Presenting a New Opportunity for Engineering Students: Introduction of an Undergraduate Degree Plan in Leadership Engineering

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Abstract

Integration of engineering and liberal arts education is central to developing the engineer of the conceptual age. The art and science of engineering is key to providing engineers with the technical and system thinking capacity needed to achieve leadership in our complex modern society. The US is at a tipping point regarding global competitiveness in technological innovation, and to a very large extent, humanity is critically dependent on the duopoly of technological innovation and liberal thinking for improvement of quality of lifestyle. To contribute and support leadership in this interplay, we are creating a new degree program in Leadership Engineering at The University of Texas at El Paso (UTEP). This program seeks to visualize and actuate a new paradigm for engineering education by responding to the call from students, alumni, businesses, and civic organisations, including the National Academies. To address these needs, the new program features problem-based, student-focused learning across disciplines and situated learning through professional practice experiences.

Lessons learned in development of this program revolved around making sure that we provided enough rigor for ABET accreditation and still maintain a high degree of program flexibility, as is typical of many other types of degrees. As such, a delicate balance was achieved with the maximum number of hours in the program mandated by the State of Texas, the general education core mandated by the University, and still providing the needed Leadership Engineering Coursework, Internship requirement, and flexible tracks in Business, Education, and Technical Specialization. Of paramount importance is that all Leadership Engineering Courses will be student oriented problem/practice based learning with intrinsic motivation, self-direction, and autonomy through authentic project and leadership experiences. Thus, as Samuel Florman stated in The Introspective Engineer[1] in 1997: “We live in a technological age, and if our society is to flourish, many of our leaders should be engineers, and many of our engineers should be leaders.”

Details of planning for the new undergraduate program in Leadership Engineering at UTEP are discussed as well as input from key stakeholders. Included is the contextual development of the program, the parameters considered as key, and the finalized degree plan. The program features are explained including engineering accreditation, and tracks and stems that provide flexibility for students. Balancing the competing demands within the curriculum, proved challenging but attainable given the strong administrative support and leadership for this program, and UTEP’s desire to provide innovative undergraduate engineering education that leads toward increased retention and advancing opportunities for serving underrepresented populations.

Background

Leadership Engineering (LE) is defined as an emerging engineering sub-field that integrates disciplinary knowledge and practice with communication, business, and leadership skills. This innovative approach to engineering has emerged as a direct result of industry’s immediate and long-term need for a new kind of engineer: one with a new skill set to work in complex 21st century contexts.

LE is about creating engineers, who have the technical competence and leadership acumen to play vital roles in the future wellbeing and success of the US and all it stands for, and the citizens of the US, and thereby the future of the world.

We see Leadership Engineering emerging in a similar way that Engineering Management coalesced a century ago. UTEP's new field of LE goes beyond and is to be distinguished from more traditional engineering management, which refers to the well-established role whereby engineering and technology development, often within consulting and company partnership, is led for the purposes of effective or efficient production. Engineering leaders (or managers) thus require the necessary people skills to coach, mentor and motivate technical professionals. In prior times, engineering professionals joining manufacturing companies sometimes become engineering managers by default after a period of time. They are often required to learn how to managerial abilities once they are on the job. To improve the opportunity for managing engineering the new field of engineering management emerged in the last century (akin to the modern era of computer science as another pertinent example of a totally-new 20th-century discipline) and is an important branch of engineering today.

Engineering management or management engineering was pioneered by Stevens Institute of Technology through the establishment of their School of Business Engineering in 1908. Subsequently over time this led to the Bachelor of Engineering in Engineering Management being offered. The first Department of Engineering Management was established at the former University of Missouri-Rolla in 1967. Thereafter numerous universities began offering professional degrees, and today highly decorated universities offer engineering management, to develop managers who understand both the business and engineering aspects of technology.

Today, there also exist professional societies and organizations dedicated to the field of engineering management. One of the largest is the Engineering Management Society (EMS), within the Institute for Electrical & Electronic Engineers (IEEE), which is the world's largest professional association for the advancement of technology. The EMS field of interest is management sciences, applicable to individuals and organizations engaged in or overseeing the management of engineering and technology. Another prominent professional organization in the field is the American Society of Engineering Management (ASEM), which was founded in 1979 by a group of 20 engineering managers from industry. The ASEM currently certifies engineering managers as: the Associate Engineering Manager (AEM) or Professional Engineering Manager (PEM) through certification examinations.

