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AUTHOR Daneshvar, K.; Tranjan, F. M.
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ABSTRACT

Although in the liberal arts the main concern is comprehensive education, it is generally accepted that an engineering curriculum, while providing the fundamentals, can change continuously to accommodate technological, industrial, and economical interests. Meanwhile, in recent years many new forms of learning have been proposed that are quite different from traditional approach. These include virtual learning, distance learning, international options, and many forms of audio-visual methods and software that are supposed to enhance educational objectives. At the same time, the technological expansion in many areas demands the introduction of new materials and the abandonment of old ones. Nontraditional topics such as optical engineering, laser electronics, market forecasting, image processing, information technology, and human soft-skills are frequently seen in the electrical engineering curricula. While the traditional courses had overlapping continuity, the new topics in electrical engineering have very little mutual relevance. This raises the question whether the traditional courses are an essential background for the electrical engineering graduate or if students should be allowed to chose what may be perceived as essential requirements. At the same time, there are concerns that the introduction of so many new topics in electrical engineering may reduce the contrast with other disciplines and definition of electrical engineering degrees. All this makes it essential to redefine the major required courses that are considered as the foundation for an undergraduate electrical engineering degree. While changes in electrical engineering are being introduced, they raise concerns about the limits beyond which the changes lead to the complete loss of the original objective. This may result in a system that does not function as it was intended and that may not be adequate for what is expected. This paper is intended to discuss the main requirements for a typical electrical engineering curriculum that can absorb changes through a dynamic process while maintaining its integrity. (Author)

Adaptive Core Requirements for An Ever Changing Electrical Engineering Curriculum

K. Daneshvar and F. M. Tranjan, Electrical and Computer Engineering
University of North Carolina, Charlotte, NC 28223

Abstract

Although in the liberal arts the main concern is comprehensive education, it is generally accepted that an engineering curriculum, while providing the fundamentals, can change continuously to accommodate technological, industrial, and economical interests. Meanwhile, in recent years many new forms of learning have been proposed that are quite different from traditional approaches. These include virtual learning, distance learning, international options, and many forms of audio-visual methods and software that are supposed to enhance educational objectives. At the same time, the technological expansion in many areas demands the introduction of new materials and the abandonment of old ones. Nontraditional topics such as optical engineering, laser electronics, market forecasting, image processing, information technology, and human soft-skills are frequently seen in the electrical engineering curricula. While the traditional courses had overlapping continuity, the new topics in electrical engineering have very little mutual relevance. This raises the question whether the traditional courses are an essential background for the electrical engineering graduate or if students should be allowed to chose what may be perceived as essential requirements. At the same time, there are concerns that the introduction of so many new topics in electrical engineering may reduce the contrast with other discipline and definition of electrical engineering degrees. All this makes it essential to redefine the major required courses that are considered as the foundation for an undergraduate electrical engineering degree. While changes in electrical engineering are being introduced, they raise concerns about the limits beyond which the changes lead to the complete loss of the original objective. This may result in a system that does not function as it was intended and that may not be adequate for what is expected. This paper is intended to discuss the main requirements for a typical electrical engineering curriculum that can absorb changes through a dynamic process while maintaining its integrity.

Introduction

The Hawthorne effect is named for a series of studies conducted from the late 1920s through the 1930s[1]. In its simplest form, the Hawthorne effect suggests that any workplace change makes people feel important and thereby improves their performance. This has been translated in the educational system to mean that changes in teaching approaches result in an excitement that promotes better learning. This simplistic view is not always accepted and it is difficult to believe that all these so-called new approaches in education are just for excitement. However, during the past few decades we have encountered a new approach to engineering education almost every year. These approaches have been simple, long term, expensive, inexpensive, direct, indirect, or just different. The results of these approaches have been published, buried, forgotten, and then rediscovered, or are still collecting dust in some engineering department storage room. The question still remains, is there any method of learning or teaching in engineering which is more effective than others or do we need to search for a new one? Meanwhile, the demands of technological advancement for new knowledge have prompted the addition of new courses and programs. This new stream of topics in the electrical engineering curriculum calls for new approaches in teaching, learning, laboratories, and requirements.

Generally, the new educational approaches have had two major objectives, which are, a. promoting the new techniques for learning enhancement and b. sugar-coating the traditional topics to increase student retention. There is no study available that shows any of these objectives has been meet or that the effort has caused any significant changes in undergraduate engineering education. Still, most of the courses are being taught in the traditional way and sugar-coating has resulted in watering down rigorous topics.

