

## **Pre-Freshman Accelerated Curriculum in Engineering (PACE) Summer Bridge Program**

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### Abstract

Faculty and administrators at universities across the country are concerned with the retention rates of freshmen. Studies have indicated that the freshman year is the most difficult year for college students. This is a transitional period from high school to college, where students must adapt to a new learning and social environment.

To address this transitional period for engineering freshmen, Morgan State University School of Engineering implemented the Pre-Freshman Accelerated Curriculum in Engineering (PACE) Summer Bridge Program. This paper describes the program, the implementation strategies, the results of placement test performance, and freshman to sophomore matriculation. PACE is a six-week summer residential program offered to incoming engineering freshmen. The goal of the PACE Program is to increase the retention rate of engineering freshmen by having them successfully complete the gate-keeping mathematics and science courses. The objectives of this program are to foster group dynamics; over-simulate the freshman learning environment; and to prepare the participants to successfully pass the Morgan State University placement test. As a result of their test profile, PACE students enroll in the ECSEL and PACE Cluster courses (developed by the Morgan ECSEL Engineering Coalition of Schools for Excellence in Education and Leadership sponsored by NSF). The ECSEL Cluster courses include Calculus, Physics, English and Introduction to Engineering. The PACE Cluster courses include Calculus or Pre-Calculus, Chemistry, English and Introduction to Engineering. As the students move from PACE through the ECSEL/PACE Cluster courses, they move as a learning community, providing mutual support for each other. They are given academic support, mentoring, tutoring and advising for successful completion of the gatekeeper courses in mathematics and science and to increase the matriculation from freshmen to sophomores.

### Introduction

The Pre-Freshman Accelerated Curriculum in Engineering (PACE) Summer Program is a merger of two previous residential summer programs: NASA/Morgan Enrichment Engineering Program (NMEEP) and the Alliance for Minority Participation (AMP) Math Bridge Program. NMEEP, which was funded by the National Aeronautical Space Administration (NASA) invited engineering students who excelled in their high school GPA's and their SAT/ACT scores to participate in NMEEP. The AMP Math Bridge Program, which was funded by the National Science Foundation (NSF), invited all science, engineering, and mathematics (SEM) students to participate in the AMP Math Bridge Program. These two programs "bridged" the connection between high school and college in order to prepare incoming freshmen for matriculation. Both NMEEP and the AMP Math Bridge Program provided studies in mathematics, English

composition, introduction to computers, and chemistry. NMEEP also provided a study in physics.

From June 27 through August 7, 1999, Morgan State University School of Engineering implemented PACE as a six-week residential summer program to bridge the connection between high school and college for forty-one (24.12%) of the one hundred seventy incoming freshmen entering into the school of engineering for fall 1999. NASA and the National Security Agency (NSA) sponsored PACE, which used the same general principles as NMEEP and the AMP Math Bridge Program.

### Goals and Objectives

In looking at transitional period from high school to college for these students, three objectives for the program were formed. First, we wanted to foster a group dynamic among the forty-one participants. Next, we wanted to create a rigorous learning environment to over-simulate the one they would be entering in the upcoming semester. Finally we wanted to successfully prepare all the students for the Morgan State University placement test. Thus, these students would be better prepared to face the transition from high school to college.

### Program Description

#### *Selection of Participants*

An invitation to participate in the PACE program is sent to those students who have been admitted to Morgan State University as engineering students. These students must submit a complete application package which includes a high school transcript, an essay indicating why he/she desires to participate in the PACE program, two letters of recommendation and a recent photograph. Their mathematics SAT (MSAT) score, high school GPA, and courses taken while attending high school (i.e. mathematics, physics, chemistry) were considered in the selection process but were not paramount since we wanted to work with a broad spectrum of students. Many of these students (33) attended public high schools from around the U.S. while the remaining 8 students attended private high schools in the U.S. or in other countries. Figure 1 indicates the demographics of the students in reference to the location of their high schools.

Using the results of how the students performed in high school, the students were initially placed into three groups for mathematics: Delta, Nu, and Alpha. The Delta group, which was the highest, had 13 participants. The middle group, which was Nu, had 13 students; and the lowest group, Alpha had 15 participants. Figure 2 indicates the average MSAT and high school GPA for each of these initial PACE groups for mathematics.

