Key Ingredients of Modern Electrical and Computer Engineering Undergraduate Programs

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(Session number: 1532)

Abstract
In this paper, we discuss the evolution of modern North American Electrical and Computer Engineering curricula designed to, among other things, satisfy guidelines consistent with ABET accreditation as well as those required by the increasingly common constraints of State Articulation. In the process of curriculum development, it is of critical importance to develop close ties with industrial partners. The particular ways by which this can be carried out effectively, including integrated industry-academe annual retreats as well as well-designed industrial surveys, are also discussed. Using the framework of the eleven learning objectives articulated by ABET, the effectiveness, or otherwise, of the learning process in undergraduate engineering has been evaluated in our program using a variety of assessment tools, essentially all of which are numerical in format and relatively simple to administer. A key feature of any assessment process should be an evaluation of self-consistency. That is also discussed here. Lastly, high rates of student attrition in any engineering program are of some concern. These, of course, tend to be particularly acute in large student-number programs. Evidence showing a simple but effective approach to help counter this is also shown.

1. Introduction
The following describes in some detail the salient features of modern ABET-accredited undergraduate programs in electrical engineering (EE) and computer engineering (CpE) currently in operation. The CpE program is modern in every sense in that it was introduced relatively recently and was submitted for accreditation for the very first time in the Fall of 1999 and, after attention to identified weaknesses, awarded full ABET accreditation under the new EC2000 criteria in 2002. Both programs are also modern in the sense that their overall structure was fashioned in such a way as to comply with state-imposed articulation requirements, implemented for the first time, as recently as 1998. Most recently, both programs were thoroughly revised to incorporate state-of-the-art material followed by the implementation of the EE program in Fall 2003 and CpE program in Spring 2004.

Any successful modern undergraduate engineering degree programs should include, among other things, an organizational structure allowing continual curriculum development consistent with the current and near-term future needs of the profession; an effective academe-industry partnership; a comprehensive assessment/evaluation paradigm; and effective student retention within the program.
In this paper, we discuss the evolution of modern Electrical and Computer Engineering curricula designed to, among other things, satisfy objectives consistent with ABET accreditation as well as the needs of major constituencies. In the process of curriculum development, it is of critical importance to develop close ties with industrial partners. Specifics here include such things as requirements of software packages, laptops, and so on. The particular ways by which this can be carried out effectively, including integrated industry-academe annual retreats as well as continually evolving industrial surveys, are discussed, with flow diagrams, in some detail.

Effective learning can only come through effective assessment of the quality of instruction. The benefits of comprehensive assessment in undergraduate engineering, consistent with the aims of ABET’s Engineering Criteria 2003-4, have been well documented. Using the framework of the eleven learning objectives articulated by ABET, the effectiveness, or otherwise, of the learning process in undergraduate engineering has been evaluated in our program using a variety of assessment tools, all of which are numerical in format. The aforementioned are relatively simple to administer and have been successful in continuously evolving operation for the past six years. Any assessment tools employed have to be carefully and periodically checked for, among other things, self-consistency. Specific examples of this are also described. One interesting corollary here is that the instruments of assessment themselves also offer insight into the quality of individual instruction. Lastly, in any engineering program, high rates of student attrition are of some concern. These, of course, can be particularly acute in large student number programs. Approaches used to counter such attrition are also discussed.

2. Program Content

The content of these programs are, as they should be, continually evolving, responding as they do to constituency input (discussed in detail later in the paper). Most of the specific observations in the following relate to the newer CpE program (to avoid needless duplication) but, in terms of more general comment re, for example, organizational structure, assessment and the like, the two programs are understandably similar. The CpE program syllabus for the Fall of 2004 is shown as a flow diagram in Fig. 1. The solid and dashed arrows of Fig. 1 indicate, respectively, prerequisite and co-requisite requirements of each course. It should be noted that the university minimum credit hour requirement is 128.

The professional component of the CpE program has a mix of digital systems, electronics and computer science. As Fig. 2 indicates a significant fraction of the institutions polled had 9 - 12 credits in this area. The syllabus arrived at here has 13 core credits.

