

Training Engineers for Professional Management through the Doctor of Engineering Degree in the School of Engineering

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Introduction

Engineering has been a long-standing profession and educational area of study. Most undergraduates seek employment after degree completion. Roughly ten years into one's career, an engineer faces a choice on which career path to pursue: technical or management. For those who decide on the management career path, many earn an MBA degree for the business knowledge and competitive advantage. However, there is another, arguably more suitable, degree for engineers on the management career track: a professional engineering doctoral degree. This degree provides additional technical knowledge plus coursework from the business school providing the student with a unique skillset and readiness to excel in a technical leadership position. This paper describes one such program, its student profiles and program revisions currently under consideration. The objective of this paper is to explain the merits of the Doctor of Engineering in Engineering degree, and its purpose in training engineers to become professional managers in a technical field.

Program History

The Doctor of Engineering degree program was created in the mid-1980's as the college's first professional doctoral degree. It went through administrative revisions in the late 1980's to become the program it is today. There were very few professional doctoral programs in the country at that time. Most of the interest in professional degrees was at the master's level. It is important to note, as well, that the title of the degree does not have the same meaning at all institutions and in all countries. Some use the Doctor of Engineering title for a research-based engineering doctoral degree.

This professional engineering degree differs from a research-based doctorate degree in that it focuses on developing deep engineering principles AND non-technical skills around organizational leadership. Emphasis is placed on engineering practice, public service and developing leadership potential, not on basic research and research methodology. This degree prepares an engineer for business leadership success working at the highest levels of the engineering profession.

The late '80s revitalization of this program came from the efforts of the then Assistant Dean of Engineering. He saw the tremendous benefits of such a degree and realized a niche need graduates of this program could fulfill. Engineers are trained for technical competence and expertise but are lacking in the areas of management and organizational systems. In order to advance into a higher level leadership role, one must have advanced skills in both technical and business areas. This person began to work with others in the college of engineering to increase the quality and improve the image of the Doctor of Engineering degree program. A program coordinating committee composed of faculty from each engineering department was convened to provide guidance and input.

Revisions mainly included aligning steps towards graduation and program milestones to the doctor of philosophy degree in terms of requirements with the university. This institution has a graduate programs office similar to how the registrar’s office functions at the undergraduate level. The graduate programs office is charged with verifying graduate students are completing necessary steps towards graduation. Details of these milestones are discussed in the next section.

At the time, the doctor of engineering degree was offered through respective departments, similar to the offerings of the Master of Engineering degree and the Master of Science degree (thesis and non-thesis options). A more unified curriculum approach was taken and program administration was moved to the college level. It now became the Doctor of Engineering in Engineering degree. Students choose technical electives in their chosen discipline to comprise the engineering credits of the degree. Collaborations were also made with the business school to identify and coordinate course offerings comprising the management and organizational leadership portion of the program curriculum. Details of the curriculum are discussed further in the next section. A summary of graduates can be found in Figure 1. Numbers heavily rely on marketing and recruitment efforts. Program directors have changed over the years which may affect graduation rates. Also enrollment is affected by industry and the job market. Those reaching a stall in their career may decide to return to school in order to open more opportunities.

