The Transformation of a College of Engineering and Applied Science Summer Bridge Program to a STEM Summer Bridge Program For Historically Underrepresented Ethnic Students

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Abstract - **This paper will examine the Emerging Ethnic Engineers Program (E3) at the University of Cincinnati College and Engineering and Applied Science (CEAS) and its impact the success of underrepresented ethnic engineers (Africa American, Hispanic/Latino, and American Indian) students who enter and graduate from the college. The program's freshman to sophomore rate is 88% compared to <50% nationally, and the graduation rate is 58% compared to 39% nationally. The 58% graduation rate is equal to that of majority students in the college.**

There has been a national effort for the past thirty plus years to increase the number of historically under-represented ethnic students who enroll and graduate from engineering. Programs commonly referred to as minority-engineering programs have been in the forefront of developing strategies to recruit and graduate these students. A summer bridge program is common component of a significant number of these programs.

This paper will examine the bridge program and its role in the success of the E3 program, its expansion in 2009 to include ethnic STEM students from the college of Arts & Sciences leading to current discussions around transforming it from a CEAS program to a campus-wide STEM bridge program for underrepresented ethnic students. This project seeks to evaluate the expansion the bridge program as a strategy for improving the success rates of Arts & Sciences underrepresented STEM students and thus increasing the university's overall graduation rate for this population.

INTRODUCTION

There is an increased level of discourse on the national and state level regarding the number of students entering and completing science, technology, engineering, and mathematics (STEM) disciplines in general and underrepresented student populations in particular. Notably, those of the National Science Foundation (NSF) Shaping the Future (1996), Building Engineering and Science Talent (BEST) The Quiet Crisis: Falling Short in Producing American Science and Technical Talent (2004), the National Academy of Sciences Rising Above the Gathering Storm (2007), National Action Council for Minorities in Engineering, Inc. (NACME), BEYOND THE DREAM From Developmental Mathematics to Engineering Careers for Underrepresented Minorities, Confronting the "New" American Dilemma (2008), and the Ohio Board of Regent's Science and Mathematics Education Policy Advisory Council Science and Mathematics A Formula for the 21st Century Success (2008). Finally, there was President elect Obama and Joe Biden's Investing in America's Future speech during the Presidential campaign and the subsequent President's Council of Advisors on Science and Technology Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future Report (2010).

These reports call for increased efforts to increase the number of underrepresented ethnic students in STEM disciplines to meet the challenge of an ever-competitive global world. There is a consensus that it has become an economic imperative. This was evident at a speech given at a roundtable presented by the National Action Council for Minorities in Engineering, Inc. and the American Association for the Advancement of Science (AAAS) in January 2008 in Washington, D.C. by Ronald Sugar chairman and CEO of Northrup Grumman; "My company looks at the STEM problem from a national security perspective. America did not win World War II because we were smarter, but because we had greater production capacity. In the Cold War, our adversaries could not compete with our intellectual capital. Today we are in a different environment, fighting a more challenging foe. Our advantage is all rooted in STEM. We need to battle to inspire youth to undertake these skills. Kids in other countries are making the sacrifice to study science and engineering. We need to leave no source of potential talent behind, but the talent pool of minorities is underutilized."

A closer an examination of the national and state of Ohio realities provides an understanding of the need/challenge of programs like the Emerging Ethnic Engineers Program (E3) and other initiatives to increase the

representation of African American, Hispanic/Latino, and Native American students in the STEM disciplines.

THE NATIONAL REALITY

Despite the high demand for engineers many engineering industry leaders have expressed concern about the supply of well-prepared engineers over the next few decades. The number of 18-24 year olds would grew by three million by 2010; and African Americans, American Indians, and Hispanics made up 60% of the population increase over that time period. The consensus among leaders in the engineering community is that the necessary increase in the engineering supply will come about only through the development of a more diverse workforce, (ACT, 2003). While these demographics have lead to larger high school enrollment of underrepresented students, it has not translated into increased numbers of these students who enter engineering. For example, in 2002 approximately 690,000 underrepresented students graduated from high school. Only 28,300 (4%) were considered "engineering eligible" based on courses taken and grades. Of these, 16,800 (59%)enrolled as freshman in engineering schools, out of 107,000 total admissions.