The senior year includes a substantial design project, typically involving team participation, as well as senior courses providing an in-depth treatment of digital logic and systems theory.

In order to validate the number of core computer science credits required for the CpE program, the present authors carried out an e-mail survey of peer institutions, the results of which are illustrated in Fig. 2.
Fig. 1

BSCpE Program Flowchart (Effective Spring 2004)

1st Semester
- CH 131 (4) General Chemistry I
- MA 125 (4) Calculus I
- EH 101 (3) Composition I
- H/SS (3) Elective
- CIS 210 (4) Introduction to C++ Programming

2nd Semester
- PH 201 (4) Calculus-based Physics I
- MA 126 (4) Calculus II
- EH 102 (3) Composition II
- H/SS (3) Elective
- CIS 211 (4) Advanced C++ Programming

3rd Semester
- PH 202 (4) Calculus-based Physics II
- MA 227 (4) Calculus III
- MA 261 (3) Discrete Math Structures
- EE 227 (1) Circuits and Devices Lab.
- EE 220 (3) Electrical Circuits

4th Semester
- MA 238 (3) Differential Equations
- EE 223 (3) Network Analysis
- MA 267 (3) Discrete Math Structures
- EE 227 (1) Circuits and Devices Lab.
- EE 220 (3) Electrical Circuits

5th Semester
- EE 331 (3) Physical Electronics
- EE321 (3) Transform Theory of Linear Sys.
- EE 302 (1) Computer Methods in EE/CQE
- EE 264 (3) Microproc. Systems and Interfacing
- EE 268 (1) Digital Logic Design Lab

6th Semester
- EE 334 (4) Analog and Digital Electronics
- EE328 (3) Feedback Control Systems
- EE 264 (3) Microproc. Systems and Interfacing
- EE 268 (1) Digital Logic Design Lab

7th Semester
- EECIS 4XX (3) Technical Elective
- EECIS 4XX (3) Technical Elective
- EE 401 (1) Intro. to ECE Design
- EE 445 (3) Microproc. System Design
- EE 446 (3) Microproc. System Design Lab

8th Semester
- EE 446 (3) Digital Computer Architecture
- EE 4XX (3) Technical Elective
- EE 460 (1) Microproc. System Design Lab
- EE 446 (3) Digital Computer Architecture
- EE 4XX (3) Technical Elective

No 300 level courses can be taken without PCS
Total: 130 Credits

Revised 10/21/2003

Fig. 2

Survey of Computer Science Credit Hours

- Category number (category 4: 9 to 12 hrs)
- Number of Institutions

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of Institutions</th>
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<tbody>
<tr>
<td>1</td>
<td>2</td>
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<tr>
<td>2</td>
<td>3</td>
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<tr>
<td>3</td>
<td>4</td>
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<td>4</td>
<td>9-12</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>
3. State Articulation (of Alabama)

This requires a common core of 63 credit hours for all publicly funded two- and four-year colleges within the state. The goal of this policy is ‘seamless’ transition of students between these institutions, particularly in the context of student transfer from the more numerous two-year institutions (‘junior’ colleges) to their four-year counterparts. These credits are almost identical for all engineering programs but, for computer engineering include the following:

- Six courses (18 credits) from a state-approved list of literature, fine arts, humanities and social sciences, including a concentration (i.e. two courses) in one specific area (e.g. history).
- The science content amounts to 15 credit hours, including four credits in chemistry and 11 in calculus-based physics (including a course on modern physics).
- The mathematics requirements include 12 credit hours in calculus, with three additional courses in differential equations, discrete mathematics and statistics. (*In the EE program, discrete math is replaced by linear algebra*).
- Required computational instruction comprises one course in C/C++.
- Two courses in English composition round out the requirements.

4. Program Realization

The genesis of any engineering program involves identification of the constituents of the program, followed by formulation of a set of basic program objectives by all of the major constituents. The complete list of constituents may be fairly long but the principal ones can be identified fairly easily. These include the student body; the faculty; alumni and industrial partners, particularly at the local and regional levels. These various constituencies should, *in concert*, formulate a relatively short set of basic objectives consistent with:

a. the mission of the institution;

b. the stated long-term goals of any larger academic unit to which the program belongs (in our case the College of Engineering);

c. the eleven learning objectives of ABET’s EC2000 criterion 3.

