RE-ENGINEERING THE ELECTRICAL ENGINEERING CURRICULUM

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ABSTRACT

Three specific programs are suggested to modify the electrical engineering curriculum to keep up with the dramatic technological developments of recent years. One of the programs is a five-year combined BS/MS program which permits the student to specialize in more than one field. The second proposal is to restructure the BS program into a multi-track program. The third one is an internship-in-industry program to provide the student with a meaningful and valuable real-world design experience before graduation.

1. INTRODUCTION

Engineering curricula in the United States, particularly curricula in electrical and computer engineering, had changed very little during the past 30-40 years. Most changes that have occurred have been in the form of course redesign and new courses replacing existing ones. Fundamental changes are necessary to keep up with the dramatic technological developments of recent years, such as computer and information processing systems, light wave technology, biotechnology, and manufacturing.

It is now generally agreed among electrical engineering educators in the United States that a 4-year BS program in engineering does not provide adequate preparation to enter the engineering profession. The technological developments dictate that today's graduates specialize in more than one field. In other words, today's engineers must be flexible engineers who can quickly change their directions of work as their companies change their product lines to penetrate other more promising markets. In many instances, engineering graduates need to specialize in cross-disciplinary fields outside the traditional boundary of their respective departments. It should be noted that the telecommunication industry in the United States has already recognized the need to have engineers with cross-disciplinary backgrounds. To meet their need, several graduate level programs involving cross-disciplinary fields have already been instituted recently at a number of US universities. An example of such a program is the Master's program in information networking at the Carnegie Mellon University [1] which is a joint venture of three schools: Engineering, Computer Science and Industrial Administration. This program involves graduate-level instruction in four academic areas: computer, telecommunications, business and public policy. Other examples of multi-disciplinary graduate level programs are telecommunications management, information systems engineering, and similar subjects being offered by the Polytechnic University of New York, the University of Colorado at Boulder, the University of Pittsburgh, and the George Washington University. However, this type of multi-field specialization is difficult to implement in a 4-year program if we continue to keep other requirements in sciences, humanities and social sciences in place with respect to the number of required credit hours.

To provide the student with a multi-field specialization, additional changes to the core course requirement must also take place. Most electrical engineering curriculum consist of a large number of core courses in every branch of electrical engineering, in addition to required courses in sciences, humanities and social sciences. As a result, the student does not have sufficient time left to specialize and they graduate as a generalist. It is therefore also necessary to restructure the core course requirements.

Another important part of the engineering education is providing the student with meaningful design experience. Design of today is considerably different from the traditional concept of design as has been taught for the last 30-40 years. In the latter case the design is usually carried out as a individual project culminating in the construction of a simple circuit or equivalent. This type of experience worked well in the old days when the industry was following sequential product development. The design of today is concurrent engineering involving

several individuals, such as designers, product planners, manufacturing engineers, and even parts suppliers, working as a team and the ultimate product is a complex system [2]. In addition, real industrial design involves developing a written report on the project. Moreover, with increasing emphasis on research at American universities, undergraduate coursework has over the years moved away from an emphasis on engineering design and practice. Steps must be taken now to reverse this trend and provide today's engineering students with real-world design experience while they are studying for their degrees.

This paper proposes three specific programs to restructure the electrical engineering curriculum in order to solve the above problems.

2. FIVE-YEAR COMBINED BS/MS PROGRAM

It is clear that the student will need a least an additional year to permit the multi-field specialization. A five-year BS program obviously would not be competitive. Existing graduate programs are often narrowly focused and are also too lengthy to satisfy this need. A more workable solution is to institute a five-year combined BS/MS program which provides both the needed time (for breadth and depth) and an appropriate incentive. Such a program should also be designed to permit the students to have a dual status in their fourth and fifth years so that they can take both upper division electives and graduate courses during these two years. The graduate units taken during the traditional senior year will allow the completion of the MS program requirements in the fifth year. At the end of the fifth year the student will have to indicate from the list of courses taken during his/her study which course is to be counted towards the BS degree and which one for the MS degree. The proposed program in most schools will not require any changes in the standard requirements for the two degrees for its implementation. However, it will provide the student with additional flexibility to plan the completion of the two degree programs.

The format for implementation will vary from school to school. The program implementation as instituted at the University of California, Santa Barbara (UCSB) is described next. Other schools can adapt this scheme with appropriate modifications as may be necessary to meet their local requirements.

To get into the combined BS/MS program of study, the interested students should notify the Undergraduate Studies Office (which is typically in the College of Engineering) of their intention to pursue this program in the beginning of the sophomore year as in most cases they need to plan their sophomore-year studies differently form other undergraduates. Before the end of their junior year, interested undergraduate majors would then apply for admission to the Graduate Division using the standard application package. No GRE record would be required at this stage.