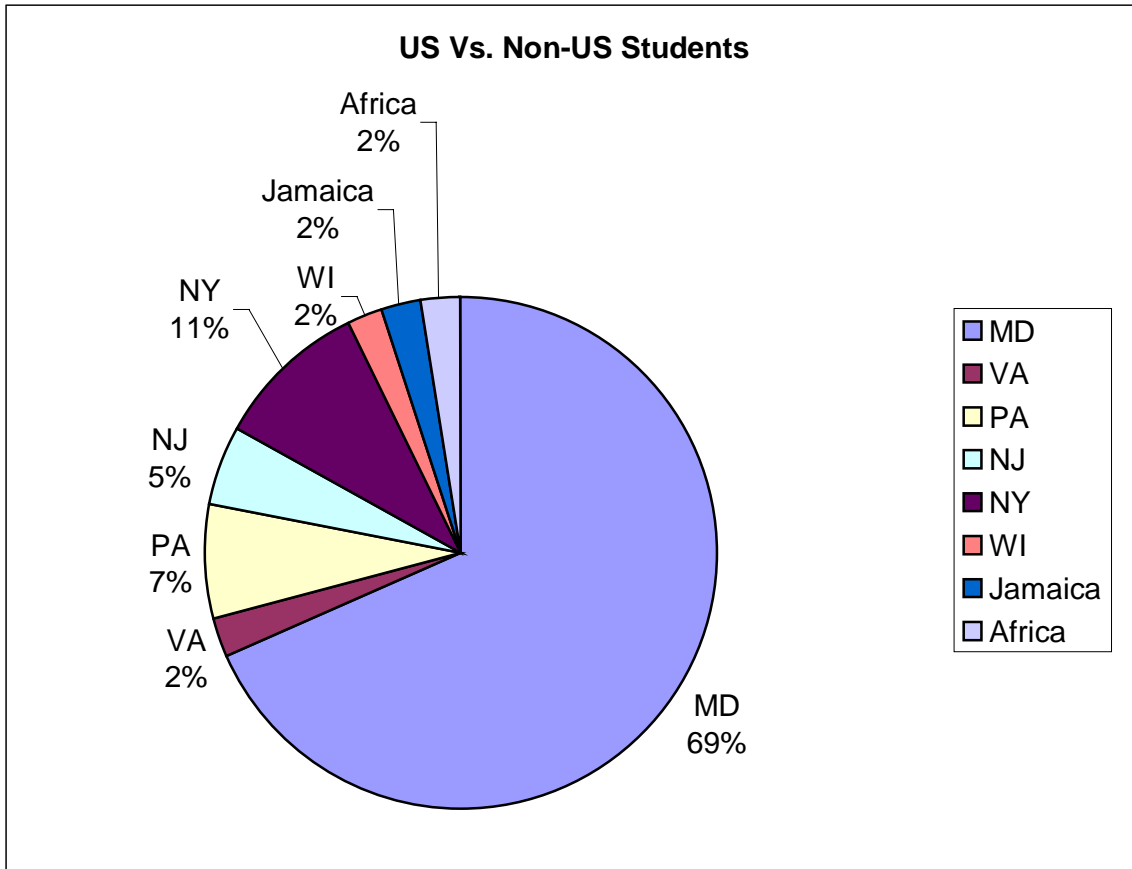


Figure 1. Demographics of PACE Students in Reference to High School Location

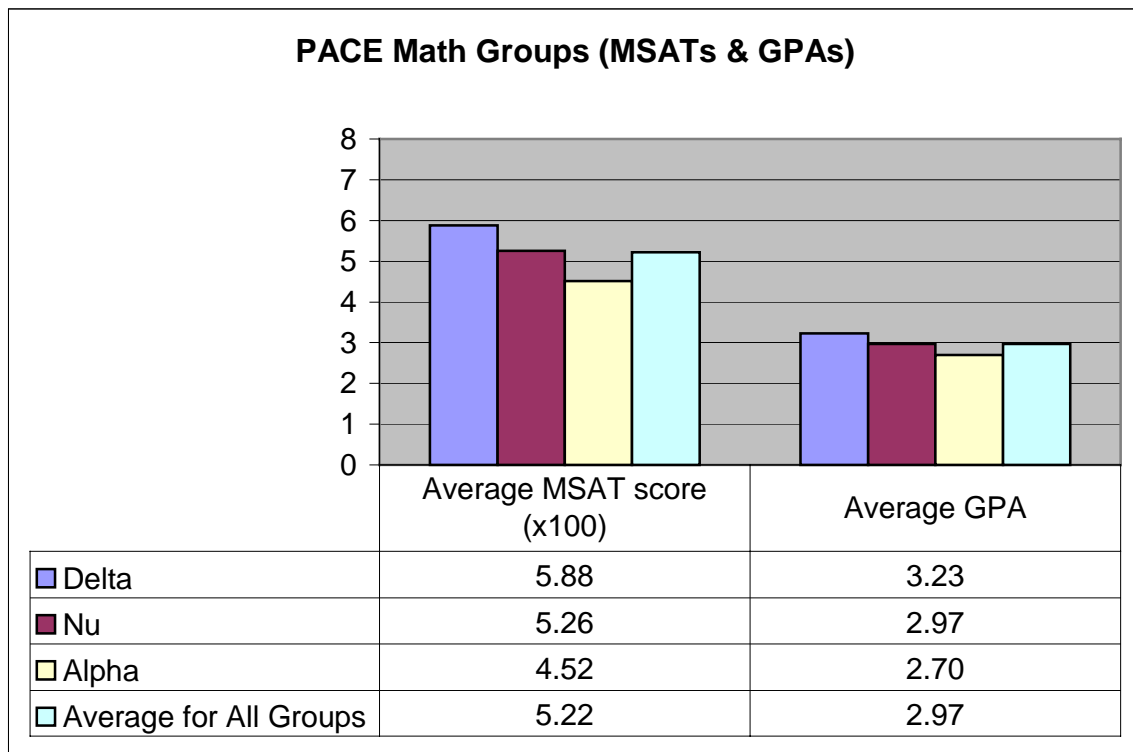


Figure 2. Initial PACE Groups for Mathematics

### *Design Structure of Curriculum*

The curriculum of the PACE program was designed to give the participants a 5-week mathematics course that would review algebra skills. Other courses such as physics, chemistry, English, and computer science are also included in the curriculum. With mathematics being the major impetus for this program, the actual topics/subjects for mathematics had to be carefully planned. Once the mathematics curriculum was finalized, the program had to be structured in such a way that the student-to-teacher ratio was not to exceed 18:1. This allowed for a minimum of 3 mathematics classes, each with its own instructor.

Although the PACE program participants were already divided into 3 groups (Delta, Nu, and Alpha), these were just preliminary in nature. The students were administered a mathematics pre-test with the results indicating the final formation for the Delta, Nu, and Alpha mathematics groups. It was also decided that the students in the two highest groups (Delta and Nu) would take the physics class, while the lowest group (Alpha) took an additional math lab instead of physics.

Each group would follow a separate mathematics track (or tier) which contained the same math topics, but each topic was covered at different stages within each tier during the program. The result was a staggered mathematics curriculum with three tiers. There are two major reasons in forming these tiers. First, to allow a participant to be able to move up or down (from one group

to another group) depending on his/her performance during the first two weeks of the program. Secondly, to minimize and control the student-to-teacher ratio as much as possible.

An example of how the vertical movement scheme would work for a student belonging to the middle math group (Nu) follows: if the student performed extremely well after week #1, that student would move up to the next higher group (Delta) for week #2. Here they would get more advanced algebra topics at a faster pace. On the other hand, if the student did not perform well, that student would move down to the next lower group (Alpha) for week #2. Hence, during week #2 the student would get a repeat of the same topics from week #1 which were covered by the middle group (Nu). This allows a participant to brush up on algebra skills where they may have a weakness. Depending on the performance of the students, this same vertical movement scheme would be repeated for the next week if necessary.