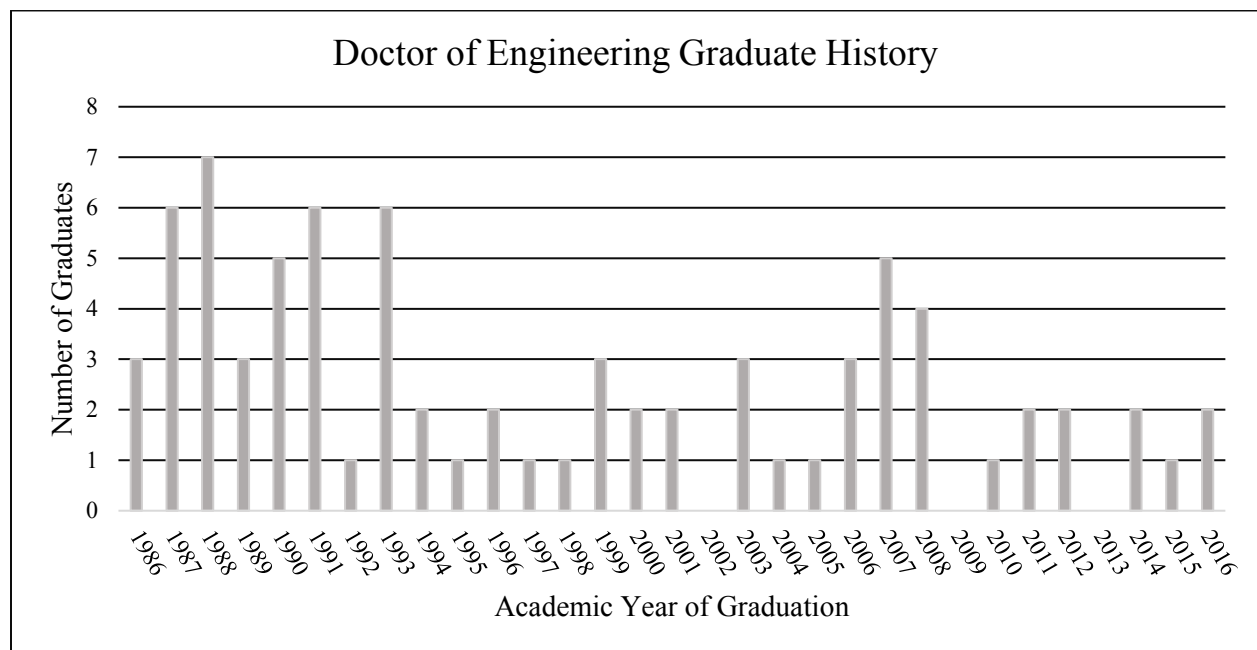


Figure 1: Doctor of Engineering Graduates

There have not been any major changes to the program since these revisions were implemented. There has, however, been a change in the type of student that is attracted to this degree. The current program director is re-evaluating the degree program in light of this, which is discussed in the Future Improvements section.

Program Structure

The Doctor of Engineering in Engineering degree was developed for the early/mid-career engineer ready to transition into a higher level leadership role. This degree was created to provide the knowledge, skills and mindset to prepare engineers for this career shift and progression. The program has three pillars: technical coursework (56 credits), business coursework (21 credits), and professional application/internship (19 credits). A full listing of coursework can be found in Figure 2. The majority of coursework hours come from an engineering technical area, thus the degree is titled Engineering and not Engineering Management. The business courses required expand beyond management, providing a broad survey of high-level business-related topics. These courses prepare graduates for positions not only in personnel management but in strategic business development and senior leadership as well.

Since this is a doctoral program, degree requirements follow that of a traditional doctor of philosophy degree. Students are required to pass the following milestones: establish advisory committee, degree plan submission, qualifying exam, internship proposal (in place of a preliminary exam), internship objectives (in place of a research proposal), a record of study report on their internship experience as the dissertation and an oral defense as the final exam. A comparison chart is shown in Table 1.

Table 1: Doctor of Philosophy and Doctor of Engineering Comparison

PhD		DEng	
Coursework	55hrs min.	80hrs	Coursework
Research	41hrs	16hrs	Internship
	96hrs	96hrs	
Qualifying Exam			Qualifying Exam
Preliminary Exam			Internship Proposal and exam per committee discretion
Research Proposal			Internship Objectives
Dissertation			Record of Study/ Internship Report
Final Exam			Oral Defense of Internship

The advisory committee is composed of faculty from the student’s technical area(s) of focus and the internship supervisor, if possible. The internship must last one full calendar year in duration and is conducted once all coursework is completed.

Internship

The student works closely with their advisory committee and the program director in selecting an intern employer and defining the intern project. Freedom is given to students to follow their particular academic objectives and career goals with the internship. Former students have had diverse internship experiences, for example one worked in the governor's office focusing on public policy and decision making while another worked for a consulting firm managing city projects. Students who remain employed as an engineer while pursuing the Doctor of Engineering degree may conduct relevant work with their existing employer for the internship credit as approved by their committee and employer. Students submit an internship proposal for approval by the advisory committee, program director, and college before commencing the internship. All coursework must be complete before beginning the one-year internship, and students must remain continuously enrolled.

Admissions Criteria

Previously, applicants were required to have anywhere between two and ten years of industry experience and were reviewed by an admissions committee composed of faculty and industry leaders. The years of experience was a filtering mechanism to prevent program changes from unsuccessful students in PhD programs. The purpose of the interview was to ensure the applicant had a clear vision of their career goals and how this degree was necessary to achieve them. Applicants would apply through an engineering department. Currently applicants apply directly to the Doctor of Engineering in Engineering degree program. A minimum of one year of experience is required, and an informal interview is conducted between the program director and the applicant. Additional elements to the application package include: a personal essay describing the applicant's career goals and interest in the Doctor of Engineering program, three letters of recommendation, resume, and transcripts. Two of the letters of recommendation must be from faculty at the institution who agree to serve on the student's committee. It is important that students make connections and have at least a tentative plan in place before being admitted. This ensures the student is serious about their educational and career goals.

