EE and ME – Together Again

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Abstract

An unfortunate premise is that neither the undergraduate Electrical Engineering (EE) nor the Mechanical Engineering (ME) degree programs can accommodate within their curriculum substantive ME or EE courses. This appears to be so because both the EE and ME disciplines are rigid within their threads and prerequisites. Yet there is a natural intersection between EE and ME for professional opportunities in the 21st century. To break this seeming impasse an interdisciplinary program of study between EE and ME has been initiated as one aspect of a General Engineering (BSE) degree with plans of study for Electromechanical Engineering and Energy and Power Engineering. These initiatives for interdisciplinary study between EE and ME have been introduced before but seem to have not been pervasive. Described here is the path that can be taken in the development and the pitfalls to be avoided in establishing such an interdisciplinary Engineering program garnered from the experience.

Where We Were

The Electrical Engineering (EE) discipline was once embellished with a significant number of Mechanical Engineering (ME) courses suitable for between-the-world-wars technical training[1]. Even as late as the 1960s EE students were required to take ME courses in statics, dynamics, materials and thermodynamics[2]. Although the 1960s was the incipient age of solid-state electronics, EE students also took compulsory courses in electric machinery and power transmission.

The rapid development of digital logic integrated circuits and the microprocessor in the 1970s shifted the extent of the EE curriculum away from these courses. Accelerating the shift were new topics such as microelectronics, probability and statistics, digital signal and image processing and digital communications and control. The result is that most, if not all, EE curricula today do not feature any substantive required courses in ME.

Bringing It Together

The integration of courses from another Engineering discipline into an undergraduate degree program seems to be fraught with difficulties. The faculty from each discipline is concerned those requisite courses define the degree program and that other courses can only be approved electives. Although a typical curriculum could include as many as three Engineering elective courses, the advising suggestion that predominates for such courses is only those from the discipline. This is especially endemic when preparatory and prerequisite courses are considered within an Engineering degree program.

EE courses such as electromechanical systems and power generation and transmission require an EE degree course in electromagnetics and transmission lines. ME courses such as heat and mass transfer and renewable and alternative energy require ME degree courses in dynamics, the mechanics of solids and fluids and thermodynamics. Thus within the confines and restrictions of the available Engineering discipline elective courses there is no opportunity for effective interdisciplinary undergraduate study.

ABET baccalaureate accreditation provide Criteria for Engineering, Engineering Physics, Engineering Science and General Engineering programs. After review, consideration and discussion the College of Engineering at Temple University sought a degree program under the General Engineering Criteria since this would provide identification seemingly not in conflict with existing Engineering discipline degree programs and flexibility in the plans of study.

Engineering, Engineering Physics and Engineering Science Criteria degree programs, of which there are 74, are often appropriately situated at smaller institutions which do not offer Engineering discipline degree programs or, as is sometimes the case, at larger institutions with multiple Engineering discipline degree programs. In the former case, the programs provide, as the name indicates, a creditable Engineering education but not in a discipline. In the latter case, these degree programs seem to be lost in the torrent of Engineering discipline degree programs. On occasion, worst yet, they are not even accredited or are promoted despairingly.

General Engineering Criteria degree programs, of which there are 19, are further identified by names that signify their technological orientation, such as Renewable Energy Engineering, Textile Engineering, Plastics Engineering and Robotics Engineering. Here, though, the College of Engineering has chosen the General Engineering Criteria and not named degree programs as an incipient manner to nurture the program. However, there remains the possibility of such designated degree program names at some point. This distinction, although subtle, seems to resonate well with the concept of interdisciplinary study and engenders the necessary cooperation from the established and accredited Engineering departments. The program is identified as General Engineering (BSE) in the College with a common curriculum and plans of study.

Setting It Up

Although General Engineering programs are sometimes offered in a separate academic department, this interdisciplinary degree was established with a Program Director and administered in the College of Engineering, rather than within either the Electrical and Computer Engineering (ECE) or Mechanical Engineering Departments by its Chair or designee. Only existing courses in ECE and ME were integrated into the plans of study for the degree. This assures compliance with the criteria for accredited Engineering baccalaureate programs and utilization of existing assessment activities for the program educational objectives and student outcomes. The College of Engineering at Temple University has four academic departments, including the Department of Civil and Environmental Engineering (CEE) and a newly establish Department of Bioengineering (BE).

The Director of the General Engineering degree program has the responsibility to insure all aspects of the Program including continuous improvement of the interdisciplinary curriculum. The Director is also the single interface between the Program and industry for co-operative work study assignments, internships, capstone design projects and professional employment. Providing an identified Director on point assures that the General Engineering degree maintains visibility and creditability within the College.

Faculty advisors from both ECE and ME provide support for appropriate course selection, seamless integration and continuing professional development. This was important for success

because once the interdisciplinary program was promulgated there were a significant number of transfers by undergraduate students from the EE and ME degree programs.

The curriculum for the General Engineering degree program features a common freshman year with the EE and ME degree programs. Students are advised throughout their first two semesters of all the degree programs available in the College and make a selection at that point. The core curriculum for all degree programs in the College includes mathematics and basic science, social sciences, humanities and communication courses, introduction to Engineering and the capstone senior design. Unique to the General Engineering degree program though are requisite courses in macroeconomics, Engineering economics and human resource management.

Plans of Study

The General Engineering BSE degree program offers plans of study, and not named degree programs or concentrations, based upon the charter of its establishment encompassing the fundamentals of Engineering. This provides the flexibility to develop interdisciplinary programs that are relevant to industry and attractive to students.

The General Engineering plan of study in Electromechanical Engineering (EME) emphasizes all aspects of electromagnetics, transducers, sensors, electronics, digital processing and mechanical principles to integrate these components into electromechanical devices and systems for automated manufacturing processes. Professional employment includes the analysis, design and installation of robotics and automation for diverse industries.

ME courses in this plan of study follow the thread of graphics, statics, dynamics, the mechanics of solids, dynamic systems and machine theory and design. EE courses follow the thread of computer programming, digital design, circuits, electronics, electromagnetics, electromechanical systems and microprocessor systems.

The General Engineering plan of study in Energy and Power Engineering (EPE) emphasizes all aspects of electrical power and mechanical energy innovation in energy generation and delivery, alternative resources, and efficient devices. Professional employment includes the control of large utility system energy and transmission and the design and deployment of alternative energy sources.

ME courses in this plan of study follow the thread of statics, dynamics, thermodynamics, dynamic systems and renewable and alternative energy. EE courses follow the thread of computer programming, circuits, electronics, electromagnetics, electromechanical systems, power engineering and electronics and photovoltaic.

Both the General Engineering BSE degree program EME and EPE plans of study have 54 semester hours of Engineering and technical courses, approximately equally distributed between EE and ME. There are two technical elective courses and a free elective.

All Engineering degree programs in the College require the Freshman *Introduction to Engineering* course and the capstone *Engineering Seminar* and *Senior Design Project* sequence. The General Engineering BSE degree program complete plans of study can be viewed at the College of Engineering website: http:// http://vader.eng.temple.edu/general-engineering/

Keeping It Going

The basic concept of interdisciplinary study, especially between the naturally related subdisciplines of EE and ME in electromechanics and energy and power, is not unique[3]. Unfortunately, nurturing such an interdisciplinary program can be more problematic. One pitfall seems to be the establishment of a separate academic department to provide the degree program. This engenders the inevitable conflict for resources. Here the General Engineering degree program in the College utilizes existing courses and Faculty and its Director consults regularly with the EE and ME Program Directors. Although the EE and ME Program Directors are often, but not always, Chairs of the Departments, in this sense the Director of the General Engineering degree program can focus on academic and not administrative concerns.

Interdisciplinary degree programs with a variety of models of execution have been studied in research in Engineering education[4, 5, 6]. The developing perception of students in interdisciplinary course work is significant to the overall success of the degree program. The relationship of the subdisciplines of EE and ME as electromechanics and energy and power in course work must go beyond the proverbial *pressure is voltage*, *current is flow* (force-voltage, velocity-current) analogy. Since ME students, generally, are still required to take the *EE for MEs* course the analogy can be infused into ME courses quite naturally.

Unfortunately, the reverse, the *ME for EEs* course, is not endemic and infusing mechanics into such EE courses as electromechnical systems and control theory remains challenging. Research in Engineering education has identified perhaps the key barriers to interdisciplinary study[7]. Students apparently lack the ability to provide the salient connections between and understanding of the contributions of various disciplines[7].

The interdisciplinary General Engineering BSE degree can be the impetus for this sea change which can benefit all Engineering degree programs. The institution of a new *ME for EEs* course, actually termed *Mechanical Systems*, as a requisite for all EE students has been identified and is being pursued as a result of the discussions on the interdisciplinary Engineering curriculum.

Selling the Program

Of course, the EME and EPE BSE degree programs are not meant to be the equivalent of the defined discipline BSEE and BSME programs, nor should they be. However, for professional careers in the areas addressed specifically by these programs the prospects for employment and success can be arguably presented as quite reasonable. EE and ME students, although well or perhaps overly prepared within the disciplines, are not equipped with the basic tools needed to, in an often heard employment mantra, *hit the ground running* in interdisciplinary EME and EPE applications.

Further Engineering study for these students in the EME and EPE BSE degree programs could certainly include additional undergraduate and graduate courses in EE and ME since they have had the prerequisites courses in the disciplines. It does seem somewhat incongruous to expect a post-baccalaureate Engineering student to take graduate courses in a discipline for which there is no undergraduate precedent.

Finally, with the curricular structure of the BSE degree programs in EME and EPE in which only existing EE and ME courses are utilized, the General Engineering degree program seems to

exhibit no unreasonable constraint on attracting students. Recent freshman enrollment data in the College show that as many entering students have selected the plans of study in the interdisciplinary General Engineering BSE degree program as those in the BSEE and BSME degree programs combined. This is a startling and unexpected result. In interviews and surveys of these freshmen, the reason seems to be the attraction of programs with names for the plans of study that are non-traditional and with defined professional employment.

ME degree programs, for example, often have a concentration in mechatronics or energy systems but within the discipline. Although creditable programs, these curricula usually do not provide significant interdisciplinary studies in EE. The General Engineering BSE degree program addresses this shortcoming.

Assessment – A Work in Progress

Following the plan outlined by other studies in Engineering education[4, 7], the assessment of this interdisciplinary approach can be marked by tangible results. These include internships and co-operative education assignments in electromechanics and energy and power and in improvement in the performance of interdisciplinary capstone senior design projects. Relationships with targeted industries and government agencies can be enhanced. However, definitive results remain a work in progress as the General Engineering degree program is nascent.

The imperative call for interdisciplinary projects in the capstone senior design project from past experience meant bringing together EE and ME students on a team. Unfortunately, the barrier to interdisciplinary applications is usually quite evident in the performance of those teams across the Engineering disciplines[7]. Preliminary indications are that students in the General Engineering degree program are well suited to contribute to focused design projects in electromechanics and energy and power.

Observations

The College is committed to the continuing development of the General Engineering degree program in essence because it requires no additional resources yet affords another opportunity for students to excel and met the demands of professional employment. The response of the constituents of the interdisciplinary program has been encouraging. The three requisite courses in economics and management again differentiate the General Engineering degree program within the College and also resonates well with potential employers.

These interdisciplinary plans of study in the General Engineering program between EE and ME also have engendered optimism for a reversal of the trend of the decline in enrollment in the EE program. The General Engineering degree program also now includes plans of study in Electro-optical Engineering with Physics and Hardware and Software Engineering with Computer and Information Sciences to the benefit of the EE program.

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