered a Bachelor of Science degree in Computer Engineering. As a result, the Electrical Engineering department has faced difficulty recruiting top students in recent years.

Second, in the summer of 1997, Lafayette College decided to implement a college-wide curriculum change called "4/4" in which non-engineering students are required to take four courses each semester for a total of 32 courses over the course of a four-year program. Engineering students are required to take a total of 38 courses consisting of four courses in each semester of the freshman year and five courses in each semester of the remaining three years. Prior to this decision, engineering students had taken 41

courses over the four years. Thus, the college instructed each academic department to form a committee to address how the curriculum would be modified to meet this new requirement.

Third, ABET 2000 also was introduced at about this same time. The Department of Electrical Engineering also would have to address what effects the new accreditation requirements would have on the department curriculum.

In light of these events, the Department of Electrical Engineering convened a four member faculty committee to address the impact on the curriculum of these three parallel events. Specifically, the committee was tasked to investigate the viability, under both the new 4/4 curriculum and ABET 2000, of introducing a meaningful computer engineering presence into the curriculum. The committee was to identify options that would allow such an introduction while meeting various constraints, recommend an option for implementation, and to develop a plan for implementing the recommended change in the curriculum.

II. Program Constraints and Options

Prior to identifying specific options for introducing a computer engineering presence, the committee had to identify the constraints that must be met. First, as described above, the program must be compatible with the new Lafayette College 4/4 curriculum. Second, all engineering programs at Lafayette are required to comply with a "common first year" in which all freshman engineering majors take the same introductory set of courses. Third, computer engineering would have to be implemented without additional resources. Thus, the department would have to staff the program with the current eight full-time faculty positions, and more importantly, the eight faculty who fill those positions. These faculty are responsible for teaching a 3-2 load during an academic year (three courses one semester and two courses the other semester) where there are typically 15 to 25 students in each class. Faculty members also are responsible for teaching laboratories.

The committee identified several general options for incorporating computer engineering into the Electrical Engineering Department that ranged from making a simple department name change to adding a separate fully accredited degree program in computer engineering. The options and their advantages and disadvantages are briefly described below.

Option 1: Change the Department Name

The first option to "introduce the presence of" computer engineering is to change the name of the department from Electrical Engineering to Electrical and Computer Engineering. Though this option is simple and very inexpensive, it is, without a substantial modification of the curriculum to include computer engineering courses, purely a cosmetic change and, most importantly, would not better prepare graduates for the increasingly computer-centric workforce and world at large.

Option 2: Offer a Computer Engineering "Cluster" within Electrical Engineering

The second option is to offer a "cluster" of computer engineering courses within the electrical engineering degree thus allowing students to concentrate within the major. According to our research, many electrical engineering departments offer the option to concentrate in one of several areas such as telecommunications, general engineering, and computer engineering. While this option offers a more substantial exposure to computer engineering than the first option, the department does not currently offer formal "clustering". The committee determined that offering "clustering" in several areas would be difficult and would probably require additional faculty resources. The committee also did not believe that this option would enable students to gain enough knowledge in a given concentration to be labeled specialists.

Option 3: Offer a Separate Fully Accredited Computer Engineering Degree
The third option is to offer a separate, fully accredited degree in Computer Engineering. Many schools, especially large universities, currently offer the Bachelor of Science in Electrical Engineering and the Bachelor of Science in Computer Engineering; some also offer the Bachelor of Science in Computer Science. While having both degrees may be feasible and even a necessity at larger schools, the committee felt that it could be dangerous for a small school such as Lafayette for several reasons. First, as reported by Rutenbar, faculty members who teach strictly in electrical engineering find severely decreasing class enrollments as the popularity of computer engineering grows [2]. Second, having two degree programs typically requires having two sets of required courses which must be offered concurrently even if enrollments are low in one of the degree areas. This would most likely necessitate additional faculty resources. Third, having two degree programs mandates having two separate accreditation processes with the associated administrative overhead. Thus, the committee concluded that having two degree programs would not be feasible without a substantial commitment of resources, including additional faculty.