Aside from the challenges in enrolling these students there is a significant gap in degree completion rates in comparison to majority engineering students. The 2003 Commission on Professionals in Science and Technology (CPST), Trends in African American and Native American Participation in STEM Education conducted a national study of the graduating engineering class of 2001. Of the 340 schools included in the Engineering Workforce Commission database, only 94 (28%) met the criteria to be included in the study analysis. More importantly, the retention rates by group could be computed for only half of the 94 institutions. The results concluded that minority retention increased from 36.5 to 38.8 and majority retention fell from 68.3 to 61.0.

Under-represented ethnic students, specifically African Americans and Hispanics make up (28.9%) of the general population, but combine for only (11.5%) of engineering bachelor degrees. In contrast, Asian American is (4.8%) of the population but account for (12.2%) of engineering bachelor degrees. And, while foreign nationals dominate the masters' and doctoral degrees in engineering, they have also earned more bachelor engineering degrees (7.2%-6.2%) in the period from 2002 – 2010 than African Americans (5.4%-4.5%). There has been some success with Hispanic students (5.5%-7.0). (ASEE, 2011).

STATE OF OHIO

Ohio has instituted several state initiatives to meet the challenge of increasing interest and enrollment in STEM disciplines. In 2008, the Ohio Board of Regents a policy report called for of a well-trained workforce for STEM related industries. The report highlighted five key strategies (1) Public Awareness and Understanding of the Importance of Science and Mathematics; (2) More Students Who Master High Level Science and Mathematics and Pursue STEM Related Careers; (3) High Quality Science and Mathematics Instruction; (4) Increased Collaboration between Postsecondary Programs and Business; and (5) Greater State Capacity to Improve Science and Mathematics Education. What was significant in the report was the data that indicated the enormous challenge that state would face in moving toward increasing the number of students who have access to a strong mathematics and science curriculum, and getting those students to enroll in STEM related disciplines. There were four significant data points that illustrated the barriers in reaching the goals of the report were:

1. 41 percent of recent Ohio high-school graduates enrolled for the first time as college freshmen take remedial mathematics and/or English, while 33 percent take remedial mathematics.
2. African-American high-school students in Ohio are half as likely as white students to enroll in upper-level science courses, and two-thirds as likely to enroll in upper-level mathematics courses.
3. Just 24 percent of Ohio high school students take a rigorous core curriculum, which is the best predictor of college success.
4. In Ohio, 39 percent of 19-year-old students enroll in college, compared to 52 percent of their peers in the states that have the highest rates of college participation.

Another key recommendation was the addition of a fourth college prep math course as part of state graduation requirements. While this was a welcomed recommendation, physics remained optional for the third science requirement for graduation.

An Analysis of the Ohio STEM Student Pool

The Ohio Board of Regents, Making the Transition from High School to College in Ohio 2005: A Statewide Perspective report indicates that many college freshman in Ohio had not taken high school courses that prepare them for STEM disciplines. Seventy percent of first-time freshman in Ohio in fall 2003 had completed the minimum college-preparatory curriculum in high school, consisting of four English courses and three courses each in math, science, and social studies. Only 24% had taken a more rigorous college-preparatory curriculum *complete core* consisting of four courses each in English, and social studies, and three courses in Science that include biology, chemistry, and physics. A look at the students who take the complete core, clearly illustrate that the historically underrepresented students lag behind the Asian and their white counterparts.

Asians or Pacific Islander	43%
White, non-Hispanic	24%
American Indian or Alaskan Native	17%
Hispanic	19%
Black/non-Hispanic	16%
Public Schools	22%
Parochial	33%

In a subsequent report Profile of Recent High School Graduates Enrolled as First-Time College Students in Fall 2007, the percentage of students taking the complete core presented a new element to the discussion. Non-resident alien students became the second largest group taking the complete core behind Asian or Pacific Islanders.