The methods of learning and transferring information among people have developed over many thousands of years and have very little room for expansion. The

procedure has been optimized over the centuries. The requirements for the best learning are well established and they are a qualified teacher who is willing to teach and a student who needs to and is willing to learn. This is probably the best we can ever do for our educational system. Besides, individual learning is a process internal to an individual and is inaccessible to teachers or anyone else. The only scientific study that indicates one's learning can be enhanced is known as "reinforcing the consequence[2]" which is beyond the function of engineering teachers and colleges. In engineering, as far as undergraduate studies are concerned, the best an institution can do is to provide the resources and environment for learning and let the students pick as much as they can or want. Therefore, the best learning enhancement tools are courses and related educational resources.

The Need for Core Requirements

In a typical undergraduate electrical engineering department there are core requirements and there are elective courses that are offered in the junior and senior years which allow specialization. The core requirements are supposed to cover the fundamental topics in the field that are essential in all areas of specialization and elective courses should provide specialization within the field. At the same time, the core requirements define the program and determine the department's objective. With established and uniform core requirements, the productivity of a department can be compared with other similar departments. Furthermore, the core requirements establish a turf and boundary of a department's operation and without it a department can very quickly turn into a general education organization. It is generally believed that the core courses must include the electrical engineering fundamentals needed to support students embarked in any area of specialization within electrical engineering. Such requirements must be general and should change constantly to accommodate new trends in technological development[3].

In many institutions the approach has been to develop a core of requirements for any area of specialization that has potential for expansion within the department. Areas such as microelectronics, optoelectronics, and computer engineering have been expanding at a rapid rate and in most schools, special core requirements for such specializations have been established. It is not clear how much longer any of these areas of specialization will stay popular and when they are not as popular, how the courses should be removed.

Of course, there are many other areas of specialization in electrical engineering where it is not clear what kind of core requirements are needed. Furthermore, developing an array of courses for any possible special interest would be impractical, if not impossible.

The argument against having core requirements is the fact that it appears such requirements are not relevant to many areas of specialization within electrical engineering. This makes it difficult to insist on topics that students may not need or want. If the students sense that the core requirement is merely an exercise that they must go through for their degree, their learning will be just enough to pass the course and make a grade. Therefore, the core requirements, while essential, must be in a form that accommodates new needs and rewards the consequence of learning. A periodic review of courses, the removal of topics that are not needed, and the addition of new concepts may produce a dynamic core requirement that addresses students' needs and technological expansion. Unfortunately, such a periodic review has its own inertia to change that produces many impassable obstacles. Furthermore, the core requirements in many institutions reflect local needs and cannot be dictated to be the same everywhere.

In recent years, mainly due to the job market and financial support, there have been many new options in electrical engineering. Although all these options may help our students get a more appropriate job at the end of their undergraduate studies, they have also raised the question of what are suitable core requirements for all these new options. The number of areas of specialization has increased and some have expanded to the extent that the core requirements no longer serve as a foundation for all areas of specialization. In some cases they are not even relevant.

Core requirement development is restricted by other parameters such as distance learning, international option, and student exchanges. While all these programs will result in enhancing knowledge and extending our services to areas that were not possible before, they also cause interface and management difficulties. Such programs require easy transfer of credit and equivalent educational requirements. All these make it essential, at least to some extent, to simplify the core requirement.

Criteria for Core Requirement

The most important consideration in core development is the fact that a four year engineering education

cannot give the student everything that may be needed for their career. We should assume that the students will continue to learn after their graduation and the engineering education should be a life time commitment. Therefore, it is not necessary to load up the curriculum with every possible concept that may or may not be of any consequence. This leads us to the concept of what students can learn. In our electrical engineering department, like many others, we are concerned about students' learning, their education, and our requirements. From what we understand from B. F. Skinner's theory of learning which is know as "reinforcing the consequence" [2], learning takes place whenever there is a reward or need to do so. Therefore, unrelated or un-needed topics with no relevance to the students' future does not re-enforcing any consequence and thus does not produce learning [3].

The core requirements must function as a road map that presents many options and lets the students pick the path which is best for them with as few restrictions as possible. Cross discipline courses and projects provide desirable expertise in today's job market and should be encouraged. In today's economy, there are job opportunities for all kinds of electrical engineers with a variety of backgrounds. Therefore, the undergraduate teaching must not be limited to an array of a pre-selected courses with a narrow point of view. Furthermore, we should expect that specific expertise beyond the core requirements, if needed, can be learned after graduation by job training and continuing education programs. If the students have broad and in-depth understanding of their field, acquiring such new expertise on the job will not be difficult and should be expected. This lead us to the fact that the cross-discipline and broad background education, probably, is the best service that we can provide for our students.