The somewhat generic nature of items (a) and (b) generally do not present any real conflict. Item (c), however, is an altogether different situation (see Fig. 3). The mandated list of requirements of Fig. 3 are challenging and largely dictate the ultimate set of objectives selected.

Fig. 4 below illustrates our (fairly typical) statement of objectives for our Computer Engineering Program corresponding to the standard laid down by ABET. The method by which those objectives are arrived at is illustrated by the flow diagram of Fig. 5.

Basically, a tentative set of program objectives is drafted by the Undergraduate Affairs Committee (UAC) in concert with a Coordination Committee comprising select faculty members from the Department together with Computer Science (which has a significant instructional input into the Program). This is against an historical backcloth of (continual) input from major constituencies. This draft goes forward to the Chair who, in turn, puts it to the test in front of representatives of all constituencies at an annual departmental retreat. Once agreement is reached
List of Requirements

a) Ability to apply knowledge of mathematics, science and engineering
b) Ability to design and conduct experiments, as well as to analyze and interpret data
c) Ability to design a system, component or process to meet desired needs
d) Ability to function on multi-disciplinary teams
e) Ability to identify, formulate and solve engineering problems
f) Understanding of professional and ethical responsibility
g) Ability to communicate effectively
h) Broad education to understand the impact of engineering solutions in a global and societal context
i) Recognition of the need for, and an ability to engage in life-long learning
j) Knowledge of contemporary issues
k) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Fig. 3

on a final wording of the objectives, the latter are voted upon by all constituencies. These are then the objectives in effect until the next annual retreat at which point they are reviewed once more. Cosmetic changes to the list of objectives are processed in the same manner as before.

EC2000 also requires defining a plurality of (measurable) outcomes validating achievement of the stated objectives of the program. The list of desired outcomes is, by necessity, larger and more detailed than the set of objectives. The set of desired outcomes, used to validate the learning objectives of Fig. 4, is shown in Fig. 6. Such a list of outcomes necessitates devising a comprehensive set of assessment tools that effectively demonstrates that they have been achieved. The process for achieving this is essentially the same as that for defining objectives and was illustrated in Fig. 5. Once again, typically, it is faculty input, via the UAC, that fertilizes the process but, ultimately, the major constituencies, at the annual retreat, arrive at the final decision on those outcomes. The set of outcomes of Fig. 6 has been validated in this fashion.

Numerical measurement of key outcomes is described in paragraphs 5 and 6 below. Non-numerical input from constituents is processed and evaluated using the flow diagram of Fig. 5 in exactly the same way. ‘Snapshot’ examples of recent significant input from constituents include:

- The word ‘legal’ in item 9 of Fig. 6 (industrial advisory board)
- The PLD and PLC senior elective labs (alumni input)
- Core courses in controls, communication and signal processing (FE exam results from NCEE)
Program Objectives

1. To provide a comprehensive educational program in Computer Engineering, founded upon strong basic instruction in science, mathematics, and hardware and software engineering fundamentals.

2. To provide students with the background, means, and opportunity to plan and conduct experiments and to apply appropriate techniques for data collection, analysis, and interpretation.

3. To develop within students necessary computer engineering design skills, including the capacity for problem formulation, background research, solution generation, decision making, implementation, communication, and teamwork.

4. To continuously refine the curriculum and course contents to implement new engineering technological trends including digital systems, Computer Architecture, parallel processing, hardware description languages, VLSI, software design, digital communications, computer networks, and the Internet, virtual instrumentation, image processing and digital signal processing as well as new design methodologies and state-of-the-art design/analysis tools.

5. To provide students with the background needed to identify global, societal, legal, and other key issues in arriving at ethical decisions in professional life.

6. To ensure that students completing the program will be able to enter successfully a chosen field in the computer engineering.

