A New Approach to Electrical & Computer Engineering Programs at Rose-Hulman Institute of Technology

Barry J. Farbrother Ph.D.
Head, Electrical & Computer Engineering
Rose-Hulman Institute of Technology

Abstract

Two new degree programs[1] are now being offered by the department of Electrical & Computer Engineering at Rose-Hulman Institute of Technology. The new Bachelor's programs in Electrical Engineering and Computer Engineering, are the result of a top-down curriculum design process which took several years to complete.

'Renaissance Engineers' are engineers who will be able to prosper in the workplace of the twenty-first century. We all agree that many changes took place in the workplace during the 1990's which are certain to continue. In order to produce graduate engineers with the appropriate skills for this new environment it is necessary to change the process by which they are trained. The conference presentation will include a discussion of the factors affecting curriculum development, a program overview, and also address departmental issues pertaining to the process of curriculum re-structuring.

The Preliminaries

Dramatic changes took place in the workplace during the 1990's which have affected the way engineering is practiced, and they will continue as we enter the new millennium. The workplace has changed, the tools of the engineering profession have changed, the generation for which we have the responsibility of training has changed, and there are increased economic pressures associated with the global environment in which our corporate counterparts operate. These factors combine to produce a *paradigm shift* in the mode of operation of the engineering workplace and we must respond by providing programs that will enable generation X[2] teenagers to become engineers who are able to prosper in this demanding environment.

At Rose-Hulman we became aware that freshmen entering college in the late 1980's and early 1990's were *different* from their predecessors. This generation has a different approach to life, different values and most certainly different academic skills and motivation! This topic will have been well-aired in a variety of forums at most institutions and, notwithstanding our desire to have high schools do more, we have to *meet students where they are!*

In addition to the realization that the *real world* was changing, the academic community also acknowledged the comparable paradigm shift occurring in criteria upon which the Accreditation Board for Engineering and Technology (ABET) would be basing accreditation decisions. (Criteria-2000).[3]

The new Electrical Engineering and Computer Engineering programs are the result of four years of curriculum re-engineering by departmental faculty who had to be convinced that such a dramatic upheaval in the departments *modus operandi* was necessary. The realization that *"change IS the status quo"* coincided with the appointment of a new department head who pro-posed a "clean sheet of paper" approach following his appointment and which was enthusiastically accepted. The unanimous approval of the faculty is absolutely essential if the task is to be completed in a reasonable time frame and

if all faculty members are to maintain their sanity!! We will not consider the task fully completed until the first cohort of students graduate in May 1998.

Phase 1 of the curriculum restructuring process started in the early 1990's with a departmental discussion which culminated on December 17, 1993 with the adoption of a set of undergraduate engineering goals. These have guided our efforts throughout this on-going process, were adopted before the recent change of accreditation policy by ABET. We believe they will stand the department in good stead as it prepares for *Criteria 2000*-based accreditation in the future.

Coupled with these external events were a number of internal factors that also contributed to the impetus for change. It is not appropriate in this paper to do more than list them and they include: the growing dissatisfaction by ECE faculty with a curriculum that had been *enhanced* over the previous decade by piecemeal addition of topics, a Commission on the Future which had generated in excess of 120 goals for the institution, a desire to embrace technological enhancements due to prior experience with computerized classrooms and symbolic algebra systems in teaching mathematics, the desire of the new department head to require a year-long senior engineering design experience and the recognition that the educational process can be enhanced by coupling it more tightly with industry.

The Premise

The underlying premise is that we must change the process by which engineers are trained if our graduates are to be able to functional effectively in the new environment. If we do not, we should not expect them to be any different from traditional graduates. That is, "If you do what you always did, you'll get what you always got"! Therefore, new engineering programs must:

- **(i) meet the student where he/she is academically**
- **(ii) provide an enduring education based upon a foundation of math and science**
- **(iii) provide an environment that enables the student to develop as an individual**
- **(iv) excite students - require them to experience their profession before graduation**
- **(v) provide a global view of their environment and acquire a systems perspective**
- **(vi) require that the student recognize the necessity of being a lifelong learner and provide him/her with the skills that enable them to accomplish this goal**

The Process

As engineers the *process* of design is an important component of our professional skill set, and our curriculum design process has utilized that expertise. In any well-organized design environment there are professional standards to be upheld, a team mentality which requires that all members understand (and adhere to) guidelines for acceptable behavior, and a sincere desire to "get the job done". Without these, the team has difficulty in functioning and every step along the way is open to conflict, delay and eventually, failure.