REQUIRED COURSES (Professional Development)	Credit Hours	OTHER REQUIRED COURSES	Credit Hours
ACCOUNTING [select one from this group] _____		SEMINAR _____	
ACCT 640 Accounting Concepts and Procedures I	3	Professional Development Seminar(s)	3
ACCT 611 Management of Taxation	3	(or other Seminar(s) approved by the program)	
COMMUNICATIONS [select one from this group] _____		INTERNSHIP _____	
COMM 636 Research in Organizational Communication	3	ENGR 684 Professional Internship	16
COMM 637 Organizational Communication Seminar	3	(Record of Study required)	
COMM 665 Communication and Technology	3	(minimum from this section)	19
FINANCE I [select one from this group] _____		ADVISORY COMMITTEE- APPROVED COURSES	
FINC 635 Financial Management for Non-Business	3	Department-oriented Graduate Level Courses	32
FINANCE II (after Finance I) [select one from this group] _____		Engineering Design Courses	12
FINC 630 Financial Management	3	Elective Graduate Level Courses	12
FINC 645 International Finance	3	(minimum from this section)	56
INEN 667 Engineering Economy	3	TOTAL MINIMUM REQUIRED	96
POLICY AND STRATEGY [select one from this group] _____			
MGMT 655 Survey of Management	3		
MGMT 680 Business and Corporate Strategy	3		
MKTG 621 Survey of Marketing	3		
POLS 645 Politics, Policy and Administration	3		
MANAGEMENT or LABOR^(a) [select one from these two groups] _____			
INEN 663 Engineering Management Control Systems	3		
MGMT 620 Strategic Human Resource Management	3		
MGMT 630 Behavior in Organizations	3		
MGMT 635 Employment Regulation	3		
MGMT 650 Human Relations and Collective Bargaining in Industry	3		
ETHICS [select one from this group] _____			
ENGR 482 Ethics and Engineering	3		
PHIL 671 Ethics for the Professional	3		
(minimum from this section)	21		

NOTES

- Typically, three years of full time study (including internship) will be required beyond the bachelor's degree to complete the D.Eng. Program.
- The final master's degree examination is required at the completion of a Master's Degree Program, as approved by the Advisory Committee. This examination is separate from the D.Eng. Qualifying Examination.
- A D.Eng. Qualifying Examination is required before completion of the second semester for a student entering the program with a master's degree.
- A Final Examination is required at the completion of the D.Eng. Program.

Figure 2: Doctor of Engineering in Engineering Curriculum

Student Profiles

Engineers seeking this degree come from many industries and at various points in their career, each with unique and specific goals. Those earlier in their career are seeking career acceleration while those later in their career are seeking career confirmation. Many students historically have 5-10 years of experience as an engineer seeking advancement into a more senior technical leadership position. These higher level positions require solving business problems related to engineering. Goals of these students is to gain a deeper understanding of engineering principles and learn operational business practices. Former students state they desired additional technical knowledge along with business courses. The traditional option would be an MBA and MEng or

PhD. Alternatively, they can pursue a doctoral degree which allows them to combine the desired engineering and business courses with a practicum instead of research providing the highest impact and applicability. One states, “I experienced a business environment that seemed to be lacking in those whom could understand the entire business process rather than just their specific niche. I wanted to be able to speak with machinists, research scientists, engineers, finance, accountants, marketing, and executive administrators.” Several students began in a traditional engineering PhD program and found themselves gravitating towards a more business or economic oriented focus. They later transitioned to the DEng program which was a better fit for their interests. Military veterans have pursued this degree as a tool to enter industry at a higher management/leadership level. Some of the positions former students have obtained are: chief operations officer, chief marketing officer, chief technical officer, higher education administration and instructors.

Current students have a wide range of goals. One is from Nigeria, and his goal is to bring hydroelectric power to his country. He would benefit from courses in public policy and inter-country relations in addition to business courses educating him on how to launch a new program. Another student has a desire to start his own company. Still two others have five to ten years of experience and want to accelerate their careers. One former student entered with one year of experience and upon graduation, received three promotions within one year as a direct result of the skills and knowledge gained with this degree. No other engineers had the business acumen and organizational mindset he had. He stated that one can learn such things on the job but it is entirely different when one enters the job with skills in hand. So for him and others with just a few years of work experience, this degree opened new doors that would not have been possible for someone early in their career.

