Elon's Enhanced Engineering Dual Degree Program

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Abstract – Engineers are problem solvers necessary for the advancement of society. With the infrastructure failing, environments stressed and population growing in number and demands, the need for more and talented engineers is clear. Elon University has developed a unique engineering dual degree program that produces well rounded engineers, special for their depth in the sciences and breadth in engineering. It is an enhanced and improved adaptation of engineering dual degree programs that most liberal arts colleges administer. When a student transfers to the engineering institution from this program he or she is essentially a true engineering junior, has a good understanding of what it is to be an engineering student and is well prepared for their final two years of schooling. This system has the potential to help increase the ranks in the engineering profession with numbers of special engineers.

Keywords: Engineering dual degree, Elon University

INTRODUCTION

There are over 420 liberal arts colleges in the United States. Many have listed in their catalogs that they support an engineering dual degree program. These programs are intended to enable a student to receive a liberal arts degree while completing a degree in some engineering discipline, all generally within five years. These programs usually require three years at the liberal arts college followed by two years at an affiliated engineering institution, hence the alternate program name of "3 plus 2".

Columbia University of New York produced the original engineering dual degree option back in the 1950's and has continued to be a major proponent of these programs. It maintains an affiliation with nearly one hundred liberal arts colleges. A cursory survey of these colleges' "engineering dual degree programs" indicates some commonalities: 1) the vast majority of these programs are housed in a physics department and are directed by a physicist, 2) they have no engineering faculty and have no engineering coursework during the three years at that college. Elon University perceives these as weaknesses and has created its program with the intent to avoid and/or correct them. Elon's system stands in sharp contrast to these programs and produces students clearly prepared for the transition to the affiliate engineering school and then onward to an engineering career.

TYPICAL ENGINEERING DUAL DEGREE PROGRAM

Columbia University started the early engineering dual degree program in house, the idea being that students would work on two degrees; one in engineering and one in a liberal arts discipline. Over time liberal arts institutions joined in affiliation with Columbia taking up most of the liberal arts requirements primarily for the liberal arts degree. The programs at these colleges have a similar structure. The students receive their basic mathematics through differential equations. They will also take course work in physics and chemistry, not too dissimilar to a two-year pre-engineering program. The student then focuses on their liberal arts coursework which typically is in physics. Therefore, at the end of three years the student has received a broad exposure to the sciences and mathematics along with fulfilling many of the general studies requirements for their liberal arts degree. The student then transfers to an engineering institution and then is expected to complete all their other requirements for the engineering degree within two years; a daunting task.

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These programs have inherent weaknesses:

- The completion of the engineering course structure in two years is unlikely. During these two years a student would be expected to take all their junior and senior level courses along with any introductory and sophomore level engineering coursework. Most challenging if not impossible.
- These programs typically do not offer any engineering courses on campus. Being stationed in the physics department, these programs are directed by a physics professor. Therefore, these programs focus is primarily on physics with little attention toward the engineering degree. Unfortunately, a common outcome is that in many of these programs students are retained in physics with few going on to the engineering school.
- These students have little or no connection to their engineering pursuit. They would receive limited advice and mentoring in support of their engineering aspirations.
- There are no engineering professors on campus. This omission leads to many of the before mentioned issues with these programs. Without an engineering educator on board who would teach any engineering courses, who would mentor and advise these students and move them on to finish their engineering degree.

Elon University takes the typical format described and administers it while addressing this format's weaknesses.

ELON'S PROGRAM

History

Elon University started its engineering dual degree program in the fall of 1999. It was patterned after a program that existed at Jacksonville University in Florida. At the outset there were two liberal arts options (engineering physics and engineering mathematics) and only one affiliate (NCSU) for the students. Over the years four more liberal arts degree options have been crafted and added; Chemistry/Chemical Engineering, Computer Science/Engineering, Environmental Studies/Environmental Engineering and Biophysics/Biomedical Engineering. There are now nine engineering affiliates; NCSU, VaTech, GaTech, Columbia, Penn State, Notre Dame, Washington University in St. Louis, University of South Carolina, and NC A&T. It is felt that giving the student an option in their liberal arts focus will better enhance and support their engineering discipline, e.g. chemistry is a better concentration for a future chemical engineer than physics or mathematics. Also, having a choice of an engineering school makes the program more practical, attractive and accessible for the student.