If the student's cumulative grade point average (GPA) is at least 3.50 (out of a 4.0 point maximum) and the recommendation letters are strong, graduate admission will be granted before the first quarter of the senior year. If the student's cumulative GPA at the end of the junior year is between 3.0 and 3.49 or is at least 3.50, the student will be asked to take the GRE, preferably during summer. Admission to graduate status will then be granted or denied before the beginning of the senior year. Graduate courses taken by the student after admission to the graduate status will count for credit towards the MS degree, provided they will not be used for satisfying the BS requirements.

At the end of the fifth year, students will fill out both the BS and the MS graduation forms, listing each course taken only on one of the two, and receive both degrees simultaneously if the respective requirements have been met. It should be pointed out here that at the end of the senior year, students have the option of filling out a BS graduation form and leaving the program with a BS degree if all BS requirements have been met. In this situation, the student can of course use graduate courses taken in the senior year to meet the elective requirements.

It is very important that students admitted to this program work out their study programs carefully in consultation with a faculty advisor before their senior year to ensure that they are indeed satisfying the multi-field specialization requirement. The faculty advisor assigned to the student must also monitor the progress of the student periodically to ensure the successful completion of the program in five years.

3. MULTI-TRACK BS PROGRAM

As indicated earlier, traditional program of study for a BS degree in electrical & computer engineering consists of a large number of required electrical & computer engineering courses in the sophomore and junior years permitting the student to take electives mostly in the fourth year. Such a program often produces engineering graduates who are mostly generalists instead of specialists. It is proposed here

that such a program be replaced with few required core courses in the sophomore year followed by various tracks of specialization with each track having additional required courses.

The proposed sophomore level core courses are:

Digital Signal Processing,
Digital Electronic Systems,
Analog Signal Processing,
Analog Electronic Systems,
Fundamentals of Computer Programming and Organization.

Some example tracks for specialization are as follows:

Computer Engineering,
Communications,
Control Systems,
Signal Processing,
Solid State Devices,
Electronic Circuits & Systems,
Wave Technology & Electronics, etc.

However, the specific tracks for specialization again will vary from school to school depending on courses available at the respective schools and the composition of the faculty.

4. INTERNSHIP-IN-INDUSTRY PROGRAM

As the best place to gain real-world design experience is an industry, we propose an internship-in-industry program. Such a program will provide the student with an unusual opportunity to combine industrial experience with his/her academic study. Students in this program will intermix academic study at the university with two or three quarters of work at a participating industrial or governmental organization. In addition to receiving financial compensations during work assignments in the industry, students will get a unique opportunity to relate the scientific and engineering principles discussed in class to current engineering problems in industries. Such a program will also provide the student with an early and close contact with serious, professional work in an industrial environment. Moreover, the student will receive academic credit for the design experience gained.

In order to function properly, it is important to have a number of companies and government laboratories who are willing to participate in this program being offered by a particular school. The student selected by a company from this group should obtain a written description of the project to be carried out during his/her internship in that company. This project description should be submitted to a faculty advisor must together agree on the work to be performed, reports and meetings required, and the number of units to be awarded after completion of the project. The faculty advisor serves as a liaison between the department and the company, and will visit the student at work in this company during the work assignment period to review the progress.

Each student in this program will have to carry out all work assignments preferably with a single company or laboratory. The technical level and responsibility of the assignments should increase as the student gains experience. While working, each student is subject to company regulations and receives regular compensation for work performed in the company.

In order to receive academic credit (which should come out of the usual unrestricted elective requirements), the student will have to write a final technical report describing the project and the outcome of the project. This report must first be cleared by the company before it is submitted to the faculty advisor assigned to that company for evaluation and grading.

5. CONCLUDING REMARKS

Three specific programs have been suggested in this paper to restructure the electrical engineering curriculum in the United States. One of these programs is the combined BS/MS program which is the easiest to implement in any university and is designed to solve one of the major deficiencies in the curriculum with very little structural changes. The second proposed change is the institution of a multi-track BS program which would require some fundamental alterations in the curriculum. The third proposal is towards providing a more realistic design experience to the engineering student which can be obtained in an industry and requires active cooperation by the industry for its implementation. However, it is in the best interest of the US industry to provide meaningful internships to our engineering students during their academic study period.

Some of the changes to the electrical engineering curriculum proposed here have already been implemented at a number of universities. For example, the Master's degree as a terminal degree for electrical engineering graduates has been recognized by the Massachusetts Institute of Technology [3] and the Carnegie Mellon University [4]. However, the important difference between the

5 year program proposed here and most other similar programs elsewhere is that in the proposed program, the student in the 4th and 5th year have a dual status, and can take either upper division or graduate level courses. Moreover, in the proposed program, the student can take almost any course outside the electrical engineering department as long as he/she has the overall program approved by a faculty advisor prior to starting the program and can justify the need for such combination of courses based on his/her professional objectives.

References

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