Asians or Pacific Islander	36%
White, non-Hispanic	23%
American Indian or Alaskan Native	23%
Hispanic	17%
Black/non-Hispanic	14%
Non-resident Alien	25%
Public Schools	21%
Parochial	32%

Furthermore, the average for all groups taking the complete core was only 22%, a drop of 2% from 2005. An analysis from fall 2003 to fall 2007 of first-year Ohio students by type of college attending (community, university regional campus, university main campus, and private not for profit) illustrates that the five year average of all students taking the complete core was 22.6%.

There also is less interest among students in pursuing an STEM degree. Table 1 is the total number of Ohio students taking the ACT each year from 2006 -2009, those who listed engineering/engineering technology as a possible college major, and the number of those students who earned ACT math score of >24 is considered the minimum score necessary some Ohio engineering colleges for admission, but many require a much higher test score.

Year	N	>24	%
2009	88,754	3,524	3.97
2008	88,103	3,887	4.00
2007	86,080	2,883	3.35
2006	81,564	2,964	3.63

More importantly, ACT has developed research to indicate students' college readiness based The College Readiness Benchmark Score, the minimum score needed on an ACT subject-area test to indicate a 50% chance of obtaining a B or higher or about a 75% chance of obtaining a C or higher in the corresponding Credit-bearing college courses, which include English composition, Algebra, Social Science and Biology. It is worth noting that Algebra is the corresponding college math course. Table 2 is the percentage of under-represented ethnic students who met the benchmark for mathematics over a five-year period. The ACT data indicates that in order for Ohio to produce the STEM graduates to reach the stated goals of the SEMPAC report it will have to increase the number of students met or exceed the college readiness benchmarks.

	2006	2007	2008	2009	2010
African American	13%	11%	12%	12%	14%
American Indian/ Alaskan Native	34%	41%	33%	36%	42%
Caucasian/White	49%	49%	51%	51%	54%
Hispanic	32%	33%	33%	35%	36%
Asian American/ Pacific Islander	64%	67%	69%	69%	72%

Table 3 illustrates the percentage of under-represented ethnic students who met the benchmark for science over a five-year period.

	2006	2007	2008	2009	2010
African American	6%	5%	6%	7%	7%
American Indian/ Alaskan Native	22%	27%	20%	25%	28%
Caucasian/White	33%	34%	36%	37%	39%
Hispanic	20%	22%	22%	24%	24%
Asian American/ Pacific Islander	43%	47%	48%	48%	53%

MINORITY ENGINEERING PROGRAMS: THE NATIONAL EFFORT TO INCREASE THE NUMBERS

The effort to increase the enrollment and graduation of underrepresented ethnic students began in the late 1970s' with the development minority engineering programs. Dr. Raymond A. Landis considered the founder of "minority engineering programs" conducted a study in 2005 to measure the progress that had been made by minority engineering programs. The study concluded that from 1973 to 2004, the percentages of underrepresented ethnic students enrolled in the freshman class increased from 4.4% to only 15.2% - a factor of less than four". (Landis, 2005)

E3 SUMMER BRIDGE PROGRAM

The E3 Program initiated its first summer bridge program in 1989. Since then over 500 students have participated in the program. The Summer Bridge Program is a seven-week residential program for incoming under-represented ethnic engineering freshman. The objective of the program is to create a "learning community" of E3 students who develop the academic and social skills necessary for achieving academic excellence from the freshman year through graduation.

FUNDING, RECRUITMENT PROCESS AND LOGISTICS

The current bridge program is being funded from a five-year NSF TYPE 1 STEP Grant. All underrepresented ethnic students (African American, Hispanic, and Native American) admitted to the college are invited. The bridge students take a bridge math pre-test to determine whether they will take the Pre-Calculus or Calculus during the program, and the subsequent chemistry and physics courses. The students also take the university's math placement test, if a bridge student does not test into pre-calculus or calculus, the summer program provides a opportunity for increased instruction and a chance to re-take the placement test.

There is a mandatory student/parent orientation outlining the goals, objectives, and expectations of the program. Parents and students must sign a contract that outlines the rules of participation and consequences for non-compliance. Administrative staff and faculty are introduced and each instructor gives an explanation of their role and their decision to teach in the program. After the orientation, there is a separate meeting with parents to discuss how they can assist in making sure that their student will be academically successful. A five-year plan academic success plan for students is presented to the parents. The staff meets weekly to discuss the progress of students as it relates to implementing the collaborative learning process and to identify students who may need some assistance in making the adjustment to the college environment. The resident/student manager provides information on their class performance, study sessions participation, and acclimation to the residence hall. He seeks information from the instructors on particular students so he can assist in their transition.

