

A Retrospective on Undergraduate Engineering Success for Underrepresented and First-Year Students

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Stephen, a native Floridian from Miami, is the Director for the Office of Student Transition and Retention (STAR) for the UF College of Engineering. As Director, his primary role includes oversight and coordination of first-year bridge programs, as well as, other student service retention focused programs. Stephen is a graduate of Miami Dade Junior College, (A.A), Florida State University (B.S. Interpersonal Communications, with a minor in Black & Minority Studies) and Florida Agricultural & Mechanical University (M.Ed. Counseling Education and Minority Mental Health).

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Dr. Curtis R. Taylor, Ph.D. is the Associate Dean for Student Affairs for the Herbert Wertheim College of Engineering and Associate Professor of Mechanical and Aerospace Engineering at the University of Florida (UF). Dr. Taylor leads and manages all undergraduate student service activities including academic, professional, and extra-curricular activities in the College. Dr. Taylor directs the soft matter manufacturing and nanomechanics research lab at UF. The application of this research seeks to develop advanced manufacturing capabilities and new technologies that utilize the unique properties of nanomaterials (i.e., lightweight, durable nano coatings, multifunctional nanocomposites, etc.) and soft materials for healthcare. Before joining Florida, he was an Assistant Professor at the Virginia Commonwealth University (VCU) in Richmond, Virginia. He received his B.S. degree (1998) in mechanical engineering from the University of Maryland, and his M.S. (2002) and Ph.D. (2005) in electrical engineering and physics from the University of Arkansas. Before coming to Arkansas in 2000, he worked for one year as a software development project manager at Capital One Financial Corporation in Richmond, Virginia. Dr. Taylor has also held internship and research appointments with the U.S. Air Force, United Technologies Corporation, and the National Center for Electron Microscopy at Lawrence Berkeley National Lab.

Professor Taylor uses his expertise, knowledge, and talents to serve the University and the larger community. He strives to inspire and motivate students of all ages to pursue careers in science and technology.

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Stephen Roberts, Fazil Najafi, Curtis Taylor

Abstract

According to the National Science Board, an increase in the admission of students from underrepresented populations will be needed to improve current enrollment trends at institutions of higher education. In particular, studies show that enrollment, retention, and graduation rates of engineering students from underrepresented populations (i.e., women, ethnic minorities) have historically been lower than those of other student populations. In addition, studies suggest students from underrepresented populations face unique and amplified issues that impede their persistence and degree completion. These impediments can include inadequate K-12 preparation, social isolation on campus and other challenges related to their successful transition into the university. Over the years, many strategies have been implemented in efforts to address these challenges. These strategies have included peer counseling, faculty, and corporate mentoring, targeted academic support programs, need-based financial assistance, centralized academic advising, and student transition support. The projected shortcoming of students completing the degree program create an urgent need for diversity within the field; it is critical to increase efforts to provide first-year and underrepresented students with the academic, social and transition support needed to promote their success.

The purpose of this research is to introduce the Successful Transition and Enhanced Preparation for Undergraduates Program (STEPUP) as a case study intervention to increase student success in engineering. The STEPUP program can serve as a model to assist institutions in the development of a comprehensive, step-by-step process to improve the recruitment, motivation, and retention of underrepresented student populations (USP). STEPUP was established at the University of Florida's College of Engineering twenty-five years ago and has demonstrated great promise and success retaining first-year students in engineering. The STEPUP program model includes parameterized engineering related courses, experiential learning activities, and teaching methodologies. The primary objectives of the program include 1). Increasing student success in transitioning into the university/college, 2). Developing experiential learning programs that promote student professional development and, 3). Retaining students within the major until graduation.

Introduction

In the field of engineering, studies have shown that enrollment, retention, and graduation rates of engineering students from underrepresented student populations (USP) such as women, African-Americans, Hispanic-Latino, Native-American, etc. have historically been lower than those of other student populations. For example, the 2017 American Society of Engineering Education Retention report indicates persistence rates to the second year for Black or African American and Latino-Hispanic students have been lower than other populations as shown in Figure 1[1]. White student persistence was 78 percent in 2003 and increased to 82 percent in 2014. Black or African-American persistence was 74.5 percent in 2003 and 74.8 percent in 2014; Latino/Hispanic student persistence was 75.2 percent in 2003 and 75.6 percent in 2014. A similar trend is shown for 6-year

graduation rates as shown in Figure 2. In 2015, the White student graduation rate was 58 percent. Black or African-American and Latino-Hispanic persistence was 35% and 45%, respectively.