## Results

The PACE Program was designed to challenge students to their fullest potential to have them reach a higher level of academic achievement. The course load and schedule was very demanding for all of the students, but success in a college-level engineering program will come to those who achieve good academic grades, demonstrate good study skills, and have a serious outlook towards school. The program was beneficial to all participants through the daily structure of the formation of the group dynamics and the learning environment.

### *Group Dynamics*

Group dynamics was fostered through three types of group formation:

- Tutoring Groups
  - 10 Groups of 4 Students
- Classroom Groups
  - 3 Groups of 10 to 15 Students (Mathematics Classes)
  - 2 Groups of 20 Students (Other Classes)
- Total Group
  - 1 Group of 41 Students

These groups instilled a sense of commitment, camaraderie, and loyalty among the PACE students.

### *Learning Environment*

In order to over-simulate the learning environment, the students took courses in English, chemistry, mathematics, and physics from 8:30 a.m. until 5:00 p.m. Lunch break was between 11:30 a.m. and 1:00 p.m.:

- Class Hours for Daytime Activities
  - 2 Hours (Delta and Nu Groups) and 4 Hours of Mathematics (Alpha Group)
  - 2 Hours of Physics

- 1 ½ Hour of English
- 1 ½ Hour of Chemistry
- 1 ½ Hour for Lunch

Daytime counselors were in each classroom to monitor and assist the instructor. These counselors also took notes on the subject matter that was discussed each day along with homework that was assigned for each evening. This information was passed on to the evening counselors, tutors and mentors.

Night time activities began at 5:00 p.m. and ended at 12 midnight. The nighttime activities consisted of

- 1 ½ Hour for Dinner
- 1 Hour for Guest Speaker (lecture from a member of the Morgan State University community)
- 2 Hours of Computer Instruction
- ½ Hour for Break
- 2 Hours of Tutoring (conducted by student tutors/mentors who reviewed what the students learned during the day)

### ***Morgan State University Placement Test***

The placement test which is administered to every entering freshman is a “battery of tests measuring basic skills in English, reading, and mathematics”. These tests determine the English, science and mathematics course each entering freshman will be able to take. Engineering freshmen are required to take an extra test in mathematics that covers functions and graphs to determine which mathematics course they will be able to take in their freshman year. These courses include Calculus, Pre-Calculus, Introduction to Mathematical Analysis, and Fundamentals of Mathematics. The Mathematics portion of the test was the PACE program's major item of focus, although the English and Reading Comprehension portions were not to be ignored. The Mathematics test contained the following mini-sections: Arithmetic, Elementary Algebra, Intermediate Algebra, and Functions & Graphs. Depending on how one scored, various combinations of the score results would determine which course a student should register for.

The PACE students as well as the PACE administrators were anxious to get the test results named Profile Reports. Upon first observation, it was discovered that 28 of the 41 participants (68%) placed into the Calculus I course (MATH 241). Table 1 shows a breakdown of where all of the participants were placed initially after taking math placement exams.

	Delta	Nu	Alpha	
Mathematics Courses				Total
MATH 241 (Calculus I)	15	8	5	28
MATH 141 (Pre-calculus)	3	1	3	7
MATH 113 (Intro to Math Analysis I)		1	2	3
MATH 106 (Fundamentals of Math)			3	3
Total	18	10	13	41

Table 1. Actual Mathematics Placement Results

The English portion of the placement test determined if a student was to be placed into a standard Reading and Writing I (ENGL 101 which meets for 3 hours a week) course or a Freshman Studies version of the course (ENGL 101 which meets for 5 hours a week). Test results indicated that 25 (61%) of the 41 PACE students placed into Freshman Studies English. The actual results for all participants are shown below in Table 2.

	Delta	Nu	Alpha	
English Courses				Total
ENGL.101	8	6	2	16
Freshman Studies English	10	4	11	25
Total	18	10	13	41

Table 2. Actual English Placement Results

For some strange reason, many summer program participants (and also non-summer program students campus-wide) entering Morgan State University are placed into this Developmental Reading course year after year. For the PACE program, many (29 or 71%) did not perform well on the Reading Comprehension portion of the placement exams; therefore, they were placed into DVRD 101 with no chance of not having to take the course.

