The Context of Change in Engineering Curriculum

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Introduction

The current world-wide trend in engineering education has been to identify the function of engineering education and knowledge as the product of its universities with the public and industry as its customers and engineering graduates as its product carriers.

It is the aim of engineering colleges to provide their students with a foundation of knowledge in science, basic theory, and technical subjects as they prepare for their real-life counterparts. Practitioners believe that the workplace requires graduating engineers to have many basic skills including the ability to work on a team and to communicate with one's peers and supervisors. In addition, there is need for the capabilities of utilizing information technology, focusing on customer and societal needs, as well as ethical and environmental concerns, and understanding global needs and market forces. Therefore, the focus of engineering education should be on the immediate applicability of the engineering knowledge to the end user.

Due to system constraints, university faculty find it difficult to remain focused on anticipating the future needs of engineering curricula. Faculty members must continually distribute their time among teaching, research, and publishing. When universities demand that faculty bring in research dollars as well as be excellent classroom performers, then the faculty must devote time and energy to these areas, which robs them of time to search for the real-world commercial needs for balancing theoretical and practical skills among graduates. The pressure to become tenured and to bring in large research dollars forces the faculty to maintain low student contact time. Often, due to the low salary scale for tenured faculty, outside consulting work is taken which again robs their schedule of time for student contact and for updating knowledge to share in the classroom. Peer pressure and competition among faculty, along with a belief that faculty receive most of their professional recognition from publishing papers and winning grant awards, are problems associated with the lack of balance between teaching, research, and publishing efforts. Yearly evaluation of faculty by department chairmen which emphasize such areas as number of publications, dollar amounts of research, and university and community services serve to sidetrack faculty from focusing on the real issues of21 st century engineering education and the context of change in engineering curriculum toward being more responsive to end users (society, industry, government, world-market, etc). Due to this bottleneck of demands on faculty time, there is also a lack of communication between employers and faculty. Faculty cannot gain enough time to spotlight attention on attuning the engineering curriculum to future markets.

In this paper the author directs the reader's attention to some of the problem issues as well as some engineering curriculum proposals that could help make the curricula more responsive to the growing demands of 21st century society.

Degree Funding and Credit Hours Reduction

In Florida over the past several years, the legislature, Board of Regents, and universities have worked on a variety of programs to improve the efficiency and accountability of university education. The most recent measurement shows that an average student in Florida's public universities take, about 24 credit hours beyond those required of a final degree. [1]

A reasonable balance between the student's need for education exploration and the state's need for greater access for all its citizens to higher education gives the student extra hours up to 10% of those required for their degree at the state's expense. The cost of "excess" hours beyond 10% will become the responsibility of students and universities. In Florida, for the first three excess hours beyond Degree Funded hours, the student pays 25% of the direct cost of instruction (about $15 per credit hour) and the university pays 75% of the cost (about $45 per credit hour). For the second three hours, the student pays half and the university pays half ($30 per credit hour). With the third three hours of excess credit, the student pays 75% of the cost ($45 per credit hour) and the university pays 25% ($ 15 per credit hour). After nine excess hours, the student pays 100% of the direct cost of instruction or about $60 per credit hour for all additional excess hours. [1]

In general, the problems are to identify the real engineering enrollment, effective student advising and existing curriculum policies. For example, in some institutions the policy is to admit engineering students to the College only after they have completed 60 hours. In Florida, a study by consultants recommends that all Florida State University Systems (SUS) engineering schools "take vigorous action to implement the educational reforms. . . . These reforms include the introduction of freshman engineering design experiences and the integration of mathematics, basic science, and engineering science instruction throughout the curriculum. The freshman engineering students at the University of Florida should be admitted directly into the College of Engineering if they meet appropriate admission standards."2

What Other SUS Engineering Colleges Are Doing

While the University of Florida (UF) is offering a pre-engineering lower division program (mainly math, physics, chemistry, general education, and communications courses), other SUS engineering colleges are incorporating a variety of engineering subjects in their freshman and sophomore years. For example, the University of South Florida (USF) includes the following courses in its lower division program: Engineering Orientation, Statics, Electrical Systems I, Computer Tools for Engineers, Thermodynamics, Introduction to Linear Systems, Instrument Systems I, Introduction to Process Engineering, Introduction to Electrical Systems, Engineering Economy, and Dynamics. The University of Central Florida (UCF) offers: Statics, Engineering Economic Analysis, Dynamics, Surveying, Engineering and Environment, Thermodynamics-Fluids, Engineering Analysis, Principles of Electrical Engineering, Introduction to Digital Circuits, and Introduction to Computer Engineering. The colleges of engineering at Florida International University (FIU), Florida Atlantic University (FAU), and Florida A&M University/Florida State University (FAMU/FSU) also offer engineering courses at the freshman/sophomore level. Their menus are not as extensive as those at USF or UCF, but they still serve to introduce the practical dimensions of engineering the lower division.[2]

Table 1 presents a survey of the number of credit hours for a bachelor of civil engineering degree. The survey was performed by Dr. Paul Thompson, Chairman of the Department of Civil Engineering at UF.