Systems Engineering (SE) traces roots to the laboratories of Bell Telephone in the 1940s, when according to Buede (2000)[4], the Department of Defense and the RAND Corporation used systems engineering approaches. In a seminal work, Paul Fitts (1951)[5] addressed systems research, and the allocation of the systems functions to physical, as referenced in INCOSE (2013)[6]. Fitts (1951) is best known for creating a list of functions at which people were better at than machines (Fitts 1951). Fitts view is pertinent to our topic, where we are presenting a new program focused on human leadership development for engineers. de Winter and Dodou (2011)[7] make note that the Fitts list recognized the importance of human involvement in systems operations, and that the work has often been misconstrued today in the literature: Hancock (2009)[8] says like many other "classics" in science, it is far more often cited than read. Through our new program we are moving human endeavor -- the role of our educated engineers -- to center stage. Our program complements Systems Engineering, and values Systems Engineering education. We include systems coursework and development of systems thinking within our program. Leadership Engineering moves human endeavor to the forefront and center of our engineering education paradigm.

Leadership Engineering may be thought of as focusing on the human - systems interface. For it recognizes that at the heart of the human endeavor to progress is leadership in all aspects of our profession, our communities, and our society. Leadership Engineering thus has similarities and differences with Systems Engineering education. Bachelor degrees in Systems Engineering may oftentimes be viewed as programs that prepare individuals to use math and science principles in the design, development and operational evaluation of total systems solutions to a wide variety of engineering problems. Leadership engineering may be seen as focusing on the locus between human will to do good, and technical disciplines of engineering, involving systems engineering, which includes the integration of management and information requirements, as applied to specific physical and structural situations.

As was the case with start-up of pioneering Systems Engineering programs, Leadership Engineering will initially be observed by the traditional disciplinary professoriate as an extension to regular engineering courses (see Muller 2013)[3], reflecting the industry attitude that engineering professionals need a foundational background in one of the traditional engineering disciplines, with the addition of practical experience to be effective as systems engineers. Undergraduate university programs in systems engineering are still relatively rare, with most programs being at the graduate level.

Since we have already been teaching Systems Engineering graduate students at UTEP during the past 5 years, we anticipate our teaching of undergraduate LE students will in some key ways be similar. As is the case with SE, our teaching in LE courses will be more focused on skills, entrepreneurial thinking, critical thinking, and problem solving, and less on transferable facts. Our goal will be to stimulated and foster deep learning processes in the students, who will actively engage subjects in a meaningful, reflective, experiential, and lasting way.

As the program progresses, we anticipate further advances in Industrial, Manufacturing, and Systems Engineering (IMSE) graduate program development at UTEP will follow our undergraduate program implementation. This has been the case with Systems Engineering, where due to the rapidly increasing complexity of the global engineering environment, our professional peers are actively developing the new discipline of System of Systems Engineering (SoSE). The Master of Engineering Management Programs Consortium[9] is a recently formed (2006) consortium of prominent universities intended to raise the value and visibility of the MEM degree. Our degree will be ABET accredited, just as Engineering Management university programs are usually accredited by ABET[10] or ATMAE[11].

In the 21st century, rapid engineering advances have led to scientific, medical, and technological breakthroughs that are transforming what engineers need to know and how they work (National Academy of Engineering, 2004)[12]. In medicine, mechatronic engineers have designed products such as pacemakers and artificial organs; in biotechnology, they are working to engineer tissues for burn victims. These kinds of efforts require engineers to develop multidisciplinary knowledge and to work on multidisciplinary teams more than they have in the past.

Advances in information and communications technologies have also caused many industries to shift focus from developing products to providing service systems. While engineers have been integral in designing and maintaining these systems, they have also had to develop broad knowledge of such systems and have had to develop knowledge of business management and marketing strategies. These new skills require that they communicate more with customers as they tailor system designs to fit individual specifications.

Engineers must also continue to develop solutions to pressing social and global problems, such as the scarcity of natural resources, the increase in global population, and the deterioration of America's infrastructures. To better address such problems, engineers must have a greater understanding of the complexity of social, economic, and political constraints on their work. They must understand the ways technology is tied to public policy so that they will be better able to advise government officials when called upon to do so.

As these examples suggest, 21st century engineers need deep disciplinary knowledge, but they also need excellent communication skills, business acumen, and leadership abilities. These skill sets are not currently part of the engineering curriculum at most universities. Granted they are part and parcel of engineering management and systems engineering programs, however, in this new paradigm, professional skills are tantamount.