7. To instill in students an attitude in life-long learning to enable continuing career success in a changing technological environment and to prepare them for professional licensure.
Constituency Input

Report Back

Chairman

EE/CpE Faculty Meeting

Undergraduate Affairs Committee

Individual Faculty

Working Environment Change
Behavioral Change
Procedural Change
Policy Change
Rule Change
Curriculum Change

Improved Program

Fig. 5.
Computer Engineering Program Outcomes

Students completing the degree requirements in the Program of Computer Engineering should have:

1. A broad understanding of the theory of mathematics, probability and statistics, including that relating to differential and integral calculus, discrete mathematics, differential equations, and complex variables.
2. An understanding of basic scientific theory and methods in the areas of chemistry and calculus-based physics.
3. An understanding of engineering fundamentals.
4. An ability to apply mathematical, scientific, and engineering principles in the field of Computer Engineering. [Criterion 3(a)]
5. An ability to plan and conduct experiments in engineering science and engineering design. [Criterion 3(b)]
6. Design skills sufficient for the successful completion of a process, component, or system. [Criterion 3(c)]
7. An ability to function on multi-disciplinary teams. [Criterion 3(d)]
8. A capacity for problem identification and formulation, background research, solution generation, and decision making. [Criterion 3(e)]
9. An ability to identify global, societal, legal and other key issues in arriving at ethical decisions in professional life. [Criterion 3(f) and 3(h)]
10. A capacity for effective written and oral communication. [Criterion 3(g)]
11. In-depth education in the hardware and software subdisciplines of Computer Engineering.
12. Recognition of the need for, and an ability to engage in life-long learning. [Criterion 3(i)]
13. Knowledge of contemporary issues and an awareness of the changing technological environment. [Criterion 3(j)]
14. An ability to use modern engineering techniques, skills, instruments, and software tools necessary for effective participation in the Computer Engineering Profession. [Criterion 3(k)]
15. An appreciation of the unique concerns regarding safety required when working with electrical systems.
16. A general preparedness for graduate school or professional licensure.
17. A consideration of factors including economic, environmental, sustainability, manufacturability, reliability, reusability, serviceability, health and safety, social, and political in the design of digital systems.

Fig. 6

5. Instruments of Assessment

If the desired outcomes listed in Fig. 6 are to be achieved then how or whether they have been achieved must be measured effectively. This may be done with a comprehensive set of instruments of assessment, each of which provides a metric on at least one of the outcomes listed. Well-considered instruments can usually address multiple outcomes, although some of the more difficult-to-measure outcomes, related to key ABET objectives of Fig. 4, require essentially one-on-one correspondence.
A fairly comprehensive set of assessment tools has been applied to this problem. All of these are numerical metrics. The most valuable of these have been found to be:

- course-by-course, end-of-semester student surveys of learning;
- course-by-course, end-of-semester faculty surveys of learning;
- (annual) graduating senior surveys;
- (triennial) alumni surveys;
- (triennial) employer/supervisor surveys;
- (semi-annual) FE examination results.

The first of these is undoubtedly the cornerstone of this assessment paradigm. Every semester significant numbers of electrical and computer engineering courses are operated, each of which, at the semester end, surveys student perceptions of the degree of learning (numerically, on a 1 – 10 scale) of the principal learning objectives of the course. One such course is shown in Fig. 7. This is done for every course offered in the semester, leading to multiple average scores for every outcome. This, in turn, leads to a program average for every outcome every semester.

Those course objectives have already been correlated matrix-wise with some of the desired outcomes of Fig. 6. With this numerical approach, an average for the class can be obtained for each given objective, and, thereby, for desired learning outcomes appropriate to that course. A portion of the survey instrument is shown in Fig. 8 below.

Unlike the above metric, the alumni (Fig. 9) and employer/supervisor surveys are more selective (Fig. 10) and address a narrower range of issue. Generally, they address outcomes that are extremely difficult to measure in-house, including interpersonal and communication skills as well as the difficult issues involving ethics.

The FE exam, administered nationally on a twice-yearly basis in the United States by the National Council of Examiners for Engineering and Surveying, (NCEES), is a potentially valuable resource for learning assessment. Although better suited in its profile to the civil and mechanical engineer, this exam is, on a topic-by-topic basis, a valuable assessment tool. For computer engineers, there are exam sections dealing with electrical circuits, digital systems, computer hardware engineering, computational and numerical methods, for example, as well as those dealing with the basic math and physical sciences.