Upon further examination of the Profile Reports, the PACE administrators discovered that those students who were placed into the MATH 141 course had only missed getting placed into the MATH 241 course by 1 to 3 points out of a minimum score of 24 to pass. This occurred in the Mathematics sections for Intermediate Algebra or Functions & Graphs. Therefore, the PACE administrators decided to move six additional students into the MATH 241 course. This brought the total number of students allowed to register for the course up to 34 (82%). Once all of the Profile Reports were looked over, the administrators decided to move more students from the MATH 113 course to the MATH 141 course for similar reasons. Also, students were moved from MATH 106 to MATH 113. Those students who were allowed to register for MATH 141 or MATH 113 missed placing into these courses by 1 to 3 points out of a minimum of 28 to pass the Mathematics sections for Arithmetic or Elementary Algebra. The final results for mathematics placement are shown in Table 3 below.

	Delta	Nu	Alpha	
<b>Mathematics Courses</b>				<b>Total</b>
MATH 241	18	9	7	34
MATH 141		1	3	4
MATH 113			3	3
<b>Total</b>	<b>18</b>	<b>10</b>	<b>13</b>	<b>41</b>

Table 3. Final Mathematics Placement Results

With further examination of the English placement results, some students again missed the standard ENGL 101 placement by 1 to 3 points out of a minimum of 32 points for Written Convention or 1 to 3 points out of a minimum of 24 point for Sentence Structure. These students were placed into the Freshman Studies version. Again, the PACE administrators decided to move these students into the standard ENGL 101 course. The final results for English placement are shown below in Table 4. The number of participants who were placed into ENGL 101 rose from 16 (39%) to 27 (66%) out of the 41 participants.

	Delta	Nu	Alpha	
<b>English Courses</b>				<b>Total</b>
ENGL.101	15	9	3	27
Freshman Studies English	3	1	10	14
<b>Total</b>	<b>18</b>	<b>10</b>	<b>13</b>	<b>41</b>

Table 4. Final English Placement Results

### Freshman Engineering Tracks

With the final placement of the PACE students based on the Profile Reports, the PACE administrators were able to schedule courses to register the students into one of four engineering tracks identified for PACE for fall 1999.

### **ECSEL TRACK**

The ECSEL Track is an initiative implemented by the Morgan ECSEL (*Engineering Coalition of Schools for Excellence in Education and Leadership*) Program. ECSEL is a coalition of seven schools and colleges of engineering in a cooperative agreement with NSF engaged in a ten-year (1990 – 2000) effort to transform undergraduate engineering education and increase the diversity of engineering graduates. These schools include *The City College of New York, Howard University, Massachusetts Institute of Technology, Morgan State University, The Pennsylvania State University, University of Maryland, and University of Washington*. The ECSEL Track is an accelerated curriculum composed of the ECSEL Cluster Courses, which includes Calculus,



Physics, English, Introduction to Engineering, and either U.S. History or World History. Normally students are not required to enroll into Physics I until after they have taken Calculus I. This accelerated curriculum allows students to study calculus and physics together. Those freshmen in the PACE Program that placed into both English 101 and MATH 241 of the Morgan State University placement test are enrolled into the ECSEL Cluster Courses. Twenty-five (61%) of the forty-one PACE students were enrolled into the ECSEL Cluster Courses fall 1999.

### ***PACE 1 TRACK***

The PACE 1 Track follows the normal curriculum for an engineering freshman which includes Calculus, Chemistry, English, Introduction to Engineering, and either U.S. History or World History. Instead of taking the regular English 101, these students were required to take the Freshman Studies English. Nine (22%) of the forty-one PACE students were enrolled into the PACE 1 Track.

### ***PACE 2 TRACK***

Except for the mathematics course, the PACE 2 Track followed the normal curriculum for an engineering freshman. The PACE 2 Track freshman enrolled in Pre-Calculus, Chemistry, English, Introduction to Engineering, and either U.S. History or World History. Four (10%) of the forty-one PACE students enrolled into the PACE 2 Track. Two of these students took the regular English 101. The other two students were required to take the Freshman Studies English. Since these students were required to enroll into a Pre-Calculus course, they lost one semester before being able to enroll into a Calculus class.