Leadership Engineering - Naming the Degree Program

The premise for typical "Engineering Leadership" programs is that you start with an engineer and then make a leader out of him or her. Thus Leadership training is the primary focus, with Engineering as the qualifier for the type of leaders being trained. The premise of our Leadership Engineering program is that the profession will attract future leaders (as is the case of many other professions that require post-graduate professional training, such as medicine and law), and the program is designed to produce engineers out of those future leaders. Thus it is a broad-based, liberal engineering program for future leaders in the public and private sectors.

Therefore we have chosen the term Leadership Engineering to describe our proposed BS-level broad-based, liberal engineering program.

Part of the struggle of any change is understanding, and adopting, a new language. This program is not entitled Engineering Leadership, something akin to Engineering Management.

It is Leadership Engineering, akin to, say, Civil Engineering. Civil Engineering is not about "Civil of engineering." In the same way, Leadership Engineering is not about "Leadership of engineering." It is about engineers who develop leadership capacity, which enables them to contribute broadly, not just in engineering circles.

While a primary objective of this program will certainly be to produce the engineering leaders of tomorrow, our proposed design is somewhat a reversal of the usual style of developing leaders from engineers.

The University of Texas at El Paso's (UTEP) Bachelor of Science in Leadership Engineering (BSLE) program is, thus, a pioneering effort to both reform engineering education and to graduate engineers who possess skill sets that will enable them to compete in the 21st century global economy. Graduates of this program will advance to a wide variety of corporate and professional roles.

Contextual Development of the Leadership Engineering Program

The Need for Engineers with Business Acumen in Industry

Currently, the service sector represents 80-percent of the U.S. economy, and it accounts for over 50 percent of the economies of Brazil, Germany, Japan, Russian, and the U.K.[13] It should be no surprise, then, that service sector industries already need engineers with business acumen. Companies like AT&T, Accenture, Hewlett-Packard (HP), and Electronic Data need engineers to design, maintain, and repair customized service systems for users. Designing such systems requires an understanding of "customerization – a buyer-centric business strategy that combines mass customization with customized marketing"[12]. Of course, to succeed in such positions, engineers need a broad range of skills in technology, business practices, and organizational management.

In recent years, according to Spohrer & Maglio (2008),[14] the scarcity of engineers with such skill sets prompted IBM to promote a new discipline called Service Science, Management, and Engineering [SSME]. SSME is "a growing multi-disciplinary research and academic effort that integrates aspects of established fields like computer science, operations research, engineering, management sciences, business strategy, social and cognitive sciences, and legal sciences" (IBM, 2010). SSME attempts to "increase productivity and innovation in services-related industries and tasks by applying scientific means and methods"[13]. Other companies have set up similar projects. For instance, HP started the Centre for Systems and Services Science, and Oracle joined with IBM to launch a "consortium called the Service Research and Innovation Initiative"[15].

Engineers working in SSME must also attain a very broad skill set in engineering, business, and the social sciences. This skill set, of course, is strikingly similar to the skill set expected from the broad-based, liberal engineering programs and to UTEP's proposed BSLE program. UTEP's proposed BSLE program, then, is uniquely suited to meet service sector industry needs. UTEP students who select the BSLE business track will be market ready for employment in this industry. In addition to their technical skills and business acumen, these graduates will also possess leadership abilities, which will make them highly desirable.

The Need for Engineers with Technical Specializations in Industry

Service sector industries also need engineers with technical expertise.

In advocating for the new SSME degree, IBM, for example, has called for a "new type of 21st century knowledge engineer—what it calls a 'T-shaped'" engineer.[16] These engineers have deep knowledge of technical skills (the vertical axis of the T). Yet, they also have a "sufficient understanding of a broad range of related disciplines to allow them to see contextual linkages, to constructively participate in interdisciplinary teams, and to continually adapt their visions and their contributions to rapidly changing conditions and needs" (the horizontal axis of the T). As IBM states in *Beyond IT* (2009)[16] its goal is to select "interdisciplinary graduates . . . who can proceed through any of the five IBM career paths."

BSLE graduates who elect a concentration in a technical specialization will become T-shaped engineers and will be better prepared for employment in the public or private sector because they will have additional disciplinary knowledge in a specialized field of engineering.

