# On Revising the Electrical and Computer Engineering Undergraduate Curriculum at New Mexico State University

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## Abstract

In the fall of 1996, the faculty of the Department of Electrical and Computer Engineering at New Mexico State University chose to begin the process of revising the undergraduate curriculum. The process of developing the new curriculum took approximately one year. Changes to undergraduate catalog took another year. Consequently, official implementation of the new curriculum began in the fall of 1998. In this paper we describe the motivation for undertaking such a large task and the method we used for developing the new curriculum. Five major highlights of the new curriculum are: 1) compliance with ABET 2000, 2) 128 semester hours for graduation, 3) introductory electrical engineering course, 4) integrated lecture, laboratory, and design in core courses, and 5) 6-credit senior capstone design. We conclude with our procedure for performing continuous development of the revised curriculum and some discussion of its implementation.

## I. Introduction

In the fall of 1996, the Department of Electrical and Computer Engineering at New Mexico State University decided to make a major revision to the undergraduate curriculum. Both internal and external factors led us to undertake such a large task. Internal factors were the department's desire to attract and retain more students and to take a fresh look at a curriculum that had been largely unchanged for more than two decades. External factors were the need to understand and comply with the new requirements of ABET 2000 and the trend of reducing the total number of semester hours to 128. Ultimately, the decision to revise the curriculum was made by our department head, as valuable time and resources are expended when conducting such a major curriculum revision.

The last time the undergraduate curriculum of the Electrical and Computer Engineering Department at New Mexico State University had been revised was in the early 1970's. Since that time, minor changes in course requirements and course content were made in piece-meal fashion. These changes were intended to solve problems in the former curriculum or to meet new ABET or university requirements. However, the cumulative effect of 20 years of minor adjustments to the former curriculum was unintended duplications and/or omissions of important topics in electrical and computer engineering. Clearly a fresh, global review of the curriculum was needed to rearrange topics into a concise sequence of courses.

Also in the fall of 1996, the department began a series of seminars focusing on student retention [1]. Several faculty members consented to being observed in the classroom, both before and after participating in this seminar series. Several principles emerged during the series. The first is that students benefit from faculty-student interactions, both inside and outside of the classroom. The second is that there are a variety of faculty-student interactions, ranging from simple fact-finding questions to those requiring critical thinking. The third is that faculty-student interaction in the first two years of the undergraduate program would have a greater impact than faculty-student interaction in the final two years. Thus, we considered how our curriculum might be able to contribute to efforts in student retention. In particular, we wanted to create a freshmen course to introduce new students to the breadth of electrical and computer engineering and to increase contact between lower-division students and the faculty [2].

One large and looming external factor for revising the curriculum was to clearly align our curriculum with the new ABET 2000 criteria. No longer is a department asked to count every design credit, but to demonstrate that design is integrated into the curriculum, that students are exposed to breadth and depth in their major, and that their work culminates in a significant design experience.

A final motivation for revising the curriculum was to follow the trend of other major institutions by reducing the total number of credit hours to 128. Recently, a court ruled that a certain university advertising a 4-year (8-semester) engineering degree had to reduce its total credit hours to 128. Under the former curriculum, 134 credit hours were required to finish a BS degree in electrical engineering at New Mexico State University. Practically, very few students finished in eight semesters, perhaps because the course load is so demanding, or perhaps because many students work during their studies, have major family commitments, or begin the program with deficiencies. Reducing a curriculum by six credits was not simple, as we wanted to maintain the high standard that we set for our electrical and computer engineering graduates, even while satisfying all state and university requirements.

## II. Method of Revision

The process of designing a new curriculum took approximately one year. A Curriculum Revision Committee was formed to carry out the task. The committee viewed the process as a large engineering design problem. We looked at revisions other universities had done recently. We defined requirements by listing the desired competencies of an electrical and computer engineering graduate. We considered our constraints, such as ABET 2000 and state and university requirements. We then took the desired competencies and successively resolved them into blocks of subtasks, which were later mapped into courses. The revised curriculum emerged as we placed these courses into a logical sequence.