Classes are from 9:00 a.m. to 4:00 p.m., Monday through Thursday and mandatory study sessions coordinated by the resident/student manager are held from Monday through Friday from 6:00 to 8:00 p.m. The current E3 students assist in the study sessions by making sure that the bridge students are implementing the collaborative learning process during the study sessions.

STAFFING

The staff consists of a director, administrative assistant, and eight instructors. The instructors are current recruited from the University of Cincinnati or area universities. One of the reasons for success of program has been the low turnover rate for instructors and staff. The chemistry instructor has been with the program twenty-four years, calculus instructor eighteen years, pre-calculus five years, English instructors three and eight years. The program has been greatly assisted by the recruitment of graduate students from the college for the physics course for the past eight years.

The resident/student manager, a high school physiology instructor from the high school across the street from the university has been with the program for eighteen years. This resident/student manager resides in the residence hall, monitors the student's compliance with the contract, student performance in the classroom and study sessions. He also coordinates the student's attendance for all field trips, special meetings, and socials.

SUMMER BRIDGE COURSES

The pre-Calculus course is to prepare students for the Pre-Calculus taken Fall Quarter of the freshman year and covers the following topic; The Real-Number System, Exponents and Polynomials, Factoring and Applications, Rational Expressions, and Applications and Equations of Line Functions.

The calculus course seeks to enhance the math skills of students who would more than likely take Calculus I in the fall quarter of the freshman year, and cover the following topics: Basic Functions, Polynomial, Exponential, Logarithmic Functions, and Trigonometric Functions, Limits Derivatives, and Differential Rules.

The chemistry course is to prepare students for Chemistry 101 taken the Fall Quarter of the freshman year. Two sections for Chemistry were held, one for the students enrolled in Pre-Calculus and the second for those enrolled in Calculus to accommodate the math skill level of the students. The course covered the following topics: Matter and Energy, Problem Solving, Math for Chemistry, Dimensional Analysis, Atomic Theory, Molecular Formulas, Aqueous Ionic Reactions, and Electron Configuration.

The physics course prepares students for Physics I taken in the Winter Quarter of the freshman year. The Introduction to Physics section and the regular Physics section uses the same syllabus with a slight variation in the introduction course to accommodate the math skill level of the students. The following topics covered are: Motion in One and Two Dimensions, Equations of Motion, Problem Solving with Component and Unit Vectors.

In 2009, the biology course was incorporated to accommodate the A&S stem students. This course prepares the students for Biology I01. The Introduction to Biology section serves to prepare students to think scientifically and apply scientific method, determine what molecules are centrally involved in life, examine their properties and uses by organisms, analyze structures determining what cells composed of, examine how cells obtain usable energy, determine what distinguishes the major groups of microorganisms.

The English course uses the same syllabus as the academic year course. Students who earn the equivalence of C in the bridge course receive advance standing for first freshman English course. The English department has allowed the summer instructors to verify the C course grade through a credit evaluation process. The objective is to reduce the fall course load by three credit hours; this

strategy was adopted in the early 1990's for the purpose of incorporating the collaborative learning courses for math and science in the schedule of the students.

INTRODUCTION TO 3-D SPATIAL VISUALIZATION

Research indicates that ethnic and women engineering student have difficulty in visualizing in three dimensions. This cognitive skill has been found to be essential, but a significant number of these students have not had the experience in working in this area. There is a misconception that this skill is one that a person is "born with", research clearly indicates that it can be learned. The objective of the course is to develop the spatial visualization skills of the bridge to students through a series of modules using a textbook and software. The course covers the following topics; Isometric Sketching, Orthographic Projection, 2-D Patterns Folding to 3-D Objects, Rotation of Objects about a Single Axis, Rotation of Objects about Two or More Axes, Reflection and Symmetry, Cross-Sections of Solids, Surfaces and Solids of Revolution, and Combining Solids. This course was added in 2010.