The first step in the design process is to solidify system specifications which, in the educational environment, is a set of educational goals upon which the faculty agree. Our process also included a discussion of the role of the department in the educational context (relationship with students) and the institutional context, (relationship with our colleagues) as well as its role relating to the professional development of the faculty (their interaction with our industrial partners). The process of developing a set of goals is as important as the product itself, perhaps even more important, as it enables the faculty to understand alternative viewpoints, requires them to rationalize their own and eventually to "buy in" to the consensus that will enable the process to move ahead. Rose-Hulman's ECE goals are listed below.

ECE DEPARTMENT GOALS FOR UNDERGRADUATE EDUCATION

(Adopted by the faculty December 17, 1993)

Each Electrical and Computer Engineering graduate shall:

- **have demonstrated a facility for independent learning, and shall have prepared for continued professional development**
- **Have participated in team design experiences in which the client is distinct from the faculty supervisor(s).**
- **have prepared at least one major individual concept-oriented technical report or paper, and one major client-oriented group project report.**
- **have completed a general engineering science core by the beginning of the junior year, and shall have completed a discipline-specific technical core..**
- **have demonstrated the ability to effectively communicate technical material in writing, one-on-one meetings, and group presentations.**
- **be prepared to practice the profession of engineering using a systems perspective broad enough to encompass technological, economic, ethical, environmental, social, and human issues.**
- **have demonstrated the effective use of the contemporary tools of the engineering profession such as computers, data analysis and management, instrumentation experimentation, and human and information resources.**

The Product

The system view of the new program has the following configuration:

Freshman year:	**Basic Mathematics and Science**
Sophomore year:	**Foundation in Engineering Science**
Junior year:	**Breadth in Major**
Senior year:	**Engineering Design & Elective**

Space constraints do not allow detailed program listings to be included with this paper, They will be available as handouts when the paper is presented at the conference.

(i) The Freshman year

At Rose-Hulman students are not required to declare a major until the end of the freshman year. The academic community is currently performing a critical review of the "first year experience" in order to better meet the needs of the entering freshmen the and to incorporate the benefits of some innovative programs[456] developed in the recent past. Faculty had a strong desire to establish contact with freshmen and this has resulted in EE and CO majors taking a design-oriented course in Logic Design during the Spring quarter. Additionally, ECE faculty have identified a set of professional skills that are to be incorporated into the new programs. The result is detailed course descriptions which incorporate *skills* requirements in addition to the traditional engineering topics.

(ii) The Sophomore year

A distinguishing feature of both new programs is that the sophomore year for both programs are virtually identical (differing only in one course) and the student is given the broad engineering science foundation which we believe is essential if they are to function effectively throughout their careers. The curriculum incorporates an innovative sequence of courses in electrical, mechanical, fluid and thermal systems which were developed with support from the National Science Foundation. The Foundation Coalition[7,89] focuses upon foundation curricula which are integrated, interdisciplinary and design-oriented. They utilize student discovery, co-operative learning and problem solving processes to emphasize broad concepts and they seek to develop the human interface (student/student, student/faculty, and faculty/faculty). In harmony with the institute's decision to require all freshmen to purchase their own laptop computer (implemented in Fall 1995), the coalition

has increased the utilization of new technology and employs associated methodologies in the classroom. Evaluation/assessment is another component which meshes well with Criteria 2000.

The engineering science courses themselves seek to inform students of the links between engineering disciplines and takes us one step towards the elimination of service courses. Starting in Fall 1995 all electrical and computer engineering majors were required to enter the Foundation Coalition Sophomore Engineering Curriculum (FCSEC) and in 1996 the Mechanical Engineering Department agreed to phase in this requirement for ME majors. We believe that upon completion of the sophomore year students should be prepared to take the Fundamentals of Engineering (FE) exam - even although they are not permitted to do so!

An additional required course, Engineering Practice, is designed to help students develop their professional identity by requiring them to practice teamwork skills, to hone their written and oral communications skills and introduces them to the concepts of professional responsibility (ethics), total quality management, team and presentation skills, and the time-value of money. Student membership of IEEE is required for successful completion of this course and we encourage participation in IEEE campus and regional activities. The "professional "track continues in the junior year with a course in design and culminates in the client-based year-long senior engineering design sequence.

(iii) The junior year

In the junior year we provide students with a broad exposure to their chosen major. This was the most contentious part of the curriculum development process for faculty members charged with the development of the electrical engineering program.

Our computer engineering colleagues identified hardware-related and software-related courses which they believed would enable them to incorporate the essential components. The team included ECE faculty members and an invited faculty member from the department of Computer Science. At this stage however, course topics were not identified - this was left until the detailed development of individual courses occurs much later in the process.