This degree also provides the knowledge for those who have a problem they want to solve and are seeking the tools to solve it. The internship provides networking opportunities and invaluable resources for the student. Some students work while attending school and use their current employer for an internship project. One example is a student working at a consulting engineering firm who developed a storm water management plan for the city. Another student interned at the Governor’s office to learn policy making.

Former Student Testimonials

One area of impact this degree has had on former students is communication. Engineers are known for their lack in communication and soft skills. This degree program prepares its graduates to be leaders in industry, which includes the ability to effectively communicate with a range of audiences. One graduate states a benefit of the DEng degree is “the ability to communicate complex topics to non-technical audiences.” This skill combined with deeper technical knowledge and credentialing have prepared several former students to serve as expert witnesses. Some students have built their own business while others have been able to contribute to the financial and economic decision making efforts of their organization. A few summarized quotes from former students are presented below:

- Business principles and economics to the design of energy efficiency programs
- Business development, becoming a Principal and manage personnel and contribute to business decisions

- Depth of technical courses helped initially and the breadth of business, leadership, management, finance courses allowed me to thrive and became most valuable once in the role of Chairman/CEO of self-owned business.
- Business courses helped with managing large engineering departments. “Most of the PhD graduates working in management didn't have skill set to review financial analysis, budget, and deal with labor issues in the work place. I was able to hand and deal with such issues with ease due to the preparation I had with the D.Eng. program. “
- “The main influence for me has been my ability to read financial statements and evaluate investment decisions. The main application has been in evaluating internal company financial decisions. “
- “The coursework that I took specifically from the business school (e.g. accounting, strategic management, project management) gave me the background I needed to understand and contribute greatly to the financial planning function required of a research and development division as part of a larger organization. “
- “The youngest manager and the youngest officer in a 100 year old company's history. Further, having the degree was a key differentiator in my selection to serve on a City Council in my late 20's. The ability to apply strategy to technical challenges, understand and maneuver through organization change initiatives, and tap into employees intrinsic motivations (all things developed through this program) have been keys to my professional success throughout my career. “
- 3 promotions within my first 4 years in the industry.

Program Considerations

At this institution, this degree is administered by the college. In addition to the fact that it is not a research-based degree and has low enrollment, many departments and faculty are unfamiliar with the program. This creates a barrier to program promotion, faculty buy-in and resident student recruitment.

Program promotion has depended heavily on the program director during their tenure of administration. One program director whose tenure lasted from 1991-2001 worked to promote the program and recruit students through several approaches. She promoted the program within the institution through awareness by meeting monthly with faculty and staff of each engineering department. These are the best advocates for the program to current students, both undergraduate and graduate. This also gives an opportunity to explain the program to faculty who may not fully understand the merits of the degree. This director also spoke of the program at the college advisory board meetings. The two-fold benefits include recruitment of future students and job placements for current students. The board members may have employees who would benefit from this degree, and they may have an internship position for a current student which could lead to a full-time, leadership position. Another method of recruiting students is at conference exhibit halls. There are a plethora of engineers at these events who are potential future students. An easy way to promote the program is through networking with these engineers who, either themselves or a colleague, may consider pursuing additional qualifications in order to move into a position of higher leadership.

Another aspect of promotion and growth is the image of the degree. One aspect affecting image is the quality of the students and in turn admission requirements. The degree should be upheld as offered for a specific purpose and a specific type of student, not as a fallback program for students struggling to gain admission to a research-based doctoral program, students struggling in an existing program or students desiring a doctoral degree but lacking direction.

Future Improvements

The program has essentially remained the same for the past three decades. There are several areas of improvement and change that are currently being considered. The first change is in the delivery method. A request for approval to offer the program in an online format for distance students has been submitted. This will allow the program to grow by reaching students who cannot leave their job for one year to attend in residence. The other area of change is in the curriculum itself, both looking at a revision of its current design and adding new focus areas for a different type of student.

As mentioned, the student profiles are changing and becoming more varied. There is a need for more flexibility in the curriculum to meet individual student's unique career interests and knowledge needed. A fundamental revision to the program goals, objectives and approach is being considered. Rather than a three pillar approach of technical, business and internship, a more customizable curriculum is proposed, allowing alignment with the student's personal developmental goals. Five facets of engineering leadership are introduced: people, strategy, technical, delivery, operations. Coursework is spread among these facets, with three additional elective courses chosen by the student in support of his/her developmental objectives. See Figure 3.

