

Undecided Engineers: A First Year General Engineering Program

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Abstract- At Florida Institute of Technology, freshmen students can enter a first-year engineering program called General Engineering that allows students to delay declaration of their major for up to one year. In this program, students learn about the different engineering disciplines in order to choose the major that best matches their interests and skill sets. Students learn the basic critical thinking and problem solving skills of an engineer while using numerical computation and computer-aided design. To give the students an idea on how the different engineering disciplines collaborate in the workforce, students of different interests are grouped together for a common design project. Student data from 2005 through 2012 showed General Engineering students graduate approximately 10% sooner than other engineering students, while having similar change of major rates, GPA's, graduation rates, and retention rates.

Keywords: general, engineering, freshman, undecided, Florida Tech

Background

Advances in research and technology throughout recent history have created a vast network in our society through the exchange of both products and ideas, creating the scientific wealth we have today. Engineering knowledge is expanding at an ever-increasing rate with breakthroughs in every field occurring almost daily and with no signs of diminishing. Simply comparing the Wright brothers' first flying machine to man's first mission to the moon, occurring a mere 66 years apart, brings both pride and inspiration to the engineers of today. Much of this innovation can be credited to the advancement of high-speed computing and real time simulations. With such tools, a single engineer is capable of fully designing and testing a complicated system using a computer in a number of days rather than years.

FIT is a small, private, STEM driven school located in Melbourne, Florida. The university was founded in 1958 by Dr. Jerome P. Keuper and initially began as a graduate school for engineers, scientists, and technicians who were working with National Aeronautics and Space Administration (NASA) in Cape Canaveral, Florida. Currently, the university offers 58 on-campus bachelor degrees with nine of these degrees being different disciplines within engineering. These disciplines include: aerospace, biomedical, chemical, civil, computer, electrical, mechanical, ocean, and software engineering. However, Florida Tech's College of Engineering (COE) offers 14 disciplines all together, including: computer science, construction management, environmental science, meteorology, and oceanography. Roughly 55% of the student population at Florida Tech is engineering majors.

Some universities offer a large array of majors, like the University of Michigan with their 250 options [1]. This makes choosing a major for most students a very difficult decision to make. Due to the numerous opportunities at Florida Institute of Technology, many incoming freshmen can be easily overwhelmed as well. To help these students, in 1994 the university introduced a new program for freshmen students, General Engineering. The program was intended for freshmen students who excel in both the sciences and mathematics and are interested in engineering, but are unsure of which discipline to choose. The General Engineering program is a one-year exploratory program, which allows students to become familiar with all of the majors in the college of engineering before declaring their major.

While enrolled in the program the majority of students will take the courses shown in Table 1, but adjustments are made depending on placement and transfer credits. These courses allow the students to take some of the basic engineering classes that are required for any of the majors in the college of engineering, which for the first few

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semesters are very similar. While students are urged to choose a major after the first semester they are allowed to stay undecided for up to two semesters.

Table 1: General Engineering Curriculum

FALL	COURSE	CREDITS	SPRING	COURSE	CREDITS
ASC 1000	University Experience	1	COM 1102	Writing about Literature	3
CHM 1101	General Chemistry 1	4	CSE 1502	Intro to Software Development	3
COM 1101	Composition and Rhetoric	3	MTH 1002	Calculus 2	4
EGN 1000	Introduction to Engineering	3	PHY 1001	Physics 1	4
MTH 1001	Calculus 1	4	PHY 2091	Physics Lab 1	1
TOTAL		15	TOTAL		15

Many universities do not offer students an introductory General Engineering class; however, Harvey Mudd College and Clemson University are two of the few schools that offer a similar program to Florida Tech's General Engineering Program. Harvey Mudd College requires their engineering students to take basic core classes, followed by students choosing from a list of electives they would like to take. These electives relate to different core disciplines of engineering (chemical, civil, electrical, and mechanical) [2]. When the engineering student graduates, he or she will have a bachelor's of science in General Engineering. Clemson requires all of the incoming freshmen engineering students to take a general engineering course where students learn about engineering science [3].