The Program

The basic philosophy of Elon's Program is to prepare the student to be an engineer with enhanced capabilities. It is felt the dual degree aspect of the program makes for a more well-rounded, more articulate and communicative engineer. Getting an engineering degree while also getting a degree in a supportive science or math should make for a brighter, more in depth engineer; one who is more prepared to be of service to the profession and the community.

Typically an engineering student enters Elon and takes an array of courses the first semester intent on giving them an appropriate introduction to engineering. Their fundamental coursework is arranged such that the first semester will include a math (Calculus I), a science (usually Physics w/Calculus I), their first engineering course, Challenges in Engineering, a writing intensive course (College Writing), a liberal arts course, and an orientation course. (Details follow in the Liberal Arts Options section.) The student then has an engineering and science course every fall and spring semester for their three years and a math course every fall and spring for their first two years. All of the engineering students, regardless of discipline, take the engineering fundamental courses and core course requirements listed in **Table I**.

All dual-degree engineering programs require the following core courses:

CHM	111	General Chemistry I	**3 sh**
CHM	113	General Chemistry I Lab	**1 sh**
CHM	112	General Chemistry II	**3 sh**
CHM	114	General Chemistry II Lab	**1 sh**
PHY	113	General Physics I with Calculus w/lab	**4 sh**
PHY	114	General Physics II with Calculus w/lab	**4 sh**
MTH	121	Calculus and Analytic Geometry I	**4 sh**
MTH	221	Calculus and Analytic Geometry II	**4 sh**
MTH	321	Calculus and Analytic Geometry III	**4 sh**
MTH	421	Differential Equations	**4 sh**
CSC	130	Introduction to Computer Science	**4 sh**

TOTAL 36 sh

Engineering Foundations

EGR	103	Challenges in Engineering	**3 sh**
EGR	206	Engineering Mechanics - Statics	**3 sh**
EGR	208	Engineering Mechanics - Dynamics	**3 sh**
At least two of the following three courses			
EGR/PHY	211/212	Circuit Analysis/ Lab	
EGR	306	Mechanics of Solids	
EGR/PHY	310	Engineering Thermodynamics	**8 sh**

TOTAL 17 sh

Table I: Core Requirements

Liberal Arts Options

There are six supportive science or mathematics liberal arts options that will be the dual or second degree these students work on as they pursue their engineering degree. Each of these liberal arts options will contribute to and strengthen the student's foundation, making for a more secure engineer on the bachelor degree level and even on to the graduate level. They are described below along with two representative templates giving their sequential coursework. The other four templates can be downloaded from the sites listed.

- Engineering Physics:

  This is a very popular dual degree for many of the mechanical, civil, aerospace and electrical engineering students. These engineering disciplines rely heavily on applied physics, therefore, this Engineering Physics degree is most useful for these aspiring engineers. The prescribed three year sequencing of this degree is presented in **Figure I** and can also be found on Elon's website at http://www.elon.edu/docs/e-web/academics/elon_college/engineering/Physics.pdf .

- Engineering Mathematics:

  The language of the engineer is mathematics. All engineering disciplines rely heavily on this fundamental study, especially for a student contemplating graduate work. Some students also have a strong affinity and comfort with mathematics, therefore, this option makes for a logical path into engineering for them. The prescribed three year sequencing of this degree is presented in **Figure II** and also on Elon's website at http://www.elon.edu/docs/e-web/academics/elon_college/engineering/Math.pdf .