The Need for Engineering Educators

The field of education also needs engineers, especially at the 8-12 grade levels. Many of the previously cited reports suggest the need for optimal mathematics, science, and engineering education at the 8-12 grade levels to draw more talented students into the field and to ensure they are adequately prepared for higher education. Historically, 8-12 grade education has been undergoing reform since the post-Sputnik era. More recently, however, the change in national science and mathematics standards has also resulted in reform.[17, 18, 19]

Education reformers currently advocate integrating engineering curriculum into grades 8-12. In 2007, for example, the National Academies published *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Future*[20], which documented the need for increased numbers of qualified scientists, mathematicians, and engineers to meet 21st century workforce demands. In response, the National Research Council (NRC) of the National Academies also released *A Framework for K-12 Science Education*[21], which recommended a more integrated curriculum of science, technology, engineering, and mathematics (STEM) to advance citizens' scientific and technological literacy.

In the near future, engineering will be an integral part of 8-12 grade instruction as reform of state standards will follow reform at the national level. Many states, in fact, are now considering, or have approved, adding engineering knowledge to science and mathematics requirements in grades 9-12. Educators also emphasize the need to increase diversity within STEM fields by integrating more underrepresented minorities, especially women. To effectively prepare for the forthcoming changes in state and national standards, our proposed BSLE will feature a concentration in education. Education track graduates will meet the need for STEM teachers, who are capable of teaching in all STEM fields and who understand and value leadership attributes. This program, then, may also influence young people to pursue STEM degrees and, thus, impact the future workforce.

The Need to Develop Industry Leaders

Leadership development is increasingly needed in industry. To meet this need, companies such as AT&T, Lockheed Martin, and Rockwell Collins have created on-site "universities" in leadership to develop promising junior engineers into leaders who will stimulate creativity and innovation in their respective environments. Lockheed Martin, in particular, invested millions of dollars in a nation-wide leadership development center at its corporate headquarters in Bethesda, Maryland.

In addition, a national survey by The Cara Group Inc.[22] of Fortune 1000 companies found that 62-percent of respondents identified a leadership skills gap in their organizations, and 84-percent increased their focus on leadership development in the last two to three years. According to Michelle Reid-Powell, CARA vice president of talent management and organizational effectiveness, "the survey revealed the need to significantly improve the quality of leadership development programs. Best practices from our client work indicate several ways to improve these programs, including elevating leadership as a differentiator in a company's strategic plan, aligning leadership development programs with business objectives and strategic business vision, and creating formal mentoring programs."[22]

To better prepare graduates for leadership positions in industry, engineering programs need to incorporate leadership development training into their programs. While a common objective of U.S. engineering programs is to produce future engineering leaders, few programs have curricular content specifically designed to develop the skill set of leaders. In fact, Graham, Crawley, and Mendelsohn (2010)[23] found that existing undergraduate engineering programs worldwide that included emphasis on leadership were either extra-curricular to engineering programs or were adjunct (i.e. ranging from a single course to a full minor). For this reason, many current engineering leaders developed their skills through post-graduate leadership training (most typically in business schools via the MBA) or in industry settings (See, for example, the Lockheed Martin Engineering Leadership Program, 2010).[24]

Responding to the call for reforming engineering education, the F. W. Olin Foundation established Olin College in 2002 and incorporated an innovative curriculum in engineering found in no other institution of higher learning. Its hands-on, interdisciplinary program aims to graduate innovative engineers who "recognize needs, design solutions, and engage in creative enterprises for the good of the world."[25]

A 2011 report on its first graduating class indicated that of its 64 graduates, six started their own businesses; 22 worked at 30 different public or private organizations; five earned Ph.D.s; 17 earned master's degrees; two are working on an M.D. or Ph.D.; and one has a J.D.[26] The report suggests, then, that a general engineering degree, when coupled with innovative pedagogical approaches, has impact. Because UTEP's BSLE program offers a broad engineering program, much like Olin College's, we feel confident that our BSLE graduates will find engineering positions in industry. Our graduates will likely find engineering positions in companies such as Lockheed Martin Aerospace & Defense; AT&T; IBM; and Halliburton.