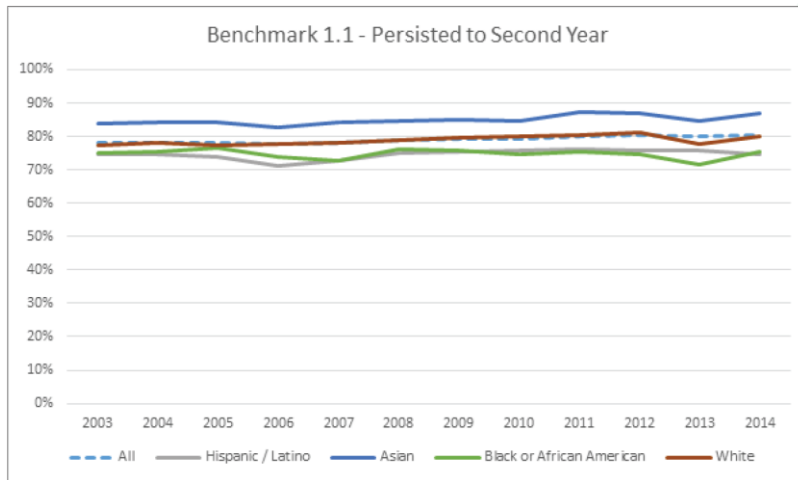


Figure 1. Chart of persistence to second year for larger racial and ethnic groups from ASEE Retention study [1].

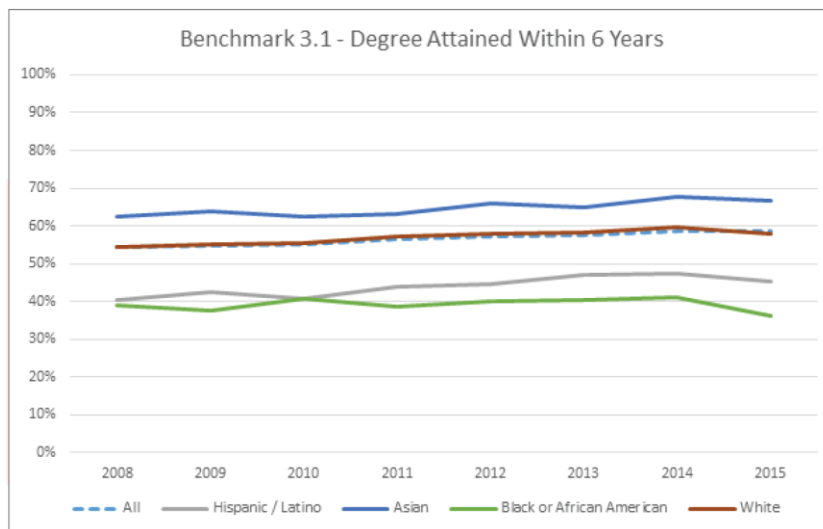


Figure 2. Chart of six-year graduation rates for larger racial and ethnic groups from ASEE Retention study [1].

The reasons why USP persist and graduate at lower rates than other populations are varied and complex. Studies suggest underrepresented students face unique and amplified issues that impede their persistence in completing the engineering degree [2], [3]. These impediments can include socio-economic disparities, inadequate K-12 preparation, social isolation, and issues related to student challenges in successfully transitioning into the university. In general, these issues can be classified into two levels: 1) before college and 2) after admission to college.

Before college

- Lack of safe and modern learning environments.
- Old school buildings that lack renovation and modernization
- Underfunded school infrastructure leaves students without the technology they need to prepare for college and jobs,
- Lack of digital literacy and high-speed internet access,
- Lack of qualified teachers and staff,
- Legislation or policies that bar the use of race in admissions decisions. Financial aid awards to students at postsecondary institutions that leads to increased reliance on standardized test scores as the primary selection tool for admission into undergraduate institutions [4],
- Higher likelihood of unstable social environments. For example, increased stress and/or health issues related to frequent moves for kids in foster care and psychological issues caused by transient lives, going to different schools, and/or peer adjustments.

After admission to college

- USP is more likely to experience high stress, isolation and a lack of "belonging" in college, which affects their confidence to participate in class and seek help [5],
- USP are less likely to become involved in extracurricular activities, and significantly more likely to work part-time or full-time while attending college [6],
- "First-generation college students often come from families experiencing greater levels of economic hardship than their second-and third-generation counterparts. Lower family income directly impacts a student's college experience on both an academic and a social level" [6],
- "First-generation college students are often the least informed about ways to obtain financial aid and student loans. They are also more likely to come from families who are resistant to incurring temporary levels of debt" [7],
- "The combination of low financial resources and less awareness to attain financial support can prevent these students from pursuing a college degree. Also, it is linked to higher levels of attrition." [7].

Many resources have been developed to address these challenges that include peer counseling, faculty, and corporate mentoring programs, academic support programs, financial aid, academic advising, and student transition support [8], [9].

This paper examines the various impediments that contribute towards first-year student attrition from the engineering major. Further, it provides a case study of a summer bridge program called the Successful Transition and Enhanced Preparation for Undergraduates Program (STEPUP) created specifically to address the above challenges. The paper will propose STEPUP as a generalized program model and best practice to be utilized by colleges and universities to promote the success of first-year engineering students in general, and USP, in particular.

UNDERREPRESENTED STUDENTS ADMISSION AND RETENTION