Introduction to General Engineering Paradigm

Not every student who enters the engineering field knows with certainty which program they want to study. With fourteen (14) different options available to them, making a decision can often overwhelm an undecided freshman. Since 1940 the number of programs available to students in the United States has tripled and hasn't shown to slow [4]. To help the students who take the General Engineering program not fall behind declared students, an introduction level course, EGN 1000 Introduction to General Engineering, was designed with a similar structure as other introductory classes. Topics were chosen to assist them to identify, and to a limited extent analyze and solve, engineering problems using tools and techniques they may not be accustomed to. EGN 1000 is split into two parts; a twice a week lecture and a once a week lab. In the lecture section the students have both mandatory homework and in class assignments with two exams split through the semester. In the lab section, weekly homework problems are assigned related to the material covered that week. Course outcomes include:

- To introduce students to various career disciplines in engineering and applied sciences.
- To introduce students to fundamental approaches in engineering.
- To create an awareness of the responsibilities of engineers to their profession.

In the classroom lectures, topics include: brief history of engineering, engineering careers, engineering units and dimensions, work-integrated experiences, student and professional ethics, student success, and engineering disciplines. Specifically, the following topics are extensively covered over the course of the semester.

- Steps in engineering design: Identify the problem, organize goals, conduct research, brainstorm solutions, develop a test, perform group review and documentation
- Creative problem solving: What is wrong, what do we know, what is the problem, what are the solutions, how do we implement our solution

2014 ASEE Southeast Section Conference

- Critical thinking
- Group brainstorming
- Design factors: Cost, performance, reliability, safety, manufacturability etc.
- Engineering ethics: Study of morality, the different regulations involved (NSPE)
 - Past engineering tragedies that could have been easily avoided such as the fuel tank from the Ford pinto and the Challenger disaster.

In order to thoroughly cover the various disciplines offered in Florida Tech's College of Engineering, a faculty member from each department gives a 50-minute presentation to the students related to what their field has to offer. Typically, presentations include an overview of the curriculum, ongoing research and design projects, and industry job opportunities. In addition, the guest speakers explain the different types of specialties that are in the discipline.

The lab sections of the course are taught by two graduate students who earned their B.S. from one of Florida Tech's engineering programs. After completing the lab, the students will have learned how to effectively use both Excel and MATLAB to manipulate data, and implement simple algorithms with code. After several weeks of technical computing, the students learn technical drawing and design in both a 2D and 3D environment. The Computer-Aided Design (CAD) part of the course covers both drawing by hand and computer including different types of part views such as isometric views and multi-view projections. During the final weeks of lab, students are given a CAD project to develop a functioning multi-part assembly. A summary of a typical lab schedule is shown in Table 2.

Table 2: Common Lab Schedule

Class	Topic
1	Excel spreadsheets
2	Excel plotting; Data organization; Machine Shop tour
3	MATLAB: Storing variables; Matrix multiplication
4	MATLAB: Plotting data; Loops: for loop, while loop
5	MATLAB / Simulink; Representing physical systems and equations with Simulink blocks.
6	Engineering Drawing and drafting
7	Engineering Drawing and drafting
8	CAD; Creo Parametric 2.0; Basic Tools
9	CAD; Creo Parametric 2.0; Making parts
10	CAD; Creo Parametric 2.0; Representing parts in drawing format
11	CAD; Creo Parametric 2.0; Making Assemblies

By the end of this course, students have been introduced to the primary topics required to think like an engineer. Having the right mindset is vital for not only becoming a successful engineer, but to complete the required courses for graduation.