Emphasis on the Leadership Aspect

A key advantage of this degree is its focus on leadership development within an engineering and societal context. The aim is to build within students leadership ***Character, Competence, and Capacity (C^3)*** by helping them learn who they must be, what they need to know, and what skills they must demonstrate in effective leadership. The courses build upon each other as the students progress through the program. We have designed the curriculum in such a manner as to give the faculty in the BSLE program substantial contact with Leadership Engineering (LE) students every semester. We have cross-listed 8 hours of the LE courses due to the parallel nature of educational objectives in Graphic Fundamentals, Engineering Probability and Statistical Methods, and Systems Engineering.

The BSLE program is also designed to meet ABET student outcomes. The outcomes "a" through "k" are primarily addressed our core engineering science courses for all engineering degrees. ABET also allows degree programs to add additional outcomes to further describe the particular attributes students will obtain by graduation. We have added two additional outcomes – “l” and “m” – which are:

(l) A knowledge of leadership issues and ability to apply leadership principles

(m) An understanding that engineers who are leaders build Character, Competence, and Capacity in themselves and others.

The degree program course listing is seen in Table 1. The Leadership Course Series (I, II, III) covers foundational leadership skills and progresses through an in-depth understanding and application of leadership. Leadership I includes topics such as leadership theories, styles, practices, and challenges as well as practice-based case studies. Leadership II continues with visionary leadership and leadership development while focusing on empowerment, integrity, and integration. This course includes practice-based case studies involving leadership and engineering design, and it prepares students for their first professional summer engagement. Leadership III builds on the foundation of Leadership I & II. It includes case studies in integrity and character, and it includes topics on opportunities, limitations, constraints and consequences (ethics), and principles of assessment and evaluation.

Professional Practice I & II are summer internships during students’ 2nd and 3rd years. These paid internships will be a minimum of 320 hours each (8 full-time weeks) and are designed to provide practice-based, professional/community service beyond the classroom experience. Students will be actively coached and mentored by employers, who are closely associated with the LE program. Students will learn to adjust to work environments, which empasize accountability and increased responsibility. The summer internships will be overseen by LE clinical faculty, who will ensure that interns are properly supervised, monitored, and given significant tasks and responsibilities. Professional Practice II builds on Professional Practice I by offering students increased responsibility. Professional Practice II also offers students both international and out-of-state internship opportunities.

The BSLE program represents our initial step in transitioning to Duderstadt’s[27] proposed recommendations of a medical school model for engineering. The broad engineering base, leadership development, and emphasis on professional practice combined with the flexibility of the tracks effectively “liberalizes” our degree. Expanding partnerships for the professional practice experiences will help prepare for the next step: a practice-based master of engineering program.

Senior Design I & II are also leadership engineering courses, and students in the LE senior design sequence will be collaborating with senior design students in other departments. LE Senior Design I & II students, however, will be responsible for directing, managing, and leading tasks within those projects in addition to having their own engineering design responsibilities.

Table 1 Outcomes (a) through (m) for the new Leadership Engineering degree program

