A REFLECTION ON CHANGES IN ENGINEERING EDUCATION IN THE LAST 40 YEARS

Amir Karimi

Mechanical Engineering Department
The University of Texas at San Antonio
akarimi@utsa.edu

Abstract

In the last 40 years, there have been many changes in how students are being educated. Many new engineering topics have been added in coverage of each engineering course. New degree programs have been created and new tools and resources have become available for teaching and learning engineering subjects. Even though there are more materials being covered in many engineering programs, the number of semester credit hours required to obtain an engineering degree has been reduced in recent years. In 1970's the first year and half to two years of curriculum was common among all engineering programs. Today only some of the math and science degree requirements are common among various engineering programs, even though there is a great deal of talk about multi disciplinary and team work. In 1960's and 70's all engineering students took the same course in introduction to engineering, but now that course is specialized for each discipline. All engineering students took a common graphic course, but now may engineering disciplines do not even require a course in engineering drawing. This paper will describe the reasoning for some of these changes and reflects on the positive and negative aspects of these changes.

Introduction

There have been many changes occurring in the society in the last 40 years. These changes affected how businesses operate and how people function at home and work. The new technologies have influenced social engagement, entertainment, communication methods among individuals, shopping habits, and searching for information. For example, two decades ago most social activities were face to face, people were communicating by writing letters or talking on the phone, bought goods by going to stores, and searched for information by going to the library. Today, many social activities are carried out through social media (Facebook, twitter, etc.), communication is done through e-mail or text messaging, increasingly most shopping is done on-line, and information is sought through internet searches. Also in recent years, engineering education has been undergoing many changes, even though there has been a great deal of talk that higher education institutions have been very slow in reforming the way students are being educated. During the last 40 years the number hours required for an engineering degree has been reduced. Some course requirements have been removed and new ones have been added. In early 1970's, the first year and half to two years of engineering requirements were common among all engineering programs; today each program requires its specialized courses during the first two years, with exception of a few mathematics and science courses. The method of delivery of lectures has been gradually changing from purely using a blackboard to using power point presentations for visual aid, providing videos, posting lectures and other learning resources on-line. The textbooks have increased the number of solved example problems and providing other learning resources. This paper briefly discusses these changes and uses the author's personal perception on how these changes have affected engineering education positively or negatively.

Summary of Major Changes

The following sections provide a summary of major changes occurred in engineering education.

Number of Semester Hour Degree Requirements:

In the early 1970's a typical engineering program required a minimum semester credit hours (SCH) of course work ranging between 134-140. For example, the author's undergraduate engineering degree from the Oregon State University in early 1970,s required 204 quarter semester hours (equivalent to 136 SCH) of course work. With the expansion of new knowledge and technical development, engineering programs had to revise their program by removing some requirements and adding new one. In many cases this resulted in increasing the total SCH required for the engineering degrees.

The University of Texas at San Antonio began offering its first engineering programs in the fall of 1982. These programs included three engineering programs in civil, electrical, and mechanical engineering. The initial civil engineering and electrical engineering programs, each, required 136 SCH of course work and the mechanical engineering program required 137 SCH of course work [1]. By 1989 the number of SCH required for each engineering program was increased to 140 hours [2].

Starting in early 1990s engineering programs became under increasing pressure by external forces to reduce the number of hours required for a degree. For example, in 2005, the Texas Legislature enacted Texas Education Code (TEC) 61.0515, which put a limit on the number of SCH public universities can require for the completion of baccalaureate degrees [3]. Accordingly the Texas Higher Education Board (THECB) asked universities to provide justification for offering undergraduate degrees that required more than 120 SCH. For various reasons, including the reason for ABET accreditation, engineering programs have been allowed to offer degrees exceeding 120 SCH. However, most engineering programs have reduced the number of SCH they require for the completion of an undergraduate degree. Table 1 provides a list of institutions in Texas offering engineering degrees. The list includes almost all the universities offering engineering degrees in

Texas. It provides information on the number of engineering degrees being offered, the type of engineering degrees, and the range of SCH required by the degrees offered at each institution. The most recent on-line catalog available on each institution's website was used to include information in Table 1.