Option 4: Offer a Single Degree in "Electrical and Computer" Engineering
The fourth option is to offer a single, fully accredited degree in "Electrical and Computer Engineering". The committee felt that for a small college like Lafayette this was an attractive option. Though this option certainly mandates changes in the current curriculum, it offers the most flexibility in terms of developing a program within the identified constraints, especially complying with the "common first year" and implementing the program with no additional resources. In addition, ABET 2000 makes the development and adoption of this type of combined degree program possible through the introduction of specific guidelines for "Electrical, Computer, and Similarly Named Engineering Programs"[3]. Thus, the committee determined that this option appears to be the most attractive way to introduce computer engineering into Lafayette College's engineering program. A change in the department name to Electrical and Computer Engineering, Option 1 naturally follows.

III. Institutional Fit

Before making a final decision, the committee considered several additional factors to ensure that a single accredited degree in Electrical and Computer Engineering would be a

good fit with Lafayette College as a whole and Lafayette engineering students in particular. First, the committee believes that this option provides the most flexibility for students. This is a distinct advantage for students who have not made a final decision about their academic major and subsequent career path when they arrive as freshmen. Though it may be less appealing to students who are certain that they want only electrical or only computer engineering, the program could prove very attractive to students who want flexibility in choosing a career path.

Second, the committee believes that this option will provide students with a definite advantage as the distinction between the two fields becomes increasingly blurred; today computer systems are finding their way into even the more traditional electrical engineering disciplines. Furthermore, since a combined BSECE degree is broader in scope than either a BSEE or BSCE degree, it suits the large number of Lafayette students who choose to pursue a career in technical management. Technical managers now need to understand not only traditional technical topics but also information technology and software design issues.

Third, the committee recognizes that the highly motivated student who is most interested in a technical career may still pursue either electrical or computer engineering in equal or more depth than with a single BS degree via appropriate selection of electives, honors projects, and/or independent research projects sponsored by the college. As another alternative, the students have the option of minoring in Computer Science or Mathematics. The Computer Science minor will be discussed later in the paper.

Finally, the committee believes that the combined BSECE degree will differentiate Lafayette College from other institutions in a positive way. Thus, the committee concluded that the option of the combined BSECE degree program would best meet the needs of both the typical Lafayette engineering student and the college.

IV. Implementation

Once the committee determined that a combined BSECE degree was the correct option to implement, it had the task of redefining the curriculum. The first step was to review the current curriculum to identify which courses were a good fit with this option, which courses would have to be modified, and which courses were no longer a fit. Second, the committee had to identify the courses that would have to be added to the curriculum to develop the computer engineering component. As part of this process, the committee had to determine which courses, both existing and new, would have laboratories with them. Also, the committee had to ensure that the “common first year”, a 4/4 curriculum structure, and staffing constraints were met.

The committee first defined its broad view of Electrical Engineering and Computer Engineering. The broad view of an Electrical Engineering curriculum is that it is comprised of circuits and electronics, signals and systems, and applied physics. Similarly, the committee broadly defined a Computer Engineering curriculum as being comprised of computer software, computer hardware, and circuits and electronics; these

broad views are depicted in Figure 1. This technical spectrum is similar to that reported by Rutenbar [2]. It can be seen that most of the overlap between these two disciplines occurs in the circuits and electronics area.