No.	Subj	Course	Course Name	SCH	A	B	C	D	E	F	G	H	I	J	K	L	M
1	COMM	1302	Business and Professional Communication	3							✔						
2	ENGL	1311	English Composition	3							✔		✔				
3	ENGL	1312	Research and Critical Writing	3							✔		✔				
4	HIST	1301	History of U.S. to 1865	3							✔	✔					
5	HIST	1302	History of the U.S. Since 1865	3							✔	✔					
6	PHIL	2306	Ethics: Phil Persp on Human Conduct & Values	3						✔				✔			
7	POLS	2310	Introduction to Politics	3							✔	✔					
8	POLS	2311	American Government and Politics	3							✔	✔					
9			Visual & Performing Arts Elective	3							✔	✔	✔				
10	CHEM	1305	General Chemistry I	3	✔						✔						
11	MATH	1411	Calculus I	4	✔				✔						✔		
12	MATH	1312	Calculus II	3	✔				✔						✔		
13	MATH	2313	Calculus III	3	✔				✔						✔		
14	MATH	2326	Differential Equations	3	✔				✔						✔		
15	MATH	3323	Matrix Algebra	3	✔				✔						✔		
16	PHYS	2420	Intro to Mechanics	4	✔				✔						✔		
17	PHYS	2421	Fields and Waves	4	✔				✔						✔		
18			Upper Division Math/Sci Elective	3	✔				✔						✔		
19	CE	2326	Economics for Engineers & Scientists	3				✔	✔						✔		
20	CE	2337	Electrical Circuits and Motors	3	✔	✔		✔			✔				✔		
21	CE	2338	Dynamics	3	✔			✔	✔								
22	MECH	2311	Intro to Thermal-Fluid Science	3	✔		✔		✔			✔		✔	✔		
23	MME	2303	Materials and Manufacturing Processes	3	✔		✔		✔								
24	MME	2434	Statics & Mechanics of Materials	4	✔				✔								
25			Upper Division Eng Technical Elective	3													
26			Upper Division Eng Technical Elective	3													
27			Upper Division Eng Technical Elective	3													
28	UNIV	1301	Foundations of Engineering	3			✔			✔	✔	✔				✔	✔
29	LE/CE	1205	Graphic Fundamentals	2			✔	✔			✔				✔		
30	LE	1302	Intro to Eng Design & Leadership	3			✔									✔	✔
31	LE	2301	Leadership Engineering I	3						✔	✔	✔	✔	✔		✔	✔
32	LE	2302	Leadership Engineering II	3						✔	✔		✔	✔		✔	✔
33	LE	2103	Professional Practice I	1				✔				✔				✔	✔
34	LE	3302	Leadership Engineering III	3						✔	✔		✔			✔	✔
35	LE/IE	3331	Systems Engineering	3	✔	✔	✔	✔	✔								
36	LE	3103	Professional Practice II	1				✔				✔				✔	✔
37	LE	4395	Senior Design I	3	✔		✔	✔			✔				✔		
38	LE	4396	Senior Design II	3	✔		✔	✔			✔				✔		
39	LE/IE	3373	Engineering Probability & Statistical Models	3	✔	✔		✔	✔						✔		
40			Track/Concentration Elective #1	3													
41			Track/Concentration Elective #2	3													
42			Track/Concentration Elective #3	3													
43			Track/Concentration Elective #4	3													

Tracks and Stems

Three tracks will be offered initially in the BSLE program: **Business, Education (Teacher Certification), and Technical Specialization (Engineering)**. All tracks require a minimum of 12 credit hours (in the track). Students will choose a track in their sophomore year. They will work closely with their LE advisor to determine their anticipated career trajectory and to determine which track best suits their goals. Careful advising of each student will result in a plan of study that will guide students' coursework the last two years of the program.

Business: The business track students can choose one of six stems in Management, Accounting, Economics, Marketing, Entrepreneurship, and General Business. These stems also parallel with the already developed minors in the College of Business for non-majors. These minors require six courses, and our program track will get students within two courses of receiving a minor if they choose to do so. Many of the students who choose the Business track will likely take those two additional courses and obtain a minor in a Business field.

Technical specialization: The technical track students will focus on a particular engineering discipline or on a specialized combination of discipline specific courses. Students can choose from a wide variety of courses in mechanical, electrical, civil, metallurgical & materials, industrial, and computer science. Students who choose this track will likely proceed into either conventional engineering employment or into graduate school to obtain an M.S. or a Ph.D. in engineering.

Education *(8-12 Teaching Certification)*: The education track students will have the opportunity to become state certified. Engineering students enrolled in this track must take 12 core credit hours in education and must complete a full-time student teaching internship. Students must also take two required state board certification exams, one in pedagogy and another in content. The content exam encompasses material in the desired teaching certification area. In this case, LE students would be eligible for secondary teacher certification (8-12) in Mathematics, Physical Sciences, Engineering, the combination of Mathematics/Physical Sciences, or a combination of all three. Students must fulfill these requirements to graduate as teacher-engineers and to teach in secondary schools.

Summary & Conclusion

The new undergraduate degree in Leadership Engineering is an innovative engineering degree program that provides a "liberal education" within a highly structured public-arena engineering program. The program is designed to provide students with a high degree of flexibility and at the same time meet the program's four main objectives. These objectives are to (1) meet general education requirements, (2) meet ABET engineering criteria, (3) provide a substantial leadership engineering education and practice, and (4) provide 12 credit hours in specialized coursework (track).

The state's general education requirements, combined with ABET's engineering, math, and science requirements, totaled 88 percent of a 120-hour curriculum. For this reason, we increased the number of credit hours from 120 to 128 so that we could include 12-hours of professional track courses and have sufficient hours for a major in Leadership Engineering. (Note: Traditional engineering majors do not have this constraint. All their credit hours count toward engineering science or engineering design coursework according to ABET.) Having 12-hours of professional track courses provides students with more options. Students who choose the Business track will be within two courses of a minor, and students who choose the Education track will meet all class requirements for 8^{th}-12^{th} grade teacher certification.

