

Pre-Engineering Options at Florida Community and State Colleges

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Introduction and Background

Students often attend community and state colleges as a first step to earning an advanced degree after completing their high school education. These programs are ideal for a wide range of students for a variety of reasons. Some are non-traditional students who are returning to the classroom from the work force while still employed full-time; some are unable to afford tuition at larger universities; some are unable to afford room and board at larger universities; some are dual-enrolled while in high school and concurrently attaining an Associate degree; and some desire a smaller class size that provides additional educational support. Most of these students start their education program by enrolling in an Associate of Arts (AA) degree. These programs, however, often are not specifically designed to transfer into an engineering Bachelor of Science degree program.

According to the Florida Department of Economic Opportunity, out of a total of 126 occupations listed for 2024 growth projection, 16% of the top 25 are engineering [1]. Of the total occupations requiring a bachelor's degree, 13% are in engineering [1]. Those employed with a bachelor's degree in engineering comprise 23% of the top one-half of the median average and 13% of the top quarter median wage earners [1]. Thus, engineering is one of the highest paying and in-demand professions with a bachelor's degree.

The goal of this paper is to promote the study of engineering in the state of Florida and potentially nationwide by those students who do not choose, for possibly many reasons, to enroll in an engineering program as a freshman student at a university. Thus, the first step is to survey the different options available to students who desire to pursue an engineering degree by first attending Florida community and state colleges. The research conducted here investigates the current Florida community and state college curricula in order to determine the degrees, programs, and courses currently available to students interested in pursuing a degree in engineering at the bachelor's level.

There are "two viable pathways to the baccalaureate degree [which] have developed in the past one hundred years - a direct entry route where a student begins and ends at a four-year institution, and a transfer route" [2]. The transfer route is usually accomplished by the student attending a smaller institution, whether two years or four years. Smaller institutions do not usually have the same "capacity constraints, corresponding increases in admissions selectivity, and increasing real tuition at four-year universities" [2]. Smaller institutions, including community colleges, can usually offer "lower cost, convenience and proximity to home, and smaller class sizes" [2].

In the fall of 2014, total undergraduate enrollment in degree-granting postsecondary institutions nationwide was 17.3 million students, an increase of 31 percent from 2000, when enrollment was 13.2 million students [3]. Undergraduate enrollment is projected to increase 14 percent from 17.3 million to 19.8 million students between 2014 and 2025 [3]. In higher education, community

colleges are surpassing the enrollment at other institutions, enrolling half of the first-time freshmen at public postsecondary institutions and 43% of all undergraduates [4]. The increased need for the ability to transfer to an institution that provides the desired bachelor's degree is enhanced as those who first attend a community college increase [2].

Engineering, being a specialized profession, requires specific courses to be completed prior to entering the junior year of an ABET-accredited program. The subset of the undergraduate population that transfers into an engineering program" has become significant as the United States looks to ameliorate the erosion of its preeminence in science and technology in the world" [2]. According to the Committee of Science, Engineering, and Public Policy and the National Science Board as reported by Ashby, "the decline of U.S. born baccalaureate and graduate degreed engineers and scientists and increasing global competition for engineers and scientists, there are those that argue that the very security and future economic prosperity of the country is threatened if the U.S. does not reverse these trends" [2].

The role played by two-year programs is an "integral part in engineering baccalaureate degree production in higher education" [2]. According to the National Science Foundation's report, 42% of recipients of undergraduate degree in engineering attended a community college [5]. "Given the increasing number of individuals who begin their postsecondary education at community colleges, transfer education is seen by many policymakers as integral to addressing the increasing need for U.S. born engineers and scientists" [2].

Ashby conducted research on community college undergraduate engineering transfer students at a research university. The College of Engineering at the University of Washington was the focus of the study. It was found that pre-engineering students who transferred from state community colleges, "graduated at the same rate as direct entry university students." While this study was limited to one engineering institution, it did "confirm the vitality of engineering transfer education and the effectiveness of transfer practices and policies" [2].