Freshman General Engineering Design Project

At Florida Tech, most College of Engineering departments require freshmen students to take an introductory class to help the students understand the types of classes that they will encounter if they stay with the program, and expose the students to a design project related to their major. This gives students valuable information to whether they will enjoy the selected program and gives students the chance to change majors before they move on into more specialized curriculum. For instance, in Introduction to Aerospace Engineering, groups of students design rockets while predicting different variables including the rocket's velocity, landing location, and the maximum height it will reach. For the Civil Engineering introduction course, the students make different batches of concrete that have varying amounts of water, cement, and aggregates. After the concrete cures, it goes through a compression test. The students analyze different types of failures that the concrete endures.

For the Fall 2013 Introduction to General Engineering class, students were placed into nine different groups of three to four students. The project was to design and build a mini-golf hole that followed certain guidelines. The requirements given to the students include: must have a par less than or equal to six, must be transportable, and must incorporate at least one feature from two different disciplines. For example, a moving object such as a windmill would be from the Mechanical/Aerospace fields. A Civil Engineering feature could be a bridge, tunnel, or building. An electronic scoreboard or lights would be from Electrical/Computer Engineering. Additionally, the students were given two 3' x 4' frames, a 4" golf hole cup, a sheet of fake grass, and a \$100 dollar budget for additional materials.

Upon project completion, the mini-golf course was available for the campus community to play. Part of the overall project grade was based on how accurately the group predicted par, so students needed to account for the difficulty of their hole. The project was graded based on:

- (20%) Construction quality (graded by judges)
- (30%) Aesthetics and enjoyment (graded by judges)
- (20%) Accurate CAD drawing of the design and/or major features(s)
- (30%) Final presentations and write-up
- Penalties:
 - (10%) If a group runs over budget
 - (2%) Every half stroke above/below the designated par based on the average score of campus community participants

The learning outcomes for this semester-long design project were used to challenge the students in various ways. By completing this project, students demonstrated:

- An ability to work in an interdisciplinary group
- Their verbal and written communication skills
- Their design-related problem solving skills
- Their knowledge of their chosen major and of other engineering major(s)
- Their construction skills

The students worked with the people in their groups who have different backgrounds, experiences, and interests. While working in groups the students demonstrated their ability to learn to work with those who have different opinions, teaching the students how to compromise and come up with solutions. Another outcome was for students to work on both their verbal and communication skills. The students communicated with each other in their project presentation and in their preliminary and final design reports. The requirements for the preliminary report were an introduction, design overview, task assignments for each group member, proposed timeline, and a budget. The final report required an introduction, design overview, final budget, discussion on the stages of the design process, CAD drawing(s) of the one or more features of the hole, and the lessons learned/conclusions.

This project also developed their hands on skills. At least one of the group members must have been machine shop certified through Florida Tech in order for the group to use the machine shop to construct their project. The last outcome of this project was for the students to have better design-related problem solving skills. Throughout projects, things typically go wrong. However, engineers need to figure out what the issue is and how to fix it. With this design project, the students will learn this skill. Examples of the golf holes can be seen in Figures 1 and 2.