ALEKS (Assessment and LEarning in Knowledge Spaces Assessment and LEarning in Knowledge Spaces

Introduced in 2009, is a web-based artificially intelligent math assessment and learning system. ALEKS uses adaptive questioning to quickly and accurately determine exactly what a student knows and doesn't know in a course. ALEKS then instructs the student on the topics she is most ready to learn. As a student works through a course, ALEKS periodically reassesses the student to ensure that topics learned are also retained. ALEKS courses are very complete in their topic coverage and ALEKS avoids multiple-choice questions. A student who shows a high level of mastery of an ALEKS course will be successful in the actual course she is taking. ALEKS also provides the advantages of one-on-one instruction, 24/7, from virtually any Web-based computer". The course is taught twice a week in the evenings during the study sessions. The goal of the course is to enhance the student's proficiency in math.

FIELD TRIPS

The students visit area companies where former E3 employees are employed and company representatives explained the importance of the summer program with a special emphasis on the collaborative learning methodology and its relevance to the engineering process. The companies are:

1. General Electric Aviation Engines Jet Engine Training Center, hosted annually by former E3 Program students currently employed by the company.
2. Toyota's Georgetown, Kentucky manufacturing plant, which produces the Avalon, Camry, Camry Hybrid, and the Solaria vehicles. Toyota Motor Engineering and Manufacturing North America, Inc. headquarters in Erlanger, Kentucky. The bridge students visited the manufacturing plant in the morning and then the headquarters in the afternoon.
3. Procter and Gamble Health Care Headquarters.

During the last week of the program students complete their final exams and attend an exit interview for each course. All students are required to prepare a written assessment of their performance, and they receive a written assessment from each instructor. The objective of the assessments and exit interview is to give students specific information as it relates to their academic and social development. It is also an attempt to get students to understand that academic excellence is something that is planned and there has to an assessment of where they are in relationship to their goals as students.

SUCCESS OF THE PROGRAM

In 2007 and 2010, 50%> of E3 engineering students earned Deans' List Honors (3.2-4.0) for fall quarter. It is important to note that the summer bridge program is not in isolation from the academic year, it is first step of a comprehensive infrastructure that continues to develop the community building strategies necessary for success. Specifically, during the bridge program the students participate in the university orientation for freshman, at this time they register as a cohort for all of their classes. The course schedules are pre-made and consist of two one and half hour credit collaborative learning courses; Introduction to Collaborative Learning Physics, Collaborative Learning for Pre-Calculus, and Collaborative Learning for Calculus. The students meet twice a week. This strategy is more effective than individual tutoring and continues the community building process. There is a syllabus and students are not allowed to do homework in these classes. The objective is provided additional instructor in a community based environment with goal of earning a C or better in the math and science freshman courses. A graduate student teaches the physics course and university faculty teach the math courses. Students repeat the cohort scheduling process for all three quarters of their freshman year. In past years the bridge math instructors have taught the academic year calculus and pre-calculus lecture courses and the collaborative learning courses.

Academically, the data indicates that the bridge students first quarter grade point average, freshman-sophomore success contribute to the higher graduation rates.

First Quarter GPA		Freshman Year Cumulative GPA
2007	3.31	3.05
2008	2.39	2.65
2009	2.90	2.90
2010	3.35	3.14

Freshman – Sophomore Success

	E3	Majority
2006 – 2007	87%	77%
2007 – 2008	89%	77%
2008 – 2009	91%	73%

Graduation Rates

2006	56%	60%
2007	67%	56%
2008	56%	65%

EXPANSION OF THE PROGRAM

In 2009, Arts & Sciences ethnic STEM students were invited to the program. A&S students would take biology while the engineering students take physics, thus making the bridge schedule compatible with previous years. Eleven A&S students participated in the program, they finished their freshman year with a cumulative 3.16 grade point average. They are now entering their senior year and they have a cumulative 3.40 grade point average. Eight out eleven (73%) are still in a stem discipline, and nine out eleven are still enrolled at the university (82%). In 2011, eleven A&S participated they finished their freshman year with a 2.80 cumulative grade point average. In 2012, eight A&S students and one Allied Heath Sciences students are participating in the summer program.