Thus, research is needed on this viable and significant university transfer student population. "[A]t the request of the National Science Foundation, the National Academy of Engineering and the National Research Council of the National Academies appointed a national ad hoc committee of two- and four-year college and university faculty and administrators to make recommendations on how to increase engineering transfers and otherwise enhance the role of community colleges in educating engineers" [2]. The report found that the transfer process is enhanced when faculty at bachelor degree engineering programs communicate with faculty at two-year engineering science programs and identifying objectives favorable to both [6]. The report does not investigate pre-engineering programs per se.

Lower cost and smaller class size can aid in successfully completing the first two years of an engineering degree. Having a dedicated pre-engineering program at one institution that ensures transfer into an ABET-accredited program would be optimal. There is a dearth of research regarding pre-engineering programs where students complete their lower division coursework at a different institution from the engineering degree conferring university. A program such as this can be delivered via universities, colleges or State community colleges. Once the pre-engineering

program is completed, these students would then be able to transfer into an engineering program as a junior.

As the goal of this paper is to promote the study of engineering in the state of Florida, the surveyed information will pertain directly to the colleges and universities in Florida. The findings, however, have the potential to be applicable nationwide.

Overview of the Florida System

The state of Florida's system of public higher education consists of four main governing bodies for higher education. These are: the Florida College System (FCS) (prior to 2009 known as the Florida Community College System), the Board of Governors State University System of Florida, the Commission for Independent Education, and the office of Student Financial Assistance [7]. The FCS currently consists of 28 public community and state colleges which are coordinated under the jurisdiction of the State Board of Education. Administratively, the chief executive officer of the system is the Chancellor of the FCS, who reports to the Florida Commissioner of Education. The State University System of Florida currently consists of 12 public four-year universities, and is overseen by a Chancellor and governed by the Florida Board of Governors. The Commission for Independent Education has responsibility for nonpublic post-secondary educational institutions, and the Office of Student Financial Assistance administers the scholarship and grant programs.

As part of the Florida Department of Education, Florida has created a Statewide Course Numbering System (SCNS). This system articulates a common courses numbering system to be used by the colleges and universities in the state. The SCNS specifies the level at which the course is taught and the topics covered in each course with the same number. Courses with the same number are guaranteed to transfer to institutions offering a course with the same course number. According to their website, the SCNS was created in the 1960's and "is a key component of Florida's K-20 seamless system of articulation. The system provides a database of post-secondary courses at public vocational-technical centers, community colleges, universities, and participating nonpublic institutions. The assigned numbers describe course content to improve research, assist program planning, and facilitate the transfer of students" [8].

This paper expounds on the FCS and the opportunities offered at these institutions that prepare students for a degree in engineering. The 28 colleges in the Florida College System are listed on Table 1 and are shown on the accompanying map in Figure 1.

The colleges in the Florida College System offer a variety of degree programs to include Bachelor of Science (BS), Bachelor of Applied Science Programs (BAS), Associate in Science (AS), Associate in Applied Science (AAS), Applied Technology Diploma (ATD), and Technical Certificate Programs as well as Associate in Arts (AA) degrees. Despite the variety of degrees offered, none of the AS, AAS, or BAS degrees include any engineering programs and of the 147 BS programs offered, only four degrees include engineering technology and none of the programs include specific engineering fields themselves [9]. The AA degree is the only degree that is guaranteed to transfer in totality to a Florida university. Thus, the AA degree and its curriculum will be the focus of this paper.

Table 1: Colleges in the The Florida College System [10]

Eastern Florida State College	Miami Dade College
Broward College	North Florida Community College
College of Central Florida	Northwest Florida State College
Chipola College	Palm Beach State College
Daytona State College	Pasco-Hernando Community College
Florida SouthWestern State College	Pensacola State College
Florida State College at Jacksonville	Polk State College
Florida Keys Community College	St. Johns River State College
Gulf Coast State College	St. Petersburg College
Hillsborough Community College	Santa Fe College
Indian River State College	Seminole State College of Florida
Florida Gateway College	South Florida State College
Lake-Sumter Community College	Tallahassee Community College
State College of Florida, Manatee-Sarasota	Valencia College

Figure 1: Map of the Colleges in The Florida College System



Students attending these FCS institutions have the ability to pursue a Bachelor’s degree at one of Florida’s universities following their attainment of an AA degree. The State of Florida has specifically designed their higher educational system so that the transfer process is smooth and guaranteed for a student who has received their AA degree from a FCS institution to be able to transfer to a Florida four-year institution and is referred to as the 2+2 system. This system operates for either a Florida state university or a Florida college [11]. This system is supported by a Statewide Articulation Agreement, general education requirements, common prerequisites, and the SCNS. These elements are in place to ensure that the Associate in Arts degree program is comparable to the first two years of a four-year program [11].