For ABET purposes, we have counted 14-hours of LE courses as ABET engineering hours and 3-hours as ABET math & science hours. These courses will be a blend of both engineering science and topics related to LE. It is through this assessment that courses in LE count as engineering per ABET standards and major coursework.

Table 2 (next page) Listing of courses in the undergraduate Leadership Engineering program

Subj	Course	Course Name	SCH	THECB	ABET
UNIV	1301	Foundations of Engineering	3	CORE	Eng
POLS	2310	Introduction to Politics	3	CORE	Gen Ed
POLS	2311	American Government and Politics	3	CORE	Gen Ed
COMM	1302	Business and Professional Communication	3	CORE	Gen Ed
ENGL	1311	English Composition	3	CORE	Gen Ed
ENGL	1312	Research and Critical Writing	3	CORE	Gen Ed
		Visual & Performing Arts Elective	3	CORE	Gen Ed
HIST	1301	History of U.S. to 1865	3	CORE	Gen Ed
HIST	1302	History of the U.S. Since 1865	3	CORE	Gen Ed
PHIL	2306	Ethics: Philosophical Perspective on Human Conduct and Values	3	CORE Req'd	Gen Ed
PHYS	2420	Intro to Mechanics	4	CORE Req'd	Math/Sci
PHYS	2421	Fields and Waves	4	CORE Req'd	Math/Sci
MATH	1411	Calculus I	4	CORE Req'd	Math/Sci
CE	2326	Economics for Engineers & Scientists	3	CORE Req'd	Math/Sci
CHEM	1305	General Chemistry I	3	Req'd	Math/Sci
MATH	1312	Calculus II	3	Req'd	Math/Sci
MATH	2313	Calculus III	3	Req'd	Math/Sci
MATH	2326	Differential Equations	3	Req'd	Math/Sci
MATH	3323	Matrix Algebra	3	Req'd	Math/Sci
		Upper Division Math/Sci Elective	3	Elective	Math/Sci
LE/IE	3373	Engineering Probability & Statistical Models	3	Req'd	Eng
CE	2337	Electrical Circuits and Motors	3	Req'd	Eng
CE	2338	Dynamics	3	Req'd	Eng
MECH	2311	Intro to Thermal-Fluid Science	3	Req'd	Eng
MME	2303	Materials and Manufacturing Processes	3	Req'd	Eng
MME	2434	Statics & Mechanics of Materials	4	Req'd	Eng
		Upper Division Eng Technical Elective	3	Eng Elective	Eng
		Upper Division Eng Technical Elective	3	Eng Elective	Eng
		Upper Division Eng Technical Elective	3	Eng Elective	Eng
LE	1302	Intro to Eng Design & Leadership	3	Req'd	Eng
LE	2103	Professional Practice I	1	Req'd	Gen Ed
LE	2301	Leadership Engineering I	3	Req'd	Gen Ed
LE	2302	Leadership Engineering II	3	Req'd	Gen Ed
LE	3103	Professional Practice II	1	Req'd	Gen Ed
LE	3302	Leadership Engineering III	3	Req'd	Eng
LE	4395	Senior Design I	3	Req'd	Eng
LE	4396	Senior Design II	3	Req'd	Eng
LE/CE	1205	Graphic Fundamentals	2	Req'd	Eng
LE/IE	3331	Systems Engineering	3	Req'd	Eng
		Track/Concentration Elective #1	3	Stream Elective	Gen Ed
		Track/Concentration Elective #2	3	Stream Elective	Gen Ed
		Track/Concentration Elective #3	3	Stream Elective	Gen Ed
		Track/Concentration Elective #4	3	Stream Elective	Gen Ed

Degree SCH: 128

LE Major Hours: 28

45	**THECB CORE(42)**	**ABET Eng (48):**	**48**
59	**THECB Req'd**	**ABET Math/Sci (32):**	**33**
12	**THECB Prescribed Electives**	**ABET Gen Ed:**	**47**
12	**THECB Track Electives**		

1. Florman, Samuel C. (2010). *The Introspective Engineer*. New York City: St. Martin's, 1996. Graham, R., Crawley, E., & Mendelsohn, B. (2010). *Engineering leadership education: A snapshot review of international good practice.* [White paper]. Retrieved from **http://web.mit.edu/gordonelp/elewhitepapter.pdf**

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