PROGRAM ENHANCEMENTS

In the past the only objective of the program was for the bridge students to earn a C or better in their freshman year math and science courses. Starting with the summer 2012 program, with the assistance of the Center for the Enhancement of Teaching and Learning office we developed a set of outcomes and measurements for the program.

Also, in an effort to assess the effectiveness of our instructors and student engage the students in their understanding of the learning outcomes for their courses; each instructor participated in the "Creating a Semester Teaching Syllabus", "the teaching syllabus workshop provides faculty with the framework and tools to develop an effective teaching syllabus for your semester courses using the course syllabus template provided by CET&L. This hands-on session consists of a mix of discussion of best practices, as well as computer-time to begin crafting your semester course syllabus. Faculty will leave with an outline/working draft of a teaching syllabus and a strong direction for making further revisions to their course. Specifically, the outcomes for this session are to: *Describe characteristics of the Teaching Syllabus and identify ways to incorporate this approach into your course *Identify what constitutes strong SLOs that are meaningful to students *Use the concept of alignment to generate unit-level and weekly outcomes".

OUTCOMES

Students in Summer Bridge Scholars Program versus non-bridge ethnic students will:

1. Build self-supporting networks that assist students achieve academic and career goals.
2. Achieve higher grades in their freshman math and science courses.
3. Earn a higher cumulative grade point average for their freshman year.
4. Achieve a higher freshman-sophomore retention rate.
5. Achieve higher five-year degree to completion rates.

ASSESSMENT/ MEASUREMENTS

Students in the Summer Bridge Scholars Program will:

1. Test into the appropriate fall semester Pre-Calculus or Calculus course after completion of the bridge program.
2. Earn higher scores on the Post Bridge and Post University Math Placement Tests.
3. Earn a C or better in their first year math and science courses.
4. Earn a cumulative 3.00 or better for the freshman year.
5. Enroll and earn advance degree at a higher rate.

ACADEMIC AND PROFESSIONAL IMPACT ON STUDENTS

1. Document the academic, professional and social development via their E-Portfolio.
2. Build relationships that transcend the undergraduate experience.

RECRUITMENT

We decided to change the name of the program to the Summer Bridge Scholars Program in an effort to combat the common myth that the program is for students who need remediation. We are also convinced that in the years that we are able to offer scholarships for the academic year the participation rate for the bridge program increase.

COURSES

Introduction to 3-D Spatial Visualization

This course is now a combination of 3-D Spatial Visualization and a "modeling" course designed to assist students with problem solving. As of now only the engineering students take the course.

ALEKS (Assessment and LEarning in Knowledge Spaces Assessment and LEarning in Knowledge Spaces

Our analysis found that students who completed 80% of the modules improved their score on the university math placement test when taken a second time. As a result the ALEKS component is incorporated into the bridge pre-calculus and calculus courses and students are required to complete 80% of the modules. We believe that the bridge math courses in conjunction with the ALEKS component will ensure that all bridge students are placed in pre-calculus or calculus.

EVALUATION

While we have taken steps to assess the effectiveness of the bridge courses, we now must develop a plan to assess the impact of the bridge program along with the academic year infrastructure on the performance of underrepresented ethnic Engineering/Applied science and Arts & Science students. There is some evidence that the bridge program may have an impact on those students who participate versus those who do not attend. Preliminary results from 2011 indicate the ethnic engineering bridge students (n=24) earned a 2.81 grade point average versus 2.29 for non-bridge ethnic students (n=25).

The university and college have a goal of increasing the ACT score requirement for admission, the university's goal is a 27, and the college's goal is 29. As a result a significant number of ethnic engineering students are being admitted to the college but not their major. These students are part of the Engineering and Applied Science Entrance Program (EASE). They have four quarters to earn the necessary grade point average to be admitted to their major. An analysis of the 2011 cohort indicated that the bridge EASE students (n=13) outperformed (2.89 vs. 2.17) their EASE counterparts (n=7). What was more interesting is that the EASE bridge students (n=13) outperformed the ethnic engineering students (n=17) who were directly admitted to their major (2.89 vs. 2.34).

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