Adaptive Core Development

The major concern in the core requirements proposed here has been to introduce changes continuously without any major effect on the department's main objective. This proposed curriculum scheme is outlined in Fig(1). Included in this figure are the basic requirements which consist of mathematics and sciences courses and fundamentals courses that introduce students to electrical engineering. The social sciences and humanities courses are traditionally from a relatively large pool that is open for students to choose from. In this curriculum, the ABET requirement of design, computer utilization, math, sciences, and breadth and depth have been specified while the restrictions of following a specific track have been removed.

After fulfilling basic requirements during the freshman and sophomore years, students can take courses from a pool with three groups of courses. These groups contain a variety of courses that are cross-disciplinary. Each group provides one of the special ABET requirements of design, computer utilization, and breadth and depth. A course stays in the pool as long as there are enough students who want to take the course. As the popularity of course diminishes, due to changes in the job market or technological advancements, it will be removed or replaced. Such an approach allows for a continuous evaluation of course content and its relevance to job market. Furthermore, this approach results in an open market approach to course offerings which will foster special efforts to keep the content of the courses in the pool up-to-date and current.

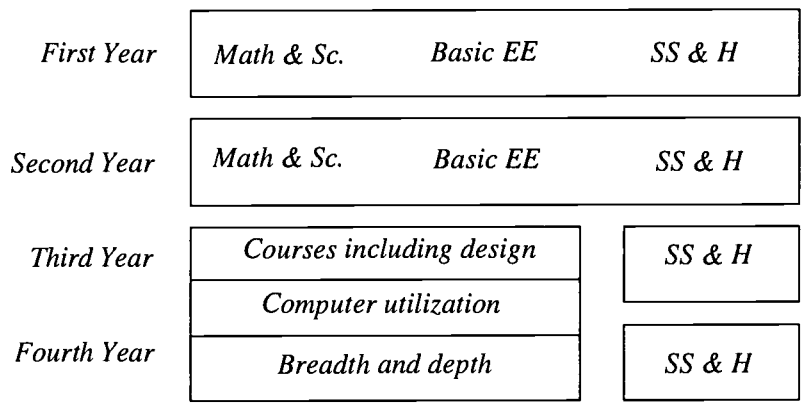
The pool, of course, contains all the courses that are offered for the junior and senior years in the electrical engineering and computer engineering department, some graduate courses that can be taken with departmental permission, and many courses from physics, chemistry, mechanical engineering, computer engineering, civil engineering, bio-sciences, and related subjects. This pool is divided into three groups which are design courses, breadth and depth courses, and courses that require computer utilization. Every student is required to take 20% of the first group, and 40% of the second group, and 40% of the third group. This way, while the ABET requirement is meet, options across many disciplines allow the students to make up a program which best suited to their objectives. We believe that such cross-disciplinary studies, if encouraged in all departments, will result in a better engineering graduate. The students choose to take courses within the pool that are most suitable or relevant to the job market or their individuals interests.

Conclusion

The advancement of science and technology has resulted in the introduction of many tracks in undergraduate electrical engineering studies. It is believed that in future there will be many more tracks and each will require special course offerings. The management of so many tracks for the granting of so many different BS degrees is very difficult and after a certain point, may be impossible. An electrical

engineering department should be concerned with comprehensive knowledge in all areas of the field, teaching along all the tracks, and encouraging course and curricula development in any new areas. But specifying a track with a specific core requirement is very difficult, if not impossible.

In this paper we have proposed a no-track core requirement which fits all possible specializations within the electrical engineering department. A pool with three groups of courses is proposed and the survival of each course in the pool is determined by student demand. During the last several years, many such courses have gained popularity among our students while many other courses have been removed because of the lack of interest from our students. The pool approach that is proposed in this paper allows open options and the fact that the content of the pool is pre-selected produces a control to maintain the electrical engineering departmental objectives and ABET requirement. We believe the pool approach is simple and is significantly different from other electrical engineering departments that have chosen to have completely open options[4].



Fig(1)

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Signature: Kasra Daneshvar

Printed Name/Position/Title: Kasra Daneshvar / Professor

Organization/Address:

Telephone: 704-687-4145

FAX: 704-687-2352

E-Mail Address: daneshvar@uncc.edu

Date: 03/19/2001