The electrical engineering faculty were charged with providing the students with an exposure to the breadth of electrical engineering - by definition a considerably more difficult task than for computer engineering! The outcome was a block of nine courses covering topics in communications systems, controls, digital systems and computers, electro-magnetics, electronics, power systems and machines.

In the Spring quarter students take a required course in design. Although we have attempted to integrate design throughout both programs this required class will formalize the design process and provide students with the necessary skills to successfully complete the senior engineering design sequence. Another "professional" track requirement is to require students to attend a minimum number of professional presentations such as those sponsored by IEEE, ACM etc.

(iv) The senior year

As they mature professionally, students are encouraged to regard their professors as mentors and colleagues rather than teachers. This is particularly appropriate in the year-long engineering design sequence where students are required to undertake a client-sponsored engineering project, that will enable them to experience all the major components of the (iterative) design cycle. The faculty member will perform the role of

consultant/project manager and not be involved to the extent that he/she performs engineering work. Besides providing the opportunity to work on real-world problems, students will be required to work in teams, develop a working relationship with the client - including the arranging of design reviews and the production of interim reports etc., and for deliverables which will include a fully documented final project report.

Our approach has involved a solicitation for "Industrial Partners in Engineering Design" in which we seek *non-critical-path projects* for our students. We require our industrial partners to cover the cost of consumables and to provide an interface person (preferably and engineer) who will be available to interact with the student team. We do not guarantee that deliverables will be produced and we state from the outset that *"failure IS an option!"*[9]

The Principles

Our undergraduate educational goals embody the system level principles that have enabled us to keep focused as we re-engineered two degree programs. The principles define what we believe are attainable educational goals. They are our goals and may differ from those that you and your colleagues develop when you embark upon your curriculum restructuring journey.

We believe that technological advancement will continue - probably at an ever-increasing pace - certainly until we no longer have to worry about how to cope with it! We believe that probably the most enduring attribute with which we can endow our students is *the ability to learn by themselves.* It is essential therefore that the process of education must move away from that of *teaching* to one in which the student becomes *an active learner* responsibility for his/her continuing education. The outcome for those who are taught and those who have learned how to learn, is the same in the short term - but markedly different in the long term. The workplace (world?) is a different place now in comparison with what it was just five years ago, and it will be very different five years hence. If our students are to be able to function effectively they must have a broad knowledge base and a systems perspective, be able to use appropriate technology, be able to interact with colleagues in their own (and other) disciplines/professions, and above all be prepared to continue their education throughout their professional lives. It is our responsibility, because we play a critical role in the first phase of an engineers career, that we too continue to change the process by which engineers are prepared for their professional lives.

Notes:

1. Space constraints prevent detailed program listing being included in this paper. They will be available as handouts to participants at the conference.

2. Generation X is considered to be the generation which followed the Hippie generation. They were born in the 1970's and include teenagers who have entered tertiary education in the early 1990's.

3. ABET Criteria-200 will be implemented for accreditation purposes beginning in 1999.

4. The Integrated First Year Curriculum in Science Engineering and Mathematics (IFYCSM) offered for the first time in 1989 was developed with funding from the National Science Foundation.

5. IFYCSEM was funded in the summer of 1988.

6. In August 1995 a Five Year Report on the program was drafted.

7. Rose-Hulman is a member of the Foundation Coalition: Arizona State University, Maricopa Community College District, Rose-Hulman Institute of Technology, Texas A&M University College Station, Texas A&M University Kingsville, Texas Women's University, University of Alabama.

8. The Foundation Coalition Sophomore Curriculum was funded 10/1/93.

9. Gene Kranz, Apollo Mission Controller said *"Failure is not an option"* when charged with the task of bringing the crippled spacecraft and its crew safely back to earth.

Biographical Information

Dr. Barry J. Farbrother is Professor and Head of the Department of Electrical & Computer Engineering at Rose-Hulman Institute of Technology. Dr. Farbrother received his B.Sc (Hons) degree in June of 1972 and his Ph.D. in June 1977 from the University of Hertfordshire, U.K. Before joining the faculty at Rose-Hulman Institute of Technology in 1982, Dr. Farbrother was a Telecommunications Engineer with Cable & Wireless Ltd., Lecturer at Hatfield Polytechnic and Senior Lecturer at the University of West Indies. Dr. Farbrother is a member of ASEE, IEE, IEEE, and HKN.

Rose/Papers/NatASEE97
bjf 970103
Document sent to Prof mack (pmack@eng.morgan.edu 1-13-97