### A. Committee Makeup

The department head of the Electrical and Computer Engineering Department asked for volunteers to form a Curriculum Revision Committee from each of the 8 specialty areas in our department: communications & signal processing, computer engineering, control systems, electronics & VLSI, electromagnetics, energy systems, networks, and photonics. The committee's charge was to "re-examine our undergraduate curriculum… All faculty, regardless of status, are encouraged to participate."

During the first meeting, we elected a chair, vice chair, and secretary, and determined to meet on a bi-weekly basis for an hour or more in each session.

### B. References

Committee members read about curriculum revisions that had occurred at other universities, notably Carnegie-Mellon [3]. It is instructive to note not only what other universities have constructed in the way of curricula, but also, why. Officers of the Curriculum Revision Committee consulted other sources of information, such as the Engineering Dean of Students, the Klipsch School Industrial Advisory Board, and documents describing ABET 2000 [4] requirements.

In between meetings, committee members met informally with other faculty in their area of specialization. They reported on the status of the revision process and solicited input from those outside the committee. Many points of view were considered during the curriculum revision process.

### C. Goals

Our goals were to attract and retain qualified students, and to graduate effective electrical and computer engineers. In the first phase, we attempted to define the desired abilities of a graduating electrical and computer engineer. As a committee, we decided that our graduates must be:

1. Grounded in mathematics and the physical sciences.

2. Able to
    - Assimilate and apply new material, i.e., continuously learn
    - Identify, analyze, and solve complex problems under real-world constraints
    - Design and build working hardware and software systems
    - Reverse-engineer existing systems
    - Use computers as an engineering tool and to enhance personal productivity
3. Professionals who communicate effectively, work in inter-disciplinary teams, and maintain high ethical standards.

**D. Constraints**

Next, we looked at the constraints, resources, and raw materials that would go into producing electrical and computer engineers. The raw materials for our program are a mix of high school graduates and returning students. The resources are our faculty, staff, laboratory and teaching space, graduate assistants, and financial resources.

The constraints for developing the undergraduate curriculum are detailed in figure 1. They arose from state, university, college, and ABET requirements. An additional constraint that the department imposed was that the total number of credit hours necessary for graduation would be no more than 128.

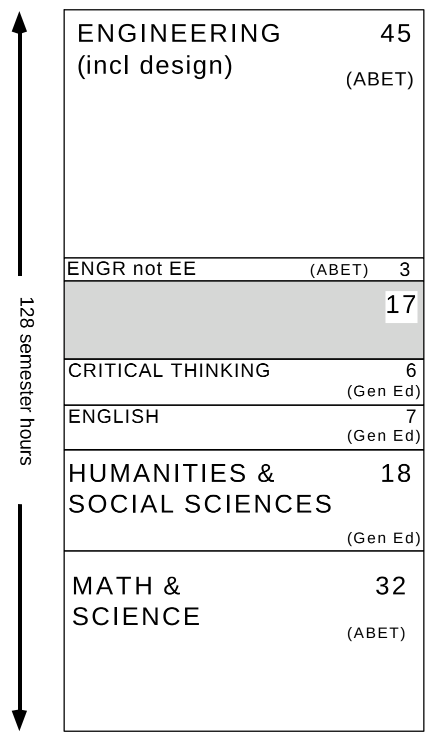


*Figure 1. Constraints on the undergraduate curriculum.*

**E. Principles**

We began the curriculum development proper by identifying several guiding principles:

- The first course in our department should introduce the breadth of electrical and computer engineering and offer a sense of the excitement of designing and building electronic systems. Students could then decide early whether to commit to the effort needed to graduate from our program.
- Students should be able to interact with our faculty every semester. This meant that every semester should contain a mix of engineering, math, science, and humanities.

- Difficult concepts should be introduced informally and in context in early courses, followed by rigorous coverage in the following courses.
- Laboratory and recitation work should be tightly integrated with lectures.
- All students must complete a capstone design course or course sequence.