Table 1. List of universities in Texas offering engineering degrees and the range of minimum SHC required for the degrees offered

University	**No. of Programs**	**Types of programs offered#**	**Minimum SCH required (range)**
Baylor	3	EE and CompE, ME, Engineering	129
LeTourneau	1	Engineering (different emphasis or concentrations)	130-137
Midwestern State	1	Engineering	131
Rice	7	BioE, ChemE, EE, CompE, CE, EnvE, MatE and NanoE	124-134
Saint Mary's Univ.	6	Engineering Science, EE, CompE, Engr. Management, IndE, SoftE	124-133
Texas A&M-College Station	13	AeroE, Biological & aglicculturalE, BioE, ChemE, CE, Comp E, EE, IndE, ME, NE, Ocean E. PetE, RadiologicalE	128-134
Southern Methodist Univ.	5	CE, Env. E, Comp.E, ME	125-126
Texas A&M-Corpus Christi	1	ME	130
Texas A&M-Galveston	1	Maritime System Engineering (Offshore and Coastal system Engineering	137
Texas A&M-Kingsville	6	ArchE, ChemE, CE, Comp.E, EE. ME	128-132
Texas A&M-Prairie View	5	ChemE, CE, CompE EE, ME,	126-135
Texas Christian University	1	Engrineering	130-131
Lamar University	5	ChemE, CE, IndE,ME	124-136
Texas State University	3	EE, ManufE, IndE	132-137
Texas-Tech University	8	ChemE, CE, CompE, EE, ConstructionE, IndE, ME, PetE	129-132
Trinity University	1	Engineering Science (various options)	129
University of Houston	7	BiomE, ChemE, CE, CompE, EE, IndE, ME	127-131
Univ.of Houston-Clear Lake	1	CompE	132
University of North Texas	5	BiomE, CompE, EE, MatE, ME	120-128

University	No. of Programs	Types of programs offered#	Minimum SCH required (range)
UT-Arlington	8	AeroE, BioE, CE, CompE, EE, IndE, ME, SoftE	120-130
UT-Austin	9	AeroE, ArchE, BioE, ChemE, CE, EE, ME, PetE, GeoSysE	125-133
UT-Brownsville	1	Engineering Physics (various options)	134-136
UT-Dallas	6	BiomE, CompE, EE, ME, SoftE, TelecommE	123-128
UTEP	6	CE, CompE, EE, IndE, ME, Met-MatE	120-128
UT-PanAm	5	CE, CompE, EE, ManufE, ME	125-127
UT-Permian Basin	2	ME, PetE	126
UTSA	5	BiomE, CE, CompE, EE, ME	125-128
UT-Taylor	3	CE, EE, ME	128
Univ. of Incarnate World	1	Engineering Management	133

\# AeroE = Aerospace Engineering, ArchE = Architectural Engineering, BioE = Bioengineering, BiomE = Biomedical Engineering, ChemE = Chemical Engineering, CE = Civil Engineering, CompE = Computer Engineering, EE = Electrical Engineering, IndE = Industrial Engineering, ManufE = Manufacturing Engineering, Mat = Materials Engineering, ME = Mechanical Engineering, MetE = metallurgical engineering, SoftE = software Engineering

Table 1 suggests that the majority of institutions have reduced the number of SCH required for their engineering programs offered to less than 130 SCH.

The major benefits resulting from the reduction of SCH requirements for the degrees are the potential for reducing time for students to graduate and reducing the cost of receiving an engineering degree. But the reduction in the SCH requirements has also resulted in the elimination of few important courses that, in author's opinion, were providing students a broad educational experience.

Table 2 compares the mechanical engineering degree requirements offered in 1989 at UTSA with those currently being required. None science and math core (general education) requirements are excluded from the table. Reducing the number of SCH degree requirements and, at the same time, adding more modern topics to the program posed many challenging. Some engineering courses simply were replaced by different engineering courses. Other courses have been eliminated to make room for new courses or to reduce the number of SCH degree requirements. A course in numerical method has replaced the structured computer programming course. The mechatronics course has replaced the course in mechanism design and a course in manufacturing has replaced the course in dynamics of mechanical systems. The second course in chemistry has been replaced by a math or science elective to give students more choice of course selection. To make room for two additional SCH needed for a capstone design course and, at the same time, reduce the number of SCH degree requirements from 140 to 128, the math science requirements for the degree have been reduced and the courses in technical writing and engineering economic analysis have been eliminated as part of the degree requirements. The author believes that both technical writing and engineering economic analysis played a vital role in producing well rounded graduates in the past.