Table 1. Survey on Number of Credit Hours for Bachelor of Civil Engineering Degree

Program	Contact	Telephone	# Semester Hours
Auburn University	Joe Judkins	(205) 844-4320	136 (204 QHrs)
Clemson University	Russ Brown	(803) 656-3002	139
University of Colorado	Stein Sture	(303) 492-3276	128
Cornell University	Dr. Meyburg	(607) 255-3690	133
Georgia Tech	Mike Meyer	(404) 894-2202	134 (201 QHrs)
University of Illinois	Neil Hawkins	(217) 333-3815	133
University of Kansas	Stan Rolfe	(913) 864-3766	132
University of Maryland	Jim Colville	(301) 405-0380	132
University of Michigan	Ben Wylie	(3 13) 764-8495	128
Michigan State	Brenda	(517) 355-5107	128
Minnesota	Steve Crouch	(612) 625-4080	128 (192 QHrs)
University of Missouri (Rolls)	Dianne	(3 14) 341-4400	139
Ohio State	Jill Collins	(614) 292-7338	134 (200 QHrs)
University of Oklahoma	Ron Sack	(405) 325-5911	135
Penn State	Chin Kuo	(814) 865-8391	132
Purdue	Vince Drnevich	(3 17) 494-2159	133
Texas A & M	UG Office	(409) 845-7436	136
Virginia Polytechnic Institute	Bill Knocke	(703) 231-6635	136
University of Wisconsin, Madison	Lynn	(608) 262-3542	131
West Virginia University	Sam Kiger	(304) 442-3391	135
Massachusetts Institute of Technology	Trend Kaalstad	(617)253-2117	120
University of Pittsburgh	Raider	(412) 624-9870	134
University of Texas, Austin	Mike Walton	(512) 471-1414	124
North Carolina State	Downey Brill	--	120
University of California, Berkeley	..	--	120
University of Florida	Paul Thompson	(352) 392-0537	136

Table 2 presents credit-hour requirements for UF engineering programs. This data was prepared by W. Viessman, Jr., Associate Dean for Academic Programs in the College of Engineering at UF. The compilation is for projected program hours for the 1996-97 catalog.

Table 2. Credit-Hour Requirements for UF Engineering Programs

Program	Required Hours					Sus Maximum
	1992-93	1993-94	1994-95	1995-96	1996-97	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Aerospace Engineering	136	135	133	131	127	127
Engineering Science	136	133	134	132	128	128
Agricultural Engineering	136	135	136	134	128	128
Chemical Engineering	143	141	141	137	134	134
Civil Engineering	145	139	139	136	131	131
Surveying and Mapping	127	127	127	125	120	120
Computer Engineering	135	128	128	126	126	126
Electrical Engineering	129	128	128	126	126	126
Environmental Engineering	134	130	130	125	122	125
Industrial and Systems Engineering	138	134	134	132	125	129
Materials Science and Engineering	136	135	136	126	128	125
Mechanical Engineering	136	131	131	128	128	128
Nuclear Engineering	132	132	132	126	126	126
Nuclear Engineering Sciences	135	134	134	130	123	126
Averages	135.6	133.0	133.1	129.6	126.6	--

Columns (2),(3),(4),(5),(6) = hours required for graduation

Note: Hours in column (6) are projected for 1996-97
Hours in column (7) are Florida State University System (SUS) recommended exception levels

The Curriculum Transforming Context

In general, each departmental unit must look at their existing baccalaureate program and downsize the curriculum without sacrificing the quality and the end product. It should be our national agenda to start the process of enhancing the education quality of freshman engineers before admission. How can this be accomplished? The foundation of this process can be a partnership between industry, high schools and universities. The partnership must work together to help bridge the gap between the abilities of high school graduates and freshman engineering students so that they can start without requiring extra courses beyond the framework of the established credit hours. Colleges across the country can work in partnership to enhance kindergarten through twelfth grade (K-12) schools in the area of math, science and engineering. The earlier K-12 preparation would remove the burden on university educators of bringing many students up to speed before progressing to true college-level material. One suggestion is to identify students interested in engineering earlier and work with curriculum modification from the 10th grade. Once these better-prepared students are admitted as freshman engineers, they can graduate within the context of established total credit hours. In other countries such as

Japan, France, and Germany upwards of 3,100 hours of core academic time during the final four years of a secondary education is required, while the U. S. average is less than half this amount.[3]

In order to create this needed alliance, "each engineering college, with local industry, should partner with at least one local school on the K- 12 level. The aim is to improve mathematics and science instruction, provide role models, and give students and teachers a greater understanding of engineering's role in society."4

Attuning Engineering Curriculum to Future Markets

Once the gap between K-12 and engineering curriculum is lessened, then we can modify each existing department engineering curriculum model to include courses to build communication skills, technical writing skills, and to insert the team approach in various courses including design.