**F. Courses**

In the analysis phase, we refined the goals outlined in section II.C into smaller subtasks that would ultimately comprise our core course offerings. A key consideration in this phase was managing repetition:

- Some of the broader core competencies require repeated practice, and were incorporated in courses throughout the curriculum. For example, students are required to write laboratory reports, participate in team projects, and solve problems using a high-level computer language in many courses.
- Other concepts that were formerly taught redundantly in several courses were consolidated into a single core course. For example, the *z*-transform is used in both discrete-time control systems and digital signal processing. It is now taught in the core Signals and Systems course, allowing the subsequent electives to devote the "found" time to advanced topics.
- Finally, many topics are covered in increasing detail in sequences of courses. One example is a bipolar transistor. To a freshman, it can be simply viewed as a current amplifier or a switch, whereas a sophomore course would discuss the physical structure, modes of operation, various mathematical models, and common applications of the device. Likewise, Laplace transforms are initially introduced as a problem-solving tool, with the general coverage of transforms deferred until the students have acquired more mathematical maturity.

Several topics suggested by the Electrical and Computer Engineering Industrial Advisory Board were incorporated into the list of subtasks during this phase. Then, from the list of subtasks, blocks of related topics were combined to serve as the main components of the final phase.

**G. Curriculum**

In the last phase, we drew up a course architecture by placing the blocks in a logical sequence of courses. The final draft of the curriculum was presented to the faculty in the spring of 1997, and was approved for initial implementation starting in the fall of 1998. Note that the Curriculum Revision Committee had no authority to implement a revised curriculum. The responsibility rested on the entire faculty.

Table 1 details the new curriculum. Major highlights of the revised curriculum are:

- It is ABET 2000 oriented.
- Only 128 hours are required for graduation
- An introductory electrical engineering course without calculus (EE111) was added.
- Each of the eight core courses has an integrated laboratory or recitation.
- A senior capstone design course and project is required for each student.

## III. Discussion

It is instructive to compare the former and new curriculum. To minimize the problems during the transition to the new curriculum, we reused elements of the current curriculum whenever they fit. It is a testament to the architects of the former curriculum design that much of their work was retained, even two decades after its inception. The major differences are:

- Total student credit hours are reduced 6, from 134 to 128.
- General education credit hours are unchanged at 28, since this is the minimum.
- Mathematics credit hours are up 3 from 21 to 24 due to the new ABET statistics requirement.

- Natural science (physics and chemistry) credit hours are down 4 from 16 to 12; math plus science still exceeds ABET requirement of 32 credits.
- Total ECE credit hours down 2 from 56 to 54.

| | | | Credits |
|---|---|---|---|
| General Education (31 credits) | | | |
| ENGL | 111G[1] | Rhetoric and Composition | 4 |
| ENGL | 218G | Technical and Scientific Communication | 3 |
| COMM | 265G | Principals of Human Communication | 3 |
| Historical Perspective | | One course | 3 |
| Human Thought | | One course | 3 |
| Literature/Fine Arts | | One course | 3 |
| Social Analysis | | One course | 3 |
| Viewing a Wider World | | Two courses, in different colleges | 6 |
| Free Elective | | Any main campus course | 3 |
| Natural Science (12 credits) | | | |
| CHEM | 111[2] | General Chemistry I | 4 |
| PHYS | 215[2,3] | Engineering Physics I | 4 |
| PHYS | 216[2,3] | Engineering Physics II | 4 |
| Mathematics (21 credits) | | | |
| MATH | 191[3] | Calculus and Analytic Geometry I | 3 |
| MATH | 192[3] | Calculus and Analytic Geometry II | 3 |
| MATH | 291[3] | Calculus and Analytic Geometry III | 3 |
| MATH | 391 | Vector Analysis | 3 |
| MATH | 392 | Differential Equations | 3 |
| Statistics Elective | | One course | 3 |
| Math Elective | | One course | 3 |
| Engineering (10 credits) | | | |
| ENGR | 101[3] | Introduction to Engineering | 1 |
| CE | 450 | Engineering Economy and Law | 3 |
| Engineering Elective | | One non-EE engineering course | 3 |
| Technical Elective | | One math, science, or engineering course | 3 |
| Electrical and Computer Engineering (54 credits) | | | |
| EE | 111[2,3] | Introduction to Electrical and Computer Engineering | 4 |
| EE | 161[2,3,4] | Computer Aided Problem Solving | 4 |
| EE | 211[2,3] | AC Circuits | 4 |
| EE | 221[2,3] | Electronics: Devices and Amplifiers | 4 |
| EE | 261[2] | Digital Design | 4 |
| EE | 311[2] | Signals and Systems | 4 |
| EE | 315 | Electromagnetics | 4 |
| EE | 332[2] | Introduction to Electric Power Engineering | 4 |
| EE | 341[2] | Control Systems | 4 |
| Breadth Elective | | Three upper division EE courses, in different areas | 9 |
| Depth Elective | | One course requiring a breadth elective as a prerequisite | 3 |
| Capstone Elective | | One or two courses requiring a depth elective as a prerequisite | 6 |
| | | Total | 128 |