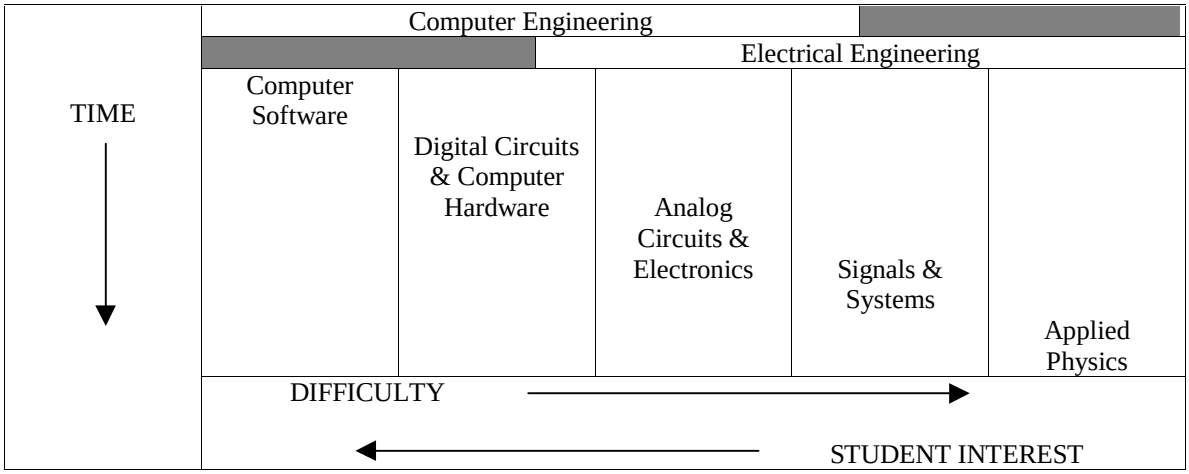

Figure 1

The committee then determined that the best approach was to design the curriculum in such a way as to introduce material to the students in a sequence consistent with both their interests and their abilities. Most incoming freshman have more experience (albeit often not true engineering experience) with computer software and hardware than they do with traditional electrical engineering topics; thus, students find the latter topics more difficult as depicted in Figure 1. In addition, the committee believes that computer software and introductory digital circuits can be taught to the students without the need for prerequisite math and physics. Therefore, to the maximum extent possible, the topic sequences will be introduced in the time sequence shown in Figure 1. The committee is hopeful that this sequence will both capture the interest of the students and allow them the time to develop the foundation necessary for the more difficult, i.e. mathematically rigorous, courses.

One of the greatest differences between the original BSEE curriculum and the new BSECE curriculum is in the area of Computer Software. Previously, the department required Electrical Engineering students to take a two credit "Engineering Science" course in computer programming. Students were encouraged to take a course in C Programming taught by electrical engineering faculty; however, they also could take a FORTRAN course taught by members of the Chemical Engineering department. The new ECE curriculum places an increased emphasis on computer software since virtually every electrical and computer engineering industry project involves software development and application. Given the staffing constraint, the committee approached the Computer Science Department at Lafayette to discuss the possibility of offering Computer Science courses to the ECE students. The decision was made jointly to offer three required courses through the Computer Science Department: a two course sequence in object oriented programming in which students learn C++ or Java and a junior level software engineering course in which students learn to design and implement large scale software projects. In addition, the discussion with the Computer Science Department

expanded to include the design of a Computer Science minor which the ECE students could complete within the four year program. These changes are reflected in the Computer Software stem as shown in Figure 2, Lafayette College BSECE Curriculum. The BSECE Curriculum with a Computer Science minor is shown in Figure 3. It should also be noted that students also receive instruction in assembly language programming in ECE 212, Digital Circuits II, where micro-controllers are covered.

The decision to incorporate these additional computer software courses in the ECE curriculum meant that some subject matter from the original EE curriculum would have to be dropped or, at a minimum, reorganized. As mentioned earlier, one of the courses replaced by the new software courses would be the Engineering Science course in C or FORTRAN Programming. The committee also decided to remove Mechanics, another Engineering Science course, from the curriculum to make room for the second course in the programming sequence. To make room for the software engineering course, the committee decided to eliminate a science elective. The removal of the two engineering science courses and one science elective essentially resulted in a paradigm shift from engineering science to computer science. This shift was controversial since the mechanics course and the science elective have been fundamental parts of all Lafayette engineering degree programs for a long time. Fortunately, the Director of Engineering and colleagues in other engineering departments recognized the need for computer software courses in a modern electrical and computer engineering curricula and supported this fundamental change.

The committee identified further changes to the curriculum in the areas of junior and senior level required courses and technical electives. Looking first at the Eng/Math/Science stem shown in Figure 2, since the Computer Science Department requires a course in discrete math, the math elective was replaced with a required course in discrete math, Math 146. Therefore, students still take five mathematics courses, although all five are specified. Second, to fulfill ECE requirements, a technical elective was replaced by an ECE/CS elective. This was a minor change since the majority of our EE students take their technical elective in the EE Department. Third, to better meet the specific needs of the various engineering disciplines, the Physics Department has modified its two-course sequence so that the first course, Physics 113, now addresses mechanics and the second course, Physics 114, now addresses electricity and magnetism. Finally, to meet the 4/4 constraints, the two-course senior design sequence, ECE 491 and 492, will be enhanced to be "full" courses. It is anticipated that ECE 491 will be a design laboratory in which students will design and implement a basic data network. This theme will tie together aspects of computer engineering and electrical engineering and will emphasize structured project work. ECE 492 will be an independent design course in which the student works closely with a faculty advisor on a project of their choice.