Engineering Physics

Freshman Year

Fall Semester

Course #	Course Name	Hrs
MTH 121	Calc. and Analytic Geo. I	4
ENG 110	College Writing ***or***	
GST 110	Global Experience	4
PHY 113	Gen. Physics I W/Calculus	4
HED 110	Wellness	2
EGR 103	Challenges in Engineering	1
ELN 101	Orientation	1
	Semester Total	16

Winter Semester

Course #	Course Name	Hrs
Gen. Studies	General Studies	4
Spring Semester		
MTH 221	Calc. and Analytic Geo. II	4
ECO 201	Principles of Economics	4
PHY 114	Gen. Physics II W/Calculus	4
GST 110	Global Experience ***or***	
ENG 110	College Writing	4
EGR 103	Challenges in Engineering	2
	Semester Total	18

Sophomore Year

Fall Semester

Course #	Course Name	Hrs
MTH 321	Calc. and Analytic Geo. III	4
PHY 213	Intro. To Modern Physics	4
EGR 206	Engr. Mechanics.-Statics	3
CHM 111	General Chemistry I	3
CHM113	General Chemistry I Lab	1
PE ___		1
	Semester Total	16

Winter Semester

Course #	Course Name	Hrs
Gen. Studies	(Travel Abroad possible)	4
Spring Semester		
CHM 112	General Chemistry II	3
CHM114	General Chemistry II Lab	1
MTH 421	Differential Equations	4
EGR 208	Engr. Mech. - Dynamics	3
PHY ***	Upper Level Physics ***or***	
EGR 306	Mechanics of Solids	4
PE ___		1
	Semester Total	16

Junior Year

Fall Semester

Course #	Course Name	Hrs
PHY 311	Classical Electrodynamics	4
Gen. Studies	General Studies	4
Gen. Studies	UL Seminar	4
PHY 397	Lab Sem	2
EGRPHY310	Engr. Thermodynamics	4
	Semester Total	**18**

Winter Semester

Course #	Course Name	Hrs
Gen. Studies	(Travel Abroad possible)	4
Spring Semester		
PHY ***	Upper Level Physics ***or***	
Gen. Studies	Soc. Studies	4
CSC 130	Computer Science I	4
PHY 398	Lab Sem	2
EGRPHY211	Circuit Analysis	3
EGRPHY212	Circuit Analysis Lab	1
Gen. Studies	Humanities	4
	Semester Total	**18**

Total Hours Required = 114

Figure I: Engineering Physics three year plan

Engineering Mathematics

Freshman Year

Fall Semester

Course #	Course Name	Hrs
MTH 121	Calculus and Analytic Geometry I	4
HED 110	Wellness	2
ENG 110	College Writing ***or***	
GST 110	Global Experience	4
PHY 113	Gen. Physics I W/Calculus	4
EGR 103	Challenges in Engineering	1
ELN 101	Orientation	1
	Semester Total	16

Winter Semester

Course #	Course Name	Hrs
Gen. Studies	Civilization?	4

Spring Semester

MTH 221	Calculus and Analytic Geometry II	4
MTH 231	Mathematical Reasoning	4
PHY 114	Gen. Physics II W/Calculus	4
GST 110	Global Experience ***or***	
ENG 110	College Writing	4
EGR 103	Challenges in Engineering	2
	Semester Total	18

Sophomore Year

Fall Semester

Course #	Course Name	Hrs
CSC 130	Computer Science I	4
MTH 321	Calc. & Analytic Geo. III	4
(REL 348)	General Studies	4
EGR 206	Engr. Mech. - Statics	3
PE ___		1
	Semester Total	16

Winter Semester

Course #	Course Name	Hrs
Gen. Studies	Travel Abroad?/Soc. Sci.	4

Spring Semester

MTH 311	Linear Algebra	4
MTH 415	Numerical Analysis *or*	
MTH 421	Differential Equations	4
EGR 208	Engr. Mech. - Dynamics	3
CSC230	Computer Science II	4
PE ___		1
	Semester Total	16

Junior Year

Fall Semester

Course #	Course Name	Hrs
MTH 341	Prob. Theory and Stat.	4
CHM 111	General Chemistry I	3
CHM113	General Chemistry I Lab	1
Gen. Studies	UL Seminar	4
EGR 310	Engr. Thermodynamics	4
	Semester Total	16

Winter Semester

Course #	Course Name	Hrs
Gen. Studies	Literature (ENG 311)	4

Spring Semester

MTH 415	Numerical Analysis *or*	
MTH 421	Differential Equations	4
MTH 312	Abstract Algebra	4
CHM 112	General Chemistry II	3
CHM114	General Chemistry II Lab	1
EGR 211	Circuit Analysis	3
EGR 212	Circuit Analysis Lab	1
	Semester Total	16