In Fig.11, we show five sets of results, in chronological sequence, for one specific subject area (not mentioned above), namely control theory. The y-axis here is the success rate for this particular cluster of questions. The double histogram is drawn to allow comparison with the national average (success rate). As can clearly be seen, in this particular example, the success rate for our students clearly lags behind that average. On the other hand, our students are required to take the exam. Nationally, however, most students take the test voluntarily. Clearly, what is important here is the trend rather than the absolute score. Improving/worsening tendencies can be detected (biannually) very easily with this instrument. In particular, effective instructors can be clearly identified by administrators when sudden jumps in the success rate are sustained.
END OF SEMESTER EVALUATION

This questionnaire is intended to assist the instructor in evaluation of the extent to which the learning objectives were achieved. Your cooperation in completing and returning it to the EE/CpE office is appreciated.

Name (optional): ________________________________

Course Number: EE 264 Course Title: Microprocessor Systems and Interfacing
Instructor: ________________________________ Semester: __________________

The principal learning objectives set for this course are summarized below. Assess your understanding of each of a scale of 1 to 10 where 1 signifies very low and 10 signifies very high.

Low (1)                      High (10)

1. Understand basic computer organization and structure.
   1 2 3 4 5 6 7 8 9 10 N/A

2. Understand use of register transfer notation (RTN).
   1 2 3 4 5 6 7 8 9 10 N/A

3. Understand the architecture of the Motorola 68HC11 microcontroller
   1 2 3 4 5 6 7 8 9 10 N/A

4. Write programs in the Motorola 68HC11 micro-controller assembly language.
   1 2 3 4 5 6 7 8 9 10 N/A

5. Understand the interfacing of serial and parallel I/O devices to the 68HC11.
   1 2 3 4 5 6 7 8 9 10 N/A

6. Understand the I/O support hardware such as counters, timers, A/D and D/A devices.
   1 2 3 4 5 6 7 8 9 10 N/A

7. Use the microprocessor as a control device.
   1 2 3 4 5 6 7 8 9 10 N/A

Fig.7.
# Course Objectives versus Computer Engineering Program Outcomes – Spring Semester 1999

**Drafted: March 8, 1999**

## Computer Engineering Program Outcomes

| Course Number and Name | 1 | 2 | 3 | 4 | (a) | (b) | (c) | (d) | (e) | (f) | (g) | (h) | (i) | (j) | (k) | 16 | 17 |
|------------------------|---|---|---|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|
| EE264 Digital System Design II |   |   |   |   | 6.9 | 4.2 | 7.3 | 6.8 | 6.8 | 6.8 | 6.8 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.7 |

### Course Objectives/Computer Engineering Program

1. A broad understanding of mathematical theory, including that relating to differential and integral calculus, discrete mathematics, differential equations, and complex variables.
2. An understanding of basic scientific theory and methods in the areas of chemistry and calculus-based physics.
3. An understanding of engineering fundamentals.
4. An ability to apply mathematical, scientific, and engineering principles in the field of Computer Engineering. [Criterion 3(a)]
5. An ability to plan and conduct experiments in engineering science and engineering design. [Criterion 3(b)]
6. Design skills sufficient for the successful completion of a process, component, or system. [Criterion 3(c)]
7. An ability to function on multi-disciplinary teams. [Criterion 3(d)]
8. A capacity for problem identification, formulation, solution generation, and decision making. [Criterion 3(e)]
9. An ability to identify global, societal, legal and other key issues in arriving at ethical decisions in professional life. [Criteria 3(f) and 3(h)]
10. A capacity for effective written and oral communication. [Criterion 3(g)]
11. In-depth education in the hardware and software subdisciplines of Computer Engineering.
12. Recognition of the need for, and an ability to engage in life-long learning. [Criterion 3(i)]
13. Knowledge of contemporary issues and an awareness of the changing technological environment. [Criterion 3(j)]
14. An ability to use modern engineering techniques, skills, instruments, and software tools necessary for effective participation in the Computer Engineering Profession. [Criterion 3(k)]
15. An appreciation of the unique concerns regarding safety required when working with electrical systems.
16. A general preparedness for graduate school or professional licensure.
17. A consideration of factors including economic, environmental, sustainability, manufacturability, reliability, serviceability in the design of digital systems.