1 Must be completed prior to enrolling in any course numbered 300 or above.
2 Including laboratory.
3 A grade of ‘C’, or better, is required.
4 Must be completed prior to enrolling in any EE course numbered 300 or above.

*Table 1. Revised undergraduate curriculum*

- Other engineering credit hours, such as thermodynamics or statics, are down 3 from 13 to 10, assuming 3 credits of free elective are taken here.

It is apparent that nothing is free. Proportional reduction over all categories was not possible since general education was irreducible. Thus, the technical areas took the biggest hit in reducing the total number of credit hours to 128. We estimate that elimination of redundant coverage of ECE topics roughly compensates for the loss of 2 ECE credit hours, so we effectively lost 1 credit hour of math and science and 3 credit hours of other engineering courses.

## IV. Revision Implementation

During the summer of 1997, course and degree requirements were re-written for the 1998-99 academic year catalog. During the year of delay between finalizing the new curriculum and its publication, several instructors began moving toward the new curriculum topics and format.

Official implementation of the revised curriculum was heralded in the fall of 1998. All students who were freshmen before 1998 have the option of choosing requirements from another catalog year. Thus, we entered a period of transition. Most students graduating in 1998 or 1999 have chosen to stick with the former curriculum. On the other hand, most students expecting to graduate in the year 2000 and beyond have adopted the new curriculum. How do they make this decision? Each student's record is reviewed one-on-one with our undergraduate faculty advisor. He determines which curriculum results in the fewest credit hours necessary to graduate. The student then chooses the curriculum with the fewest credit hours.

With the implementation of the new curriculum, the Curriculum Revision Committee was disbanded in favor of a Standing Curriculum Committee that will serve as a "continual curriculum improvement committee." This new committee comprises four faculty members who are elected to serve staggered two-year terms. In addition, three *ex officio* members are on the committee: the freshmen advisor, the undergraduate advisor, and the department head. Thus far, the major task of the Standing Curriculum Committee has been to oversee the transition to the new curriculum. As increasing numbers of graduates emerge from the new curriculum, this body will assess curriculum effectiveness and make adjustments as needed.

## V. Assessment Plan for the New Curriculum

The new curriculum will be assessed by those who provided guidance in its creation. Klipsch School faculty who noted deficiencies in students entering their courses can now monitor the preparation of entering students. Industrial managers will be polled for feedback about the coop and graduating students that they hired recently and, as time goes on, several years prior. The students themselves can also provide objective feedback, especially after they have worked a few years. It is the task of the Standing Curriculum Committee to collect and analyze such information and continually refine the curriculum.

Students who entered the program under the former curriculum are by and large choosing to graduate based on the requirements of the new curriculum. The unfortunate result during this transient is that such students are graduating with fewer ECE credit hours. How can that be? Under the new curriculum, five of eight core courses were expanded from 3 to 4 credits. Rather than forcing students to re-take these courses, we are accepting the 3-credit version for the 4-credit version. The result is that up to 5 ECE credits are substituted with other course work.

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[4] EAC -- Engineering Accreditation Commission, see http://www.abet.org/eac/eac.htm for up-to-date information.



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