The Statewide Articulation Agreement guarantees the transfer of 60 credits earned as part of the AA degree. It does not, however, guarantee the transfer into the college or university of the student’s choice – only that students have an equal opportunity to compete to enter limited access programs. It is up to the student to know the specific transfer admission requirements in order to be prepared as possible to compete for entrance into a four-year program [11].

The challenge for students interested in pursuing a degree in engineering is that the requirements for the AA degree are very flexible and are not designed for admittance into such a customarily limited access and high-demand program area. While it may be possible to attain an AA degree and transfer directly into an engineering program, the AA degree must be crafted carefully. Without proper advising, students will not meet the pre-requisites for transferring into a Bachelor of Science engineering program. This type of advising requires a level of understanding of engineering curriculum not usually possessed by those who are not familiar with the engineering profession.

In the latest FCS Annual Report, there were over 800,000 students currently enrolled in colleges in the FCS. The student enrollment for the 2014-2015 academic year shown in Table 2 reveal that approximately half are pursuing an AA degree.

Table 2: Student Characteristics for the Florida College System in 2014-2015 [10]

Student Characteristics 2014-15

Headcount (Unduplicated)	813,538
Full-time	35%
Part-time	65%
Average Age	25
Gender	59% female
Minority	58%
Students with disabilities	22,226

Student Enrollments 2014-15

Associate in Arts	339,727
Continuing Workforce Education	112,667
Associate in Science & Associate in Applied Science	110,542
Baccalaureates	34,528
Adult and Secondary Education	28,081
College Credit Certificate	23,046
Career Technical Certificate	2,304
Educator Preparation Institute	2,304
Apprenticeship	2,262
Advanced Technical Certificate	300
Certificate of Professional Preparation	146

Note: Students may enroll in more than one program

According to the Division of Florida Department of Education website,

“Florida's colleges remain the primary point of access to higher education in Florida, with 65 percent of the state's high school graduates pursuing postsecondary education beginning at a Florida college, and 82 percent of freshman and sophomore minority students in public higher education attending one of Florida's 28 colleges” [12].

Additionally, institutions in the FCS have a strong Dual Enrollment population. Dual enrollment allows high school students an opportunity to enroll in postsecondary courses and receive both high school and postsecondary credit [13]. Dual enrollment programs allow high school students with a minimum 3.0 grade point average (GPA) to take college courses directly from a Florida college or university. Successful performance in the course results in the award of college credit. The program currently serves over 35,000 students a year with the number of students expected to grow annually [14].

The question is, if a student desires to attend a state or community college with the intention of transferring to pursue a four-year Bachelor of Science engineering degree, what are the programs and courses available to prepare them to compete for a transfer slot into an engineering program?

Florida College System Institutions Program Summary

What follows is a compilation of all of the institutions in the FCS and the programs available that have any relationship to engineering. The research bore out that the terminology varies greatly from institution to institution, and focused exclusively on the AA degree. Thus, a student desiring to attend a FCS institution for the first two years and then transfer into an engineering program does not necessarily have a clear pathway to success. What follows is a listing of all programs related to engineering at each of the 28 FCS institutions.

Table 3: Table of Colleges and the AA Degree Terminology and Program of Study

Florida College System Institutions Alphabetically	AA Degree Terminology	Program of Study/Topics
Broward College [15]	AA by Career Pathway	Separated into 8 career pathways. Engineering topics fall into the STEM pathway.
Chipola College [16]	AA by Transfer School	Create an AA plan based on college student wants to transfer into. Various engineering programs detailed into a combined Engineering Guide
College of Central Florida [17]	AA by Program	Over 50 program areas to choose from. Various engineering programs grouped into one Engineering
Daytona State College [18]	AA	By design with Faculty or Advising