Table 2 Comparison of mechanical engineering degree requirements at UTSA, based on 1989-91 and 2012-13 catalogs.

Course name or equivalent	SCH required in 1989-91	SCH required in 2012-14
CHE 1103-General Chemistry I	3	3
CHE 1303-General Chemistry II	3	NR
CS 2073-Programming with Engr Applications	3	NR
EGR 2103-Statics	3	3
EGR 2513-Dynamics	3	3
EGR 2323-Applied Engineering Analysis I	3	3
EGR 3323-Applied Engineering Analysis II	3	3
EGR 3713-Engineering Economics Analysis	3	NR
EE 2213 Electric Circuits and Electronics	NR	3
EE 2423-Network Theory I	3	NR
EE 3313-Electronic Circuit I	3	NR
EE 3401 Network and Electronics Lab	1	NR
ENG 2413-Technical Writing	3	NR
MAT 1214-Calculus I	4	4
MAT 1224-Calculus II	3	4
MAT 1224-Calculus III	3	NR
PHY 1903, Engineering Physics I and	4	3
PHY 1911 Physics Laboratory I	1	1
PHY 1923,-Engineering Physics II	4	3
PHY 1931 Physics Laboratory II	1	1
Math/Science Elective	NR	3
ME 1302-Introduction to Mechanical Engineering	1	2
ME 1402-Mechanical Engr Practice and Graphics	2	2
ME 2173-Numerical Methods	NR	3
ME 3113-Measurements and Instrumentation	3	3
ME 3244-Materials Engineering and Laboratory	4	4
ME 3263-Manufacturing Engineering	NR	3
ME 3293-Thermodynamics I	3	3
ME 3323 Dynamics of Mechanical Systems	3	NR
ME 3543 Dynamic Systems and Control	2	3
ME 3663-Fluid Mechanics	3	3
ME 3813-Mechanics of Solids	3	3
ME 3823-Machine Element Design I	3	3
ME 4293-Thermodynamics II	3	3
ME 4313-Heat Transfer	3	3
ME 3513-Mechanism Design	3	NR
ME 4543-Mechatronics	NR	3
ME 4733-Mechanical Engineering Laboratory	2	3
ME 4812-Senior Design I	NR	2

ME 4813-Senior Design II	3	3
ME Technical electives	9	9

Common Course Requirements for Engineering Degrees:

In the 1970's and 1980's many courses were common in several engineering degree requirements, especially at the freshman and sophomore levels. For example, the 1972-74 University of Portland catalog [4] lists exactly the same course requirements for the first two years of programs of study in civil, electrical, and mechanical engineering. In addition several upper division courses were common to all three programs. In smaller engineering schools, sharing common courses as a part of degree requirements of various engineering programs was done to save faculty and space resources. However, requiring the same courses for several engineering programs was a common practice even at larger public universities.

In early 1970, Oregon State University was the only public institution in the state of Oregon offering engineering programs. The 1972-73 Oregon State University catalog shows that the university was offering undergraduate degrees in agricultural, chemical, civil, electrical and electronics, engineering physics, general engineering, industrial, mechanical, and metallurgical and nuclear engineering [5]. The catalog shows that the first year and half of the requirements were identical for all programs. All students were required to take the same 6 quarter hour (4 SCH) of engineering orientation. A course in statics was common requirement for all engineering programs. The same course in engineering economics was a common requirement for all engineering programs. Six quarter hours (4 SCH) of thermodynamics were required for agricultural engineering, chemical, mechanical, aerospace, nuclear, and metallurgical engineering degree programs. An additional 3 quarter hours (2 SCH) of thermodynamics was a requirement for chemical, mechanical, aerospace, nuclear, and metallurgical engineering degree programs. All students pursuing degrees in civil, industrial, mechanical, and metallurgical engineering were required to complete 9 quarter hours (6 SCH) of course work in materials engineering. A fluid mechanics course was common requirement for agricultural and civil engineering degrees. Six quarter hours of a combined course in fluid mechanics and heat transfer (transfer and rate processes) was a common requirement for agricultural engineering, chemical, mechanical, aerospace, nuclear, and metallurgical engineering degree programs. Students pursuing degrees in chemical, mechanical, and metallurgical engineering were required to complete three additional quarter hours of course work in heat transfer.