### ***PACE 3 TRACK***

As with the PACE 2 Track, the PACE 3 Track followed the normal curriculum for an engineering freshman except for the mathematics course. The PACE 3 Track freshman is required to enroll into the Introduction to Mathematical Analysis, which is a two semester course that covers algebra, geometry, trigonometry, and pre-calculus. These students were also required to take the Freshman Studies English. Three (7%) of the forty-one PACE students enrolled into the PACE 3 Track. These students lost two semesters before being able to enroll into a Calculus class.

### **Conclusion**

Morgan State University School of Engineering regular curriculum for an entering freshman is Calculus, Chemistry, English, Introduction to Engineering, and either U.S. History or World History. The only criteria for a student to be placed into the ECSEL Track is to have participated in the PACE Summer Program and pass the Morgan placement test. The ECSEL Track, which is an accelerated curriculum that includes the ECSEL Cluster Courses (Calculus, Physics, English, Introduction to Engineering, and either U.S. History or World History), is an initiative implemented by the Morgan ECSEL. Thus, there would be no ECSEL Track without the PACE Summer Program.

However, by removing the PACE criteria from the ECSEL Track and only using passing the mathematics sections of the Morgan placement test, an analysis can be made between the PACE students and the non-PACE students as to how many students placed into Calculus which is the gate-keeping course. The total 1999 population was 96 students. Of those 96 students 41 (43%) were PACE students. Thus, 55 (57%) were non-PACE students. Of the total 1999 population, only 40 (42%) students placed into Calculus. Of those 40 students, 12 (13%) non-PACE students of the total population placed into Calculus, while 28 (29%) PACE students of the total population placed into Calculus.

The School of Engineering ran the PACE program during summer 2000. The total 2000 population of entering freshmen was 134 students. Of those 134 students 50 (37%) were PACE students. Thus, 84 (63%) were non-PACE students. Of the total 2000 population, only 50 (37%) students placed into Calculus. Of those 50 students, 12 (9%) non-PACE students of the total population placed into Calculus, while 38 (28%) PACE students of the total population placed into Calculus. Without the PACE Summer Program, fewer students would place into Calculus. Thus, the efficacy of the PACE Summer Program is validated.

#### Bibliography

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#### Biographical Information:

##### CARL WHITE

Carl White is Associate Professor of Electrical Engineering at Morgan State University. He received his B.S.E.E. in 1981 and M.S.E.E. in 1983 from Howard University. In 1988, he received his Ph.D. in Engineering from Cornell University. He is the Local Principal Investigator at Morgan for the ECSEL Coalition (Engineering Coalition of Schools for Excellence in Education and Leadership) and the Principal Investigator for the Pre-Freshman Accelerated Curriculum in Engineering (PACE) Program. It is his concept to develop the undergraduate student leadership skills through the development and coordination of the school of engineering pre-college and college programs. Dr. White is also the Director of the Morgan State University School of Engineering COMSARE (Center of Microwave, Satellite and RF Engineering) Laboratory

##### MYRA W. CURTIS

Myra W. Curtis is the ECSEL Local Program Director at Morgan State University. Ms. Curtis received her B.S. degree in Mathematics from Morgan State University in 1970. Before joining the staff at Morgan, she spent twenty years in industry in designing, programming, and testing software systems on various platforms for the Department of Defense, National Aeronautics and Space Administration (NASA), and the Department of Transportation. She has taught mathematics and computer science in the public and private sector. Ms. Curtis works closely with the ECSEL student leaders in developing and coordinating the school of engineering pre-college and college programs.

##### CLIFTON S. MARTIN

Clifton S. Martin is a senior electrical engineering student at Morgan State University. Since 1998 he has been the current ECSEL student leader. As the ECSEL student leader he has been instrumental in the development and transformation of the school of engineering pre-college and college programs, i.e. the Saturday Academy and the

PACE Program. He has received the 2001 U.S. Black Engineer of the Year Student Leadership Award and a citation from the Baltimore City Council for his student leadership with the Saturday Academy.