Eastern Florida State College (formerly Brevard Community College) [19]	AA with Transfer Area	Separated into 11 career pathways. Various engineering programs grouped into Engineering.
Florida Gateway College (formerly Lake City Community College) [20]	AA	By design with Faculty or Advising
Florida Keys Community College [21]	AA with Transfer Plan	Engineering not specifically highlighted as a transfer plan. Engineering would be by design with Advising
Florida SouthWestern State College (formerly Edison Community College) [22]	AA	By design with Faculty or Advising
Florida State College at Jacksonville [23]	AA	By design with Faculty or Advising
Gulf Coast State College [24]	AA with Options	Over 50 program areas to choose from. Various engineering programs grouped into one Engineering
Hillsborough Community College [25]	AA with Transfer Tracks	Over 30 program areas to choose from. Various engineering programs grouped into one Engineering
Indian River State College [26]	AA with Tracks	Over 30 program areas to choose from. Various engineering programs grouped into one Engineering
Lake-Sumter State College [27]	AA with Meta-major	Separated into 8 Meta-Majors. Various engineering programs grouped into STEM
Miami Dade College [28]	AA by Pathway	Over 50 program areas to choose from. Various engineering programs grouped into 10 specific Engineering programs
North Florida Community College [29]	AA with Meta-major	Separated into 8 Meta-Majors. Various engineering programs grouped into STEM Emphasis
Northwest Florida State College [30]	AA by Transfer Major	Over 50 program areas to choose from. Various engineering programs grouped into 15 specific Engineering programs
Palm Beach State College [31]	AA University Transfer Degree	By design with Faculty or Advising
Pasco-Hernando State College [32]	AA	By design with Faculty or Advising
Pensacola State College [33]	AA Concentrations	Over 30 program areas to choose from. Various engineering programs grouped into Pre-Engineering
Polk State College [34]	AA	By design with Faculty or Advising
Santa Fe College [35]	AA Advisement Track	Over 30 program areas to choose from. Various engineering programs grouped into Engineering

Seminole State College [36]	AA University Transfer Degree	Many program areas to choose from, offered by department. Various engineering programs grouped into 10 specific Engineering programs
South Florida State College [37]	AA	By design with Faculty or Advising
St. Johns River State College [38]	AA	By design with Faculty or Advising
St. Petersburg College [39]	AA	By design with Faculty or Advising
State College of Florida (Manatee Community College) [40]	AA Transfer Plans	By design with Faculty or Advising
Tallahassee Community College [41]	AA with Transfer Maps	Separated into 8 Meta-Majors. Various engineering programs grouped into STEM
Valencia College (Valencia Community College) [42]	AA Transfer Plans and Pre Majors	Over 30 program areas to choose from. Various engineering programs grouped into Engineering

As noted in Table 3, the programs offered are AA degrees. There are no AS degrees focused on engineering or pre-engineering. It is important to note that AA degrees do not have actual majors associated with them. There are only one set of requirements to complete an AA degree. The programs described by the institutions above use electives to shape the AA degree into a specific program of study. Only by looking at a transcript of the courses actually completed will the focus of any particular AA degree be known.

Upon investigation, the focus of these AA degrees can be categorized in three ways. In the first category, the institution promotes the AA degree as part of the 2+2 system, relying on the student to design a program with the guidance of a member of the faculty or advising staff. The second category outlines a specific AA curriculum in detail depending on what type of engineering program the student is interested in or what school and engineering program the student plans to transfer into. The third category groups the AA programs into different focus areas (often referred to as meta-majors) and suggest an AA curriculum based on the future area of study. In this category, programs supporting the preparation for transfer into and engineering field are groups into STEM, Pre-Engineering, or Engineering. A breakdown of the category relating to each institution in provided in Table 4.