Figure 1: Mini-Golf Holes under Construction

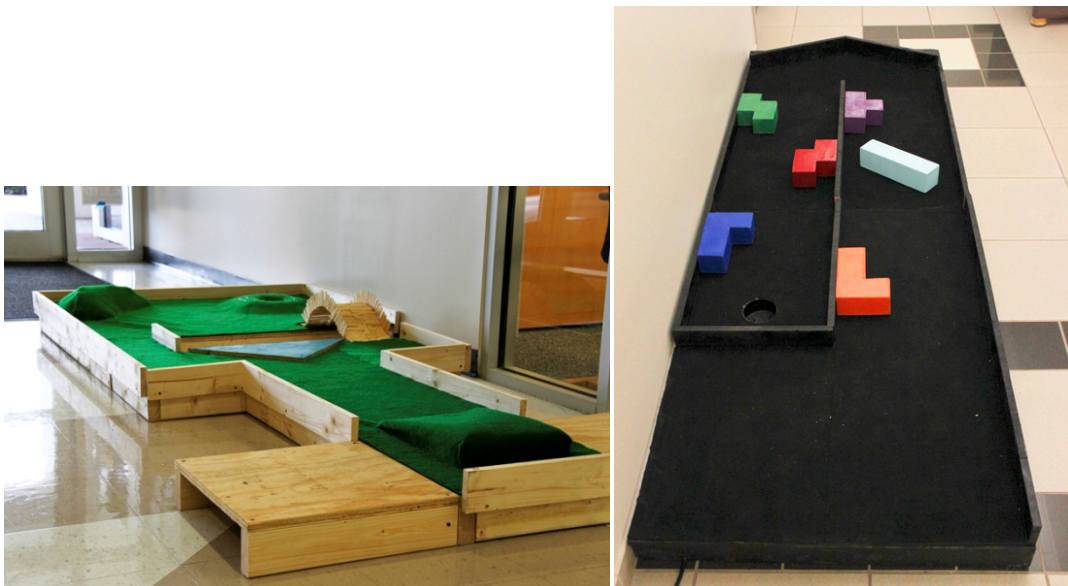


Figure 2: Finished Mini-Golf Holes

Florida Institute of Technology General Engineering Program

According to The New York Times, roughly 75% of college students change their major before graduating [5]. This includes engineering students who lose sight of why they were studying engineering in the first-place, which is highly due to the passive lectures and traditional teaching styles. By switching majors often, students may fall behind in their coursework requiring them to pay additional tuition [6]. The General Engineering program at Florida Tech allows students to learn about all of the College of Engineering majors and to make an informed major selection, reducing the number of times the student will change his or her major. Table 3 shows the average number of times an engineering student changed his major at Florida Tech in the years 2005 through 2007. Those years were chosen, as six-year graduation rates also exist for later comparison. The percentage rates for the General Engineering students do not count the required major change during the freshman year. A clear trend is not evident in the limited amount of data; however, General Engineering students on average change their major 3 percentage points less than all other engineering students at Florida Tech. In addition, over 88% of students who changed their majors stayed within the College of Engineering, indicating that they could have benefited from the General Engineering program's focus on selecting an engineering major.

In 2005, the graduation rate for full time students attending a four-year university and graduating within six years was 59 percent [7]. In Table 4, one can see the graduation rates for both the students within the COE departments and the General Engineering program. Again due to limited data, no clear trend is visible. In 2005 and 2006, it can be seen that the COE program retained more of its students relative to General Engineering, but in 2007 a relative increase in retention occurred within the general program. For the students who stayed within the COE program until graduation, the 95% confidence interval for the six-year graduation rate is 49.9 ± 6.43 . General Engineering students who remained with an engineering program until graduation had a six-year graduation rate of 42.3 ± 22.68 . Students who left the COE program demonstrated a relatively higher six-year graduation rate of 56.5 ± 6.57 , while General Engineering students exiting the program had a six-year graduation rate of 46.5 ± 18.13 . As more data becomes available, more precise estimates of the six-year graduation rate will be available.

Table 3: Average Times a Student Changes Their Major

	Fall 2005	Fall 2006	Fall 2007	Average
College of Engineering (excluding General Engineering)	0.28	0.26	0.20	0.25
General Engineering Students	0.23	0.29	0.15	0.22

Table 4: Six-Year Graduate Rates

		Fall 2005	Fall 2006	Fall 2007	Total
College of Engineering (excluding General Engineering)	Initial Cohort	297	315	356	968
	Graduated within COE (%)	150 (50.5)	169 (53.7)	164 (46.1)	483 (49.9)
	Graduated within University (%)	175 (58.9)	186 (59.0)	186 (52.2)	547 (56.5)
General Engineering Students	Initial Cohort	28	20	23	71
	Graduated within COE (%)	11 (39.2)	6 (30.0)	13 (56.5)	30 (42.3)
	Graduated within University (%)	13 (46.4)	7 (35.0)	13 (56.5)	33 (46.5)

Table 5 shows the initial and retained number of freshman students in both the COE (excluding General Engineering) and General Engineering, which have similar trends throughout their eight-year period. The numbers differed primarily during the last two years but with more incoming students. Also during the past two years, there has been an increase in the number of students joining the program, consistent with how FIT has been growing in size. Again, no clear trend is evident. General Engineering has shown a higher retention rate in four years (2007, 2008, 2010, and 2012). COE had a higher rate in three years (2005, 2006, and 2011) along with a slightly higher overall rate, 78.2% compared with 76.4% for General Engineering.