Referring again to Figure 2, the committee made significant changes to both the applied physics stem and the signals and systems stem. First, a second course in Electromagnetics was replaced with a course in Opto-Electronics. Second, two changes were made in the signals and systems stem. To start, the existing course in Communications was replaced by a course emphasizing Digital Communications, ECE

433, to allow a more thorough discussion of digital modulation and noise. Next, two electrical engineering courses in this stem, Controls and Data Acquisition, were combined to create a course in Industrial Control Systems, ECE 332. In addition, this combination of two courses into one created a slot for ECE 313, Computer Organization. This course was formerly a popular elective; now it is a required junior level course in the Computer Hardware stem.

Thus, the new BSECE curriculum as shown in Figure 2 consists of three courses in the Computer Software stem, three courses in the Computer Hardware stem, three courses in the Circuits and Electronics stem, three courses in the Signals and Systems stem, and two courses in the Applied Physics stem. Students also take an introductory course in engineering, nine courses in Math/Science, two ECE electives, an ECE/Computer Science elective, a course in Values in Science and Technology (VAST) and the two-course senior design sequence. Furthermore, the curriculum includes a total of eight Social Science/Humanities (Soc/Hum) courses, reflecting the strong liberal arts background of Lafayette College. These include one course in English, a First Year Seminar (FYS), four Soc/Hum electives, and two free electives. If a student elects to add a minor in Computer Science, the ECE/Computer Science elective is chosen to be in the Computer Software stem and the two free electives from the Soc/Hum stem are replaced with two electives taken in the Computer Software stem as shown in Figure 3.

V. Implementation Challenges

The committee recognizes that there is a lot to be done if the implementation of the BSECE curriculum is to be successful. In this section, specific challenges that are foreseen are enumerated and potential methods to meet them are identified.

First, the classes of 2001 and 2002 have the option to pursue the BSEE or the new BSECE. However, the BSECE will replace the BSEE and be the only option for the class of 2003 and beyond. Therefore, there will be some overlap of the two programs which will mandate that dual course offerings will be necessary for a short time. Second, the development of the new courses and modification of the existing courses will be critical. The department must examine elective offerings in ECE and Computer Science to ensure that students have a balanced selection of courses in each of the five technical stems of the curriculum. Third, currently seven of eight full time tenure track positions are filled; so the department is planning to hire one person with expertise in computer engineering in order to properly staff the new combined BSECE program. However, this has proved difficult given the strong industry demand for Ph.D.s in Computer Engineering.

ABET has already been informed that we are changing our curriculum and they will be kept abreast of our progress through our next accreditation visit in 2002. Furthermore, initial indications are that the change to a single BSECE degree is being well received by our students. Of the twenty-seven students in the Class of 2001, nineteen have indicated that they wish to pursue the BSECE degree (over 70%). The other eight students have indicated that they wish to pursue the BSEE degree. This high percentage of students choosing the BSECE degree is particularly encouraging given that this degree was not

being advertised when these students were applying to Lafayette College. We expect a similar response from the class of 2002 when they are asked to declare a degree choice later this year.

Bibliography

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WILLIAM D. JEMISON

William D. Jemison received the BSEE degree from Lafayette College in 1985, the MESc degree from Penn State University in 1988, and the Ph.D. degree from Drexel University in 1993. He joined the faculty of Lafayette College in 1996. He teaches courses in applied electromagnetics, analog and digital circuits, and control systems. Prior to 1996 Dr. Jemison served as a senior engineer and project manager at the Naval Air Warfare Center, Lockheed Martin Corporation, and Orbit/FR in the field of microwave system design. Dr. Jemison is a Senior Member of the IEEE.

JOHN F. GRECO

John F. Greco received the BSEE degree from the City College of New York in 1967, and the Ph.D. degree from the City University of New York. After working at GTE/Sylvania in Massachusetts and the University of Petroleum and Minerals in Saudi Arabia, he joined the Electrical Engineering Department at Lafayette College in 1977. Dr. Greco is currently teaching courses in digital circuits and systems.

WILLIAM A. HORNFECK

Professor Hornfeck has been an engineering educator for more than twenty-two years, the last ten of these as Electrical Engineering Department Head at Lafayette College. Professor Hornfeck earned the BS degree from Pennsylvania State University, and the MS and Ph.D. degrees from Auburn University, all in Electrical Engineering. He has been an engineering consultant to government and industry, and is an active member of the IEEE Computer Society, the National EE Department Heads Association (NEEDHA), and the Pennsylvania Region of NEEDHA.