Total Hours Required = 110

Figure II: Engineering Mathematics three year plan

- Computer Science/Engineering:

  For the student interested in computer and/or electrical engineering, getting a good foundation in computer science is very valuable. This dual along with the computer engineering degree would produce an engineer well versed in computer software and computer hardware; a very attractive combination. The prescribed three year sequencing of this degree can be found on Elon's website at http://www.elon.edu/docs/e-web/academics/elon_college/engineering/BioPhysics.pdf.

- Chemistry/Chemical Engineering:

  This dual will give the student an opportunity to take more chemistry than a typical chemical engineer might take. To become deeper in a science foundation of the engineering discipline pursued is a strong plus. That is the general theme with all of the dual degree options and particularly with chemical engineering. The prescribed three year sequencing of this degree can be found on Elon's website at http://www.elon.edu/docs/e-web/academics/elon_college/engineering/Chemistry.pdf.

- Environmental Studies/Environmental Engineering:

  In many cases environmental engineers do not have the opportunity to receive the diverse environmental studies courses possible with this dual degree. Here the environmental engineer will take biology and addition chemistry coursework as well as literature, political science and philosophy courses focused on environmental issues. The prescribed three year sequencing of this degree can be found on Elon's website at http://www.elon.edu/docs/e-web/academics/elon_college/engineering/EnvStudies.pdf.

- Biophysics/Biomedical Engineering:

  In collaboration with the Biomedical Engineering Department at Washington University in St. Louis the dual for biomedical engineering students was crafted. The student will take a set of courses in biology (3) and advanced physics (3) that will prepare them for their upper level coursework in Biomedical Engineering. The prescribed three year sequencing of this degree can be found on Elon's website at http://www.elon.edu/docs/e-web/academics/elon_college/engineering/BioPhysics.pdf.

Benefits

Benefits of this program are recognized by both students and the university.

The university sees a fine group of students that tend to be bright, certainly more skilled and interested in the sciences and math and exhibit a maturity level above the university's norm. The university gains from their presence, albeit small (about 1% of the student body). These students are clearly a boon to the math, physics and chemistry departments. These students swell these departments' ranks with intelligent and motivated students.

The university is now affiliated with some top tier institutions such as Penn State, Georgia Tech (ranked as two of the top ten engineering schools in the country) and Columbia. It is clear from the agreements established with the affiliates that they see Elon as an extension of their institution and vice versa. These affiliations bring prestige to Elon.

The benefits to the student of a program like this can not be overstated. The following attempts to highlight a few of these benefits.

- Small is good:

  The first years of an engineering degree are formative and difficult. Starting at a small institution enables the student to receive supportive and focused instruction at, what is primarily, a teaching institution.

Of course one of the major benefits for the student is small class size. This program at Elon is seen as an alternative to the large institution, therefore, class size is intentionally small, making for more concentrated attention and support. In a program like this a student will most likely never see an auditorium class, certainly not at an Elon.

The small institution also brings side benefits like all classes are taught by the professor of record (no graduate students) and few adjuncts.

- Options and flexibility:

  If a student is unclear of which engineering discipline to pursue, this program has built in flexibility. All students receive a similar freshmen year (see Liberal Arts Options section) and take most all the same engineering foundational courses during their stay at Elon. The Challenges in Engineering course (see section on "Challenges in Engineering") taken their first year helps the student in their decision process as does the individual mentoring they receive (another advantage of a small program).

  Even the liberal arts major selection can, with planning, be delayed in most cases to the end of the first year. For the student that chooses to drop out of engineering they have a built in fall back since they are already working on a liberal arts degree. In fact, the majority of students that do drop engineering continue at Elon pursuing that degree.

Transferring to the engineering school

After three years at Elon the students transfer to an engineering institution to complete their engineering degree. The transfers are fairly seamless because of the course evaluations completed and the equivalencies established by the affiliates and attested to in a signed agreement. The five year framework works well as the vast majority of our students complete both degrees in five years. If we consider the few that needed a summer to fill in some delinquent course, over 90% of these students have completed both degrees on schedule.