An initial comparison of average semesters to graduation between the COE students and the General Engineering students was conducted. Table 6 illustrates that on average, students from the COE program took approximately 10% longer to graduate, taking about nine semesters compared to eight semesters for General Engineering students. This difference may be attributed to General Engineering students putting more thought into what program they would be most interested in, and most likely to succeed in. In order to better understand the data, and identify the likelihood of self-selection bias, the average GPA's of COE and General Engineering students were analyzed. The average GPA's throughout six semesters, starting from first semester freshman year to sixth semester junior year between the two groups were sampled and the trends showed that both programs held fairly even GPA's, differing only a few percentage points each year.

Table 5: First-year retention numbers

		Year								
		2005	2006	2007	2008	2009	2010	2011	2012	Total
COE	Initial	297	315	356	321	274	269	365	402	2599
	Retained (%)	229 (77.1)	251 (79.7)	257 (72.2)	251 (78.2)	209 (76.3)	212 (78.8)	300 (82.2)	325 (80.8)	2034 (78.2)
General Engineering	Initial	28	20	23	21	21	17	39	34	203
	Retained (%)	21 (75.0)	13 (65.0)	18 (78.3)	18 (85.7)	16 (76.2)	14 (82.4)	27 (69.2)	28 (82.4)	155 (76.4)

Table 6: Average Semesters to Graduation

		Fall 2005	Fall 2006	Fall 2007
COE (exclude Gen. Eng.)	# of Students	175	186	186
	Average semesters to graduation	9	9	9
General Engineering	# of Students	13	7	13
	Average semesters to graduation	8	8	9

Conclusions

The General Engineering program has shown to be an invaluable resource for students at Florida Institute of Technology over the past years by giving students the option to begin their studies while reviewing their options to make an informed decision. The General Engineering program saves students time (and thus money) over the course of their studies. Further collection and analysis of student data will provide greater insight into the overall impact of the General Engineering program. The next step of analyzing the General Engineering program would be examining the retention and graduation data before the program started in 1994 and compare the program's impact. The program was started in 1994; therefore it is one of the newer programs on campus. Program enrollment has been consistent with overall engineering trends, showing a strong interest and demand. The General Engineering program allows students to avoid proceeding down a path they may not be fully committed to, leading to shorter graduation times and potentially higher retention and graduation rates.

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Biographical Information

Denis Andre

Denis Andre received his bachelors of science degree in Mechanical Engineering at Florida Institute of Technology. He has an interest in Heat Transfer and is currently pursuing his Masters in Thermal Fluid Science. During his undergraduate studies he participated in the Formula SAE design project and led the GROVER or grooming rover senior design project, which was used to clean docked boats of light biofouling.

Alexandra Boggs

Alexandra Boggs received her bachelors of science degree in Civil Engineering at Florida Institute of Technology. She is currently a Fast Track student at Florida Tech which allows her to graduate with her masters in Civil Engineering a year after she completed her bachelors. While a student, she has participated in the Concrete Canoe Team at FIT.

Matthew J. Jensen

Dr. Matthew J. Jensen is currently an Assistant Professor of Mechanical Engineering and the ProTrack Co-Op Coordinator at Florida Institute of Technology. He received his bachelor's degree in Mechanical Engineering from Rose-Hulman Institute of Technology and received his doctorate from Clemson University in Mechanical Engineering. His research interests include applications in automotive/transportation safety, electro-mechanical systems, work-integrated learning and engineering education.