Table 4: Table of Colleges and Categorization of the AA Degree Program of Study

Florida College System Institution (by Alphabetical order)	AA Degree Program of Study Categories		
	I	II	III
Broward College [15]			X
Chipola College [16]		X	
College of Central Florida [17]		X	
Daytona State College [18]	X		

Eastern Florida State College [19]			X
Florida Gateway College [20]	X		
Florida Keys Community College [21]	X		
Florida SouthWestern State College [22]	X		
Florida State College at Jacksonville [23]	X		
Gulf Coast State College [24]		X	
Hillsborough Community College [25]		X	
Indian River State College [26]		X	
Lake-Sumter State College [27]			X
Miami Dade College [28]		X	
North Florida Community College [29]			X
Northwest Florida State College [30]		X	
Palm Beach State College [31]	X		
Pasco-Hernando State College [32]	X		
Pensacola State College [33]		X	
Polk State College [34]	X		
Santa Fe College [35]		X	
Seminole State College [36]		X	
South Florida State College [37]	X		
St. Johns River State College [38]	X		
St. Petersburg College [39]	X		
State College of Florida [40]	X		
Tallahassee Community College [41]			X
Valencia College [42]		X	

Analysis of Course and Degree Offerings

The challenge of each of the programs identified in Table 4 is that the math and science requirements of a general AA degree do not meet the requirements needed in order for the student to transfer directly into an engineering program. If the student were to attain the needed courses to be prepared to transfer into an engineering program, the student would exceed math and science the requirements for an AA degree.

The situation becomes even more exasperated if the student does not enter the college institution ready to take calculus. Students not ready to enter calculus as freshmen are typically unable to complete the recommended math and science courses required to transfer into an engineering program in two years. Thus, quite often the students complete the requirements of the AA degree and are ready to graduate and transfer before they meet the upper level requirements of an engineering Bachelor of Science program. This is particularly true of dual enrolled students who are still meeting high school math requirements as part of the AA degree and are only beginning calculus at the FCS institution their senior year of high school, which is concurrently their second year of the AA degree program.

Conclusions

This is the first in a series of papers that seeks to assist the students, the institutions that serve them as well as the region and the engineering profession. By investigating the current status, it is proposed new programs or policies be developed that foster the ability for students to transfer to a university engineering Bachelor of Science degree program. By investigating the pre-engineering options in Florida schools, several conclusions can be reached. While there are various programs offered at each of the 28 institutions in the FCS that appear to be directed toward engineering, only in a few specific cases will a student be able to complete that program in a two year time frame and then transfer as a junior into an engineering Bachelor of Science degree program within the Florida University System. Because of the unique math and science requirements, it is very challenging to transfer directly into an engineering program.

Thus, the current status of pre-engineering programs offered by FCS is essentially non-existent. While Florida has a strong 2+2 program, the availability of a two-year degree program specifically set up to allow students the ability to transfer directly into an engineering program as a junior is woefully lacking. The legislatively mandated Florida SCNS provides a foundation upon which a pre-engineering program can be developed so that students will be able to seamlessly make that transition.

Students who attend a community or state college as a first step to attaining their goal of earning an engineering degree, if not well versed or advised, will spend needless time and money attaining credits that will be of little or no value in attaining their engineering degree. This stark fact could very well discourage many students from pursuing an engineering degree.

The benefit of having a pre-engineering program designed specifically for potential engineering students would be ideal for a wide range of students for a variety of reasons. FCS institutions allow flexible programs that allow non-traditional students who are returning to the classroom from the work force to go to school while still being employed full-time. Additionally, these institutions offer a more affordable alternative to students who are unable to afford the tuition, fees, room, and board at larger universities. Another benefit these institutions provide is usually smaller class size and additional educational support, which is attractive to many students. Younger individuals who are dual-enrolled and balancing high school while attending an institution of higher education may be less intimidated at a smaller institution, allowing them to adapt more easily, potentially leading to a higher success rate.

While students would benefit from more information being available on websites and in a more user friendly way or by increasing the knowledge base of advisors at the community and state college level, there is still substantial risk involved. What is really needed is a program of study specifically designed to transfer into an engineering Bachelor of Science degree program. This would benefit the students, the engineering profession, the Florida economy, as well as the Florida Community and State Colleges. Addressing the impediments of student transfer directly into an engineering Bachelor of Science degree program in Florida via a workable and successful pre-engineering program, creates a vibrant win-win situation.

Future research is required into the requirements for entry into 300 engineering courses. By investigating the pre-requisite requirements in the various engineering programs at Florida Universities the viability of an AS degree in pre-engineering can be determined. The culmination of this study is expected to lead to a detailed pre-engineering curriculum proposal.

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