ISMAIL I. JOUNY

Ismail I. Jouny received the B.Sc. degree (with honors) from Beirut University in Lebanon, and the MS and Ph.D. degrees from the Ohio State University. He joined the faculty of Lafayette College in 1990 and teaches courses in communications and signal processing. Dr. Jouny received the Lafayette College Jones award in 1996 for outstanding teaching and scholarship. He is a senior member of the IEEE.

Lafayette College BSECE Curriculum

Yr.	Soc./Hum	Eng/Math/Science	Computer Software ECE STEM - 0	Computer Hardware ECE STEM - 1	Circuits & Electronics ECE STEM - 2	Signals & Systems ECE STEM - 3	Applied Physics ECE STEM - 4
1F	First Year Seminar	ES 101 Intro to Eng. (L) Math 161 Calc. I (L) Chem 121 (L)					
1S	Eng 110	Math 162 Calc. II (L) Physics 113 (L) ES231 Natures or Chem 122 (L)					
2F	Soc/Hum	Math 263 Calc. III (L) Physics 114 (L)	CS 102 Principles. of Computer Science I (L)	ECE 211 Digital Circuits. I (L)			
2S		Math146 DisStruc ES225 - VAST	CS 103 Principles of Computer Sceience II (L)	ECE 212 Digital Circuits II (L)	ECE 221 Analog Circuits (L)		
3F	Soc/Hum	Math 264 Differential Equations		ECE 313 Comp. Org.	ECE 322 Electronics I (L)	ECE 331Networks	
3S	Soc/Hum		CS 205 SW Eng.		ECE 323 Electronic II (L)	ECE 332 Digital Communications	ECE 341 Electromagnetics I
4F	Soc/Hum	ECE 491 SrDes1 ECE Elect.				ECE 433 Industrial Control Systems (L)	ECE 442 Opto-Electronics
4S	Free Elec. Free Elec.	ECE 492 SrDes2. ECE Elect. ECE/CS Elec.					
# = 38	Eng: 1 FYS: 1 Soc/Hum: 4 Free Elec: 2	Math: 5 Chem: 1 or 2 Eng.Sci: 3 or 2 Physics: 2 ECE Elect: 2 ECE/CS Elect: 1 Sr. Des. 2 VAST 1	Comp Software: 3	Comp.Hardware: 3	Circuits & Electronics:3	Sig&Sys: 3	App. Phy: 2

Figure 2. (L) indicates the course has a laboratory

Lafayette College BSECE with a Computer Science minor

Yr.	Soc./Hum	Eng/Math/Science	Computer Software ECE STEM - 0	Computer Hardware ECE STEM - 1	Circuits & Electronics ECE STEM - 2	Signals & Systems ECE STEM - 3	Applied Physics ECE STEM - 4
1F	FYS	ES 101 Intro. Eng. (L) Math 161 Calc. I (L) Chem 121 (L)					
1S	Eng 110	Math 162 Calc. II (L) Physics 113 (L) ES231 Natures or Chem 122 (L)					
2F	Soc/Hum	Math 263 Calc. III (L) Physics 114 (L)	CS 102 Pr. Of CS I (L)	ECE 211 DigCkts. I (L)			
2S		Math146 DisStruc ES225 VAST	CS 103 Pr. Of CS II (L)	ECE 212 Dig Ckts. II (L)	ECE 221 Analog Ckt. (L)		
3F		Math 264 Diff Equ.	CS 202 Algorithms	ECE 313 Comp. Org.	ECE 322Electronics I (L)	ECE 331 Networks	
3S	Soc/Hum		CS 205 SW Eng.		ECE 323 Electronic II (L)	ECE 332 Digital Communications.	ECE 341 Emag. I
4F	Soc/Hum	ECE 491 Sr Des1 (L)	ECE/CS Elec			ECE 433 Industiral Control Systems (L)	ECE 442 Opto-Electronics
4S	Soc/Hum	ECE 492 SrDes 2 (L) ECE Elect. ECE Elect.	Free Elec				
# = 38	Eng: 1 FYS: 1 Soc/Hum: 4	Math: 5 Chem: 1 or 2 Eng.Sci: 3 or 2 Physics: 2 ECE Elect: 2 Sr. Des. 2 VAST 1	Comp Sof: 3 Free Elec. 2 ECE/CS Elec 1	Comp.Hard: 3	Circuits: 3	Sig&Sys: 3	App. Phy: 2

Figure 3. (L) indicates the course has a laboratory