Historically this degree has been targeted at engineers with 10-15 years of experience desiring an elevation in their career into a technical leadership position. A newly arising student profile is the engineer who has completed their career in industry and now teaches at an institution of higher education. This institution titles these engineers Professor of Practice. A new curricular thread is being developed to prepare these engineers for a second career in academia. This thread is composed of courses from the colleges of engineering and education, and the internship is fulfilled at the institution. The objective is to provide students with knowledge and tools to effectively teach in the classroom environment. Educational topics include course design, pedagogy, student learning theory and assessment techniques. This degree will benefit anyone with an engineering background and desire to teach engineering concepts.

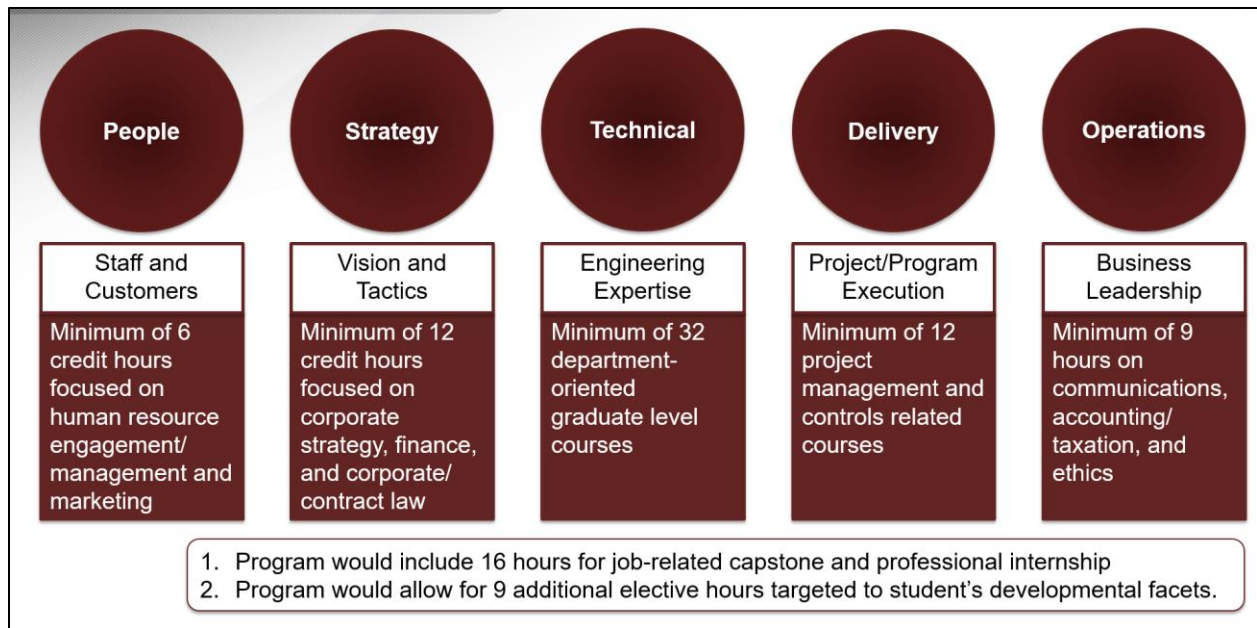


Figure 3: Proposed Program Curriculum Approach

Summary and Conclusion

This Doctor of Engineering program has existed for three decades and has served a specific purpose: provide the skillset for an engineer to excel in an industry leadership position. Its objective is changing to encompass a wider variety of students still with a need for a professional degree but with more varied career trajectories. For example, engineers ending their career in industry and moving to higher education as instructors. The program's foundation has rested upon the three pillars of advanced technical coursework, business coursework and a one-year internship practicum. To accommodate the changing student profiles, a revision to the traditional curriculum requirements is being explored. For those students remaining in industry or seeking to start their own business, a five facet approach to engineering leadership is proposed. For those seeking to transition out of industry into education, a new curriculum track is being explored to incorporate courses from the College of Education instead of the College of Business. While a small program with low enrollment numbers, due mainly to the lack of program promotion and awareness, the degree has highly benefited its students to achieve accelerated career progression and achievement of personal career goals.

Acknowledgements

The authors would like to thank former program director Dr. Karan Watson for her input on the program's history and current program director and former student Dr. Chuck Wolf for his perspectives on the value of this degree and sharing his proposed program revisions.