All of the students in this program that have completed their three years at Elon have gone on to an engineering school. Most have gone to an affiliate, however, several have entered and gotten degrees from the University of Florida, University of Texas, Austin, University of Tennessee and George Mason (added flexibility for these students).

Also, all the students that left Elon in good standing received their engineering degree and a growing number are now pursuing a graduate degree in engineering. The program obviously prepares them well.

Investments

Elon believes strongly in this program. It has invested in a program that encourages students to pursue their engineering degrees and it is felt gives much to this academic community. The major investment is in faculty. Elon has two engineering faculty on board. They teach all the engineering courses, advise and mentor all the engineering students and direct the program. The student, therefore, is engaged with engineers from the outset and will receive at least one engineering course each fall and spring, taught by one of these engineers.

Elon has allocated space to the program. This space includes offices for both faculty and a small computer and study lab (six computers) designated exclusively for engineering students. A location was established for a spacious (1000 sq. ft.) and well equipped engineering workshop that was built completely on donations from appreciative parents. A whole floor in one of the most spacious dormitories on campus has been designated a "learning community" for math, science and engineering students only.

Elon also supports the program with an annual operating budget and an annual library allocation.

On top of this Elon also offers several engineering scholarships that help recruit and support excellent engineering students. These students help form a strong nucleus with each entering class.

All of these efforts, financial and otherwise, are evidence of Elon's commitment to this program. It is recognized that the students in this program contribute much to the university as an academically prepared

group (average SAT's are 10% higher that overall average at Elon). (The fact that about 80% are male is also attractive to the administration on a campus which is 60% female.)

"Challenges in Engineering"

Over the years the program has worked to improve and no course has received more effort that the introductory course(s). Presently the typical engineering introductory material (such as ethics, technical communication, engineering disciplines, etc.) is given in a two semester, three credit hour course entitled Challenges in Engineering, EGR 103. During the first semester (fall freshmen year) the freshmen are introduced to the engineering design process and the varied engineering disciplines along with other basic introductory material. They work in teams and make three presentations during the semester. However, a major component of this first semester is a freshmen design project. This year they created underwater robots. During this project they become familiar with the engineering design process, develop their design skills and learn to work in groups.

The second semester (spring freshmen year) has two major components along with some more engineering basics. One major component will be a segment on computer graphics and 3-D modeling using SolidWorks. The other major component is a service learning effort. The students prepare class projects in science and engineering and then go out into the local community (past examples include the Salvation Army Boys and Girls Club and AIG, Academically and Intellectually Gifted, students at a local elementary school). The students create and direct class exercises with their projects. The intent is 1) to raise an interest in the sciences and engineering with this young audience and 2) instill in the engineering student that they have an opportunity, ability and obligation to serve the community.

The Challenges in Engineering course is foundational and instructive. It should give the student some insight into how an engineer thinks and some of their engineering tools. It is also to be engaging and stimulating with the intent of helping retain these gifted students.

CONCLUSIONS

Engineering dual degree programs have existed for some fifty years and are offered at many liberal arts colleges. However, these programs are limited in scope, options and functionality. Elon's enhanced engineering dual degree program was created with the intent of given engineering students a true option to the standard four year engineering programs; a program that prepares them to be well-rounded engineers with depth in the sciences and breadth in engineering.

The Elon program enables the student to realistically work toward a degree in engineering while getting a degree in a supportive science or math. This is accomplished by having engineering faculty at the liberal arts college teaching engineering courses. These faculty give the engineering student at least one engineering class each fall and spring semester. Thereby, at the end of the student's three years at Elon the student has finished two years of engineering coursework, along with completing much of their liberal arts degree. When a student transfers to the engineering institution he or she is essentially an engineering junior and has a good understanding of what it is to be an engineering student. They are well prepared for their final two years of schooling haven taken up to six engineering courses.

The adoption of a program such as Elon's at other liberal arts colleges could help boaster the ranks of engineers in the United States with excellent engineers.

Dr. Richard D'Amato

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