

Panel - Reforming Mathematics Requirements for a Modern Engineering Education

Rachid Manseur, Adrian Ieta, Zohra Manseur

State University of New York at Oswego, manseur@oswego.edu, ieta@oswego.edu, zmanseur@oswego.edu

Abstract - The need for reform in undergraduate engineering curricula has been recognized in recent years. One important and vital aspect of such a reform concerns preparatory mathematics in engineering education and the revision of mathematics content in a modern engineering curriculum, the topic of this panel session. It has become increasingly obvious that the standard series of three calculus courses followed by one course on differential equations is now obsolete and insufficient to provide needed mathematical skills for a modern engineering education. ABET now requires discrete mathematics and applied statistics among other topics. Newly developed engineering programs have adopted different mathematics courses in their degree programs. A new electrical and computer engineering program is under development at the State University of New York at Oswego where a modern engineering curriculum must also face the challenge of smooth integration within the existing traditional curricular organization of a public university. The panelists will discuss the evidence in support of reform and engage discussions on directions, course content, and other issues for a successful revision of engineering education.

Index Terms – revision, modernization, mathematics content, engineering education.

INTRODUCTION

Mathematical skills are vital to learning engineering and too many important areas of mathematics, clearly needed for a thorough understanding of important engineering concepts, are simply left out of the curriculum due to time and content limitations. Among these topics are linear algebra, complex functions and variables, vector analysis, numerical analysis, discrete mathematics, and applied statistics to name a few. On the other hand, careful review of current mathematics support courses reveals that many covered topics have minimal relevance to engineering especially when considered within particular disciplines in engineering. Another aspect that will be addressed is the role of modern computation tools such as advanced calculators with numerical and symbolic computation software that may help streamline mathematics content in undergraduate courses. The panel presentations concentrate on Electrical and Computer Engineering programs to show the need for reform and discuss possible approaches to improving math content within engineering education including revised

mathematics prerequisites and insertion of mathematics content within engineering courses.

MAIN TOPICS

This discussion is based on a review of mathematics education needs for adequate support of an engineering curriculum. Each engineering course builds on pre-requisite knowledge in mathematics that is determined by the course contents and its major topics. In doing so, a program of study in mathematics that satisfies the educational objectives of a modern and innovative engineering program can be established. This review of mathematics requirements for engineering education becomes even more important in light of the competition in a global economy where engineering graduates must compete within a skilled workforce trained in educational systems that emphasize mathematical skills and engineering training to a larger extent. Several studies indicate that engineering students in the US do not have adequate mathematical skills for engineering studies at the freshman level [1]-[3], a situation that reduces their competitiveness within the global economy.

TO REFORM OR NOT

The first question to be addressed in this session is whether the mathematics content in today's engineering curriculum is adequate. An opinion in favor of reform is clearly expressed in the following quote from the Millennium Project:

“Clearly the engineering curriculum needs a major overhaul. To some degree, this will require modernizing the approaches to science and mathematics instruction, e.g., recognizing that discrete rather than continuous mathematics is the foundation of the digital age, ... and new scientific concepts and tools have made obsolete much of the traditional curriculum”[4].

GOALS AND OBJECTIVES

A naturally connected question is then whether a curriculum can be developed with mathematics courses that improve the scope and quality of a modern engineering education. The goals of the mathematics components of the curriculum must satisfy four broad conditions:

1. All the mathematics skills needed in the engineering curriculum are covered;

- The mathematics content adequately supports the engineering program's objectives;
- Engineering students acquire mathematical knowledge and skills that enhance and facilitate their learning in engineering.
- Students are enabled to effectively use modern computing tools in solving engineering problems.

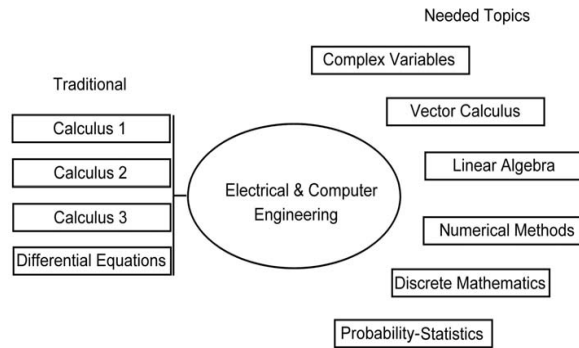


FIGURE 1.
MATHEMATICS IN AN ECE CURRICULUM.

PANEL DISCUSSION TOPICS

The panelists presentations will address the four topics of discussion presented here.

I. Inadequacies of the traditional curriculum

Figure 1 contrasts the traditional mathematics content within an electrical and computer engineering curriculum and some mathematics area that are needed yet not covered. Many engineering schools offer a one-course-sequence-fits-all series of courses in mathematics due to limited resources. The traditional series of three calculus courses and differential equations has been a feature of engineering and science education in many schools for well over a century. However, engineering science and mathematics have undergone many changes, including the developed of tolls and techniques, that have rendered certain mathematics topics obsolete and others more important.

II. Description of a modern curriculum

A modern engineering curriculum can be designed and implemented in many different ways. A few mathematics courses can be developed or modified and inserted within the curriculum to improve and facilitate learning. However, there are mathematics topics that can be more effective if taught or reviewed as part of engineering courses where they are most needed. This is an important issue for discussion in this panel session.

III. Curricular Constraints

One major constraint in reforming mathematics within an existing curricular infrastructure is the limited number of credits allocated to mathematics. Engineering curricula are

designed to be completed within a four year period and a bounded number of credits. Furthermore, general education requirements include a set of courses that take up a sizable portion of the curriculum. Increasing the number of mathematics courses must come at the expense of reducing courses in other areas of the curriculum. Most if not all of the work in reforming mathematics content in engineering education must therefore be based on modification and optimization of existing mathematics courses.

IV. Modern Tools in Computing

During the last decade, hardware and software computing tools have progressed to include symbolic as well as numerical computations and graphing capabilities. Such tools were not available when the traditional curriculum was established. An important aspect of reforming mathematics education consists in the integration of these modern tools and a possible shift from computational methods to conceptual methods and application of mathematical analysis to problem solving. This topic is the subject of heated discussions within academia and will be discussed in this panel session as well.

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AUTHOR INFORMATION

Rachid Manseur, Director of Engineering, Computer Science Dept., SUNY Oswego. manseur@oswego.edu.

Adrian Ieta, Physics Dept. SUNY Oswego. ieta@oswego.edu

Zohra Manseur, Mathematics Dept. SUNY Oswego. zmanseur@oswego.edu.