At UTSA, until 1991, all students pursuing degrees in civil, electrical, and mechanical engineering were required to complete the some courses in computer science, introduction to engineering, engineering graphics, technical writing, and engineering economic analysis. Students pursuing degrees in civil and mechanical engineering were required to take the same courses in statics, dynamics, and mechanical solids. A course in thermal sciences was required in the civil engineering program and was one of the technical elective options in electrical engineering. Today, each program requires a separate course in introduction to engineering. Electrical engineering no longer requires a course in engineering graphics. Civil and mechanical engineering programs do not require any course in computer sciences. The civil and mechanical engineering offer their own version of engineering graphics and mechanical solids. The engineering economic analysis is required only in civil engineering program. A thermal science course is no longer a required, nor is an elective course in civil and electrical engineering programs.

Until early 1990s, Texas A&M University-College Station had common degree requirements for the first year and half of most engineering programs. Today, still the freshman year is almost identical for degrees in aerospace engineering, biological and agricultural engineering, biomedical engineering, chemical engineering, civil engineering, computer engineering, electrical engineering, industrial engineering, mechanical engineering, nuclear engineering, ocean engineering, petroleum engineering and radiological health engineering [7]. This allows students with to change majors within the college.

Student Outcomes (d) and (h) of the Criterion 3 of ABET-Engineering Accreditation Commission [6] requires the engineering programs to demonstrate that their graduates have: (d) an ability to function on multidisciplinary teams and have: (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context. It can be argued that when a degree program requires courses common in several engineering programs and courses outside of the discipline, it prepares their graduates to function better on multidisciplinary teams and provides them with a broader educational experience. The author believes that old degree requirements when students had to take common courses with students from other disciplines and required more courses from other disciplines prepared students better for job market right after graduation. When the degree requirements are more focused on a single discipline, then graduates might be better prepared for pursuing a graduate degree.

Engineering Textbook:

In early 1970's the engineering textbooks included very few solve example problems in each chapter. Therefore students had to struggle more when solving homework assignments. Through the struggling students learned to be patient and put a greater deal of thinking into solving a particular homework assignment. The thinking process gave them a better understanding of the subject. It also gave them more confidence in solving new problems. Today, each chapter in the engineering textbook contains numerous solved example problems. The solved example problems help students to learn the materials in the chapter better and find answers to some of their questions without approaching their instructors. The homework problems at the end of each chapter are very similar to the solved example problems. In addition, most students have access to solution manuals of engineering textbooks [8]. Therefore, most students do not gain the experience of solving new problems on their own, unless the instructor is assigning problems that are not from the textbook.

Basic Computational Tools:

Prior to 1972, slide rules were the essential computational tools in solving engineering problems and computers were very seldom used as a tool for analysis of engineering problems at the undergraduate level [9]. In early 1970's calculators replaced slide rules as the basic computational tool for solving engineering problems. A few year later programmable calculators became available.

Prior to the introduction of personal computers (PCs) in the early 1980's, complex computer codes were needed for solving some engineering problems that are simple task today. For example, the evaluation of thermodynamic properties of steam and other commonly used substances required access to mainframe computers and proficiency in programming languages. As the personal computers became more available, affordable, and as the operating systems became more user friendly, their applications were gradually integrated into many engineering. The computational tools available today has made it easy to solve open ended engineering problems that were impossible two decades ago.

References

1. URL:http://utsa.edu/ucat/archive/UG82-84/09d_Sci&Math_82-84.pdf
2. URL: http://utsa.edu/ucat/archive/UG89-91/09c_Sci&Engr_89-91.pdf
3. URL:http://www.thecb.state.tx.us/index.cfm?objectid=E9397442-BB73-FD0B-A3FEA11EFC507CEA#Q2
4. 1972-74 university og Portland Bulletin, September 1972
5. Oregon State University Bulletin, Catalog Issue 1962-73
6. URL: http://catalog.tamu.edu/pdfs/13-14_UG_Catalog.pdf
7. URL: http://www.abet.org/eac-criteria-2014-2015/
8. Karimi, A. and Manteufel, R., "Does Student Access to Solution Manual Pose a Challenge?" ASEE-2011-2753, Proceedings of the 2011 ASEE Annual Conference, June 26-29, 2011,Vancouver BC, Canada.
9. Karimi, A. "Use of Interactive Computer Software in Teaching Thermodynamics," IMECE2005-81943, Proceedings of IMECE2005, ASME International Mechanical Engineering Congress and Exposition, November 2005 Orlando, Florid.