![Fig. 8.](image-url)
**ALUMNI SURVEY**

Present employer: ____________________________ Supervisor: ____________________________

Employer address: ____________________________

Based upon your workplace experiences since graduation, how well do you feel your education at the University of South Alabama prepared you on a scale of 1 (low) to 10 (high): Check not applicable (NA) when appropriate.

1) Oral communication skills:
   
   |   |   |   |   |   |   |   |   |   |   |   |
   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | NA |
   |

2) Written communication skills:
   
   |   |   |   |   |   |   |   |   |   |   |   |
   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | NA |
   |

3) Analytical/ design skills:
   
   |   |   |   |   |   |   |   |   |   |   |   |
   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | NA |
   |

4) Computer/math skills:
   
   |   |   |   |   |   |   |   |   |   |   |   |
   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | NA |
   |

5) Practical problem solving skills:
   
   |   |   |   |   |   |   |   |   |   |   |   |
   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | NA |
   |

6) Your ability to function as a team player:
   
   |   |   |   |   |   |   |   |   |   |   |   |
   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | NA |
   |

7) Your attitude towards life-long learning/keeping up-to-date:
   
   |   |   |   |   |   |   |   |   |   |   |   |
   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | NA |
   |

8) The way you deal with professional and ethical issues:
   
   |   |   |   |   |   |   |   |   |   |   |   |
   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | NA |
   |

9) Your overall ability to use techniques, skills and modern engineering tools in the workplace:
   
   |   |   |   |   |   |   |   |   |   |   |   |
   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | NA |
   |

10) Were you prepared for contract law:
    
    |   |   |   |   |   |   |   |   |   |   |   |
    | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | NA |
    |

11) Did you attend graduate school after your graduation from our Program ______ Yes ______ No

12) Are you a member of your professional society? ______ Yes ______ No

13) Are you a licensed professional engineer? ______ Yes ______ No

Please write additional comments on the back.
Employer/Supervisor Survey

Company_________________________Representative__________________

Email address______________________Date__________________________

Based upon your experience with graduates possessing a BSEE/BSCpE from the Department of Electrical and Computer Engineering at the University of South Alabama, how would you rate them in regard to the following skills/traits on a scale of 1 through 10* (10 high).

My observations include: ________Electrical Engineers________Computer Engineers

1) Oral communication skills:  
   1 2 3 4 5 6 7 8 9 10 NA
   __ __ __ __ __ __ __ __ __ __ __

2) Written communication skills:  
   1 2 3 4 5 6 7 8 9 10 NA
   __ __ __ __ __ __ __ __ __ __ __

3) Design skills:  
   1 2 3 4 5 6 7 8 9 10 NA
   __ __ __ __ __ __ __ __ __ __ __

4) Computer/math skills:  
   1 2 3 4 5 6 7 8 9 10 NA
   __ __ __ __ __ __ __ __ __ __ __

5) Technical/practical skills:  
   1 2 3 4 5 6 7 8 9 10 NA
   __ __ __ __ __ __ __ __ __ __ __

6) Ability to function as team players:  
   1 2 3 4 5 6 7 8 9 10 NA
   __ __ __ __ __ __ __ __ __ __ __

7) Attitude to life-long learning/keeping up-to-date:  
   1 2 3 4 5 6 7 8 9 10 NA
   __ __ __ __ __ __ __ __ __ __ __

8) Professional conduct in the work place:  
   1 2 3 4 5 6 7 8 9 10 NA
   __ __ __ __ __ __ __ __ __ __ __

9) Overall job performance of our graduates under your direction:  
   1 2 3 4 5 6 7 8 9 10 NA
   __ __ __ __ __ __ __ __ __ __ __

*or tick not applicable (NA) when appropriate

Fig. 10.
6. Assessment Data Evaluation

Collection of adequate assessment data is extremely important. Evaluation of that data, however, is equally so. For one thing, it can inform the assessor of the usefulness of the information gathered. An important characteristic of the assessment process is that the metrics should exhibit an acceptable level of correlation with one another. Any metric offering numerical scores at significant odds with other metrics should itself be assessed as to its real worth, if any. The greater the correlation of the various metrics with one another, the greater is the degree of confidence that may be placed upon them. Parker et al [1] have already demonstrated surprisingly strong correlations between all of the instruments described above. When all of the results of the various instruments of assessment have been fully evaluated, a numerical score (on a 1 to 10 scale) for each of the desired outcomes should be obtainable, that number representing an average of all of the above-mentioned instruments.

Clearly, what these metrics tell us is a single digit number in the range, 1 – 10, for each of the 17 Program Outcomes listed in Fig. 6. In turn, a correlation matrix for the outcomes of Fig. 6 and the Program Objectives of Fig. 4 can establish a similarly averaged single digit evaluation for each of the latter. In the view of the present authors, any number less than 6.0 is unacceptable and must be subject to vigorous self-examination via the processes visualized in the flow diagram of Fig. 5. Numbers in the range 6- 8 are acceptable but mediocre and indicate areas requiring fresh attention. On the other hand, in our experience, numbers > 9.0 ought to be treated with some skepticism. In summary, numbers ≥ 6.0 for each item of Fig. 4 means that all of the Program objectives have been met.

7. Software Requirements

A modern electrical or computer engineering program must inculcate a knowledge and understanding of at least some of the more powerful commercially available software packages. A flexible set of options exists to cover all student needs in most programs. In our program, most
computational needs are met with MathCad and Matlab. Basic circuits are analyzed with PSpice; analog and digital electronics with Electronic WorkBench. Digital logic is dealt with using Multisim and VHDL. In addition, customized software is used in advanced teaching labs involving PLCs and PLDs.

8. Retention and Student Mentoring

High student morale is a key ingredient of any healthy engineering program. All too often, especially in larger engineering schools, it is easy for the borderline student to lose a sense of identity. Engineering administrators have a duty to foster a climate in which all students feel that their concerns are being documented and being attended to.

One possible vehicle for dealing with the above is a student-faculty forum in which representatives of the student body meet with one (or more) carefully selected faculty to discuss concerns in an informal environment. Such concerns may range from the routine (computer lab access hours, for example) to more serious stuff (such as poor quality of instruction). It is important that the faculty selected for this forum be a person demonstrably having the confidence and trust of the student body. Younger members of the faculty are generally more likely to succeed in this respect. It is also important that student concerns to be responded to in a timely fashion.

One final word on this: it is extremely important that administrators try to maintain a personal touch in dealing with students. We have found that when a student’s cumulative GPA falls below the probationary threshold, a relatively informal written communication from the Departmental Chair to that student, expressing concern, can have a surprisingly positive effect. This is demonstrated in the histogram of Fig. 12 showing a representative selection of case studies showing semester GPA’s before and after receipt of the aforementioned letters.

![Histogram of Semester Grades before and after personal letter](image)

**Fig. 12**

It is equally important that the administrator be just as timely in *praising* subsequent performance improvements.
9. Concluding remarks

In the above, we have attempted to show how a modern electrical and computer engineering degree program must reflect, in a balanced fashion, the wishes and aspirations of its major constituencies. In order to achieve this, there must be well-defined goals and carefully specified outcomes showing that those goals have been achieved. Part and parcel of this is an effective set of assessment tools, the results of which must be carefully analyzed to ensure effective remedy of weaknesses. Finally, at all times, all engineering programs, large and small, must try to inculcate, by whatever means, a personal interest in the welfare of the individual student.

Acknowledgements
The authors would like to thank faculty members of the Department of Electrical and Computer Engineering, (past and present), who contributed greatly to this paper by providing input to the various figures and related data, in particular to Y. Tung for Fig. 1 and H. Parker for Figs. 11 and 12.

Bibliographic Information

3. EC/ABET 2000 Criteria for Accrediting Engineering Programs (http://www.abet.org)

Biographical Information

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