One model suggested by F. A. Kulacki and Evan C. Vilachos seems an interesting alternative curriculum proposal. Figure 1 is adapted from their model.[5] The Kulacki idea has the following conceptual framework: 1) focal study areas would require a four-year, integrated plan of study which would be developed by the second semester of the engineering program; 2) courses within each study plan would necessarily come from limited populations across the institution, but would be selected to provide significant writing experiences in each year of the undergraduate program; 3) focal study areas would require more than introductory courses, hereby leading the student to material generally reserved for the third and fourth years of study for majors in the humanities and social sciences; 4) fourth-year courses would be selected so that students would experience considerable verbal communication in the discussion of major texts and authors.

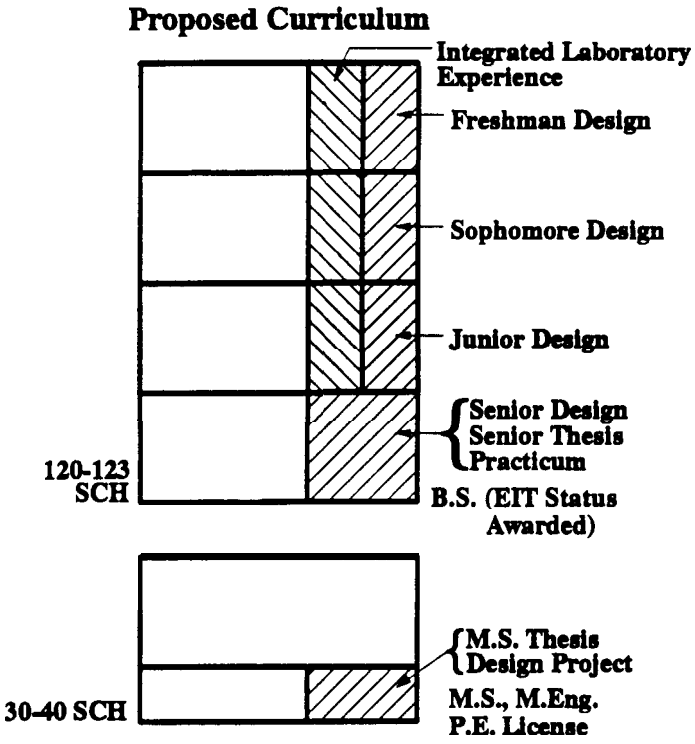

Figure 1. Proposed Curriculum and its Articulation With Post-baccalaureate Study

The registration and licensing of engineers can, we believe, be efficiently accommodated within the proposed restructured curriculum. First, we propose that the status of Engineer In Training (EIT) be granted to graduates of the undergraduate program on the basis of the reformulated program of study which brings into better balance information, judgment, and practice through the four years of study. Graduates who enter industry with the baccalaureate degree would not be disadvantaged in the professional sense, and they would enter practice with a motivation to continue their education and become fully licensed. At the conclusion of a master's degree program and an appropriate examination process coupled with an educational outcomes assessment, the Professional Engineer license could be awarded. To maintain the license, the graduate engineer would be required to complete a limited number of post-collegiate courses in engineering and/or scientific subjects on a continuing basis. This scheme will provide some assurance that the engineer's technical skills are maintained and upgraded and that career growth can be a shared responsibility of the individual and the employer. [5]

Conclusion

The trend is downsizing and restructuring the engineering curriculum. The total credit-hours limit established at UF seems reasonable at this time. We must include in curriculum a framework to satisfy the end users (or customers). The end users require from engineering colleges graduates educated with a broad technology base and transferable skills such as communication, information technology, business understanding and foreign language competence. This can be accomplished at an earlier stage with industry/high school/university partnerships. In addition and as part of curriculum, industry and government could assist college students by providing two to three months of work experience following completion of a student's third academic year.

A new curriculum must be end-user responsive. Students need to understand:

- the political process
- personal finance
- fundamentals
- business plans
- office management and computer skills
- legal and ethical issues
- the need for independence and entrepreneurship; and
- how to work as a team and develop team skills.

There is a sense of urgency to undertake the planning of new curricula. Society is demanding improvements in undergraduate engineering education and it is time for us as educators to be accounted for and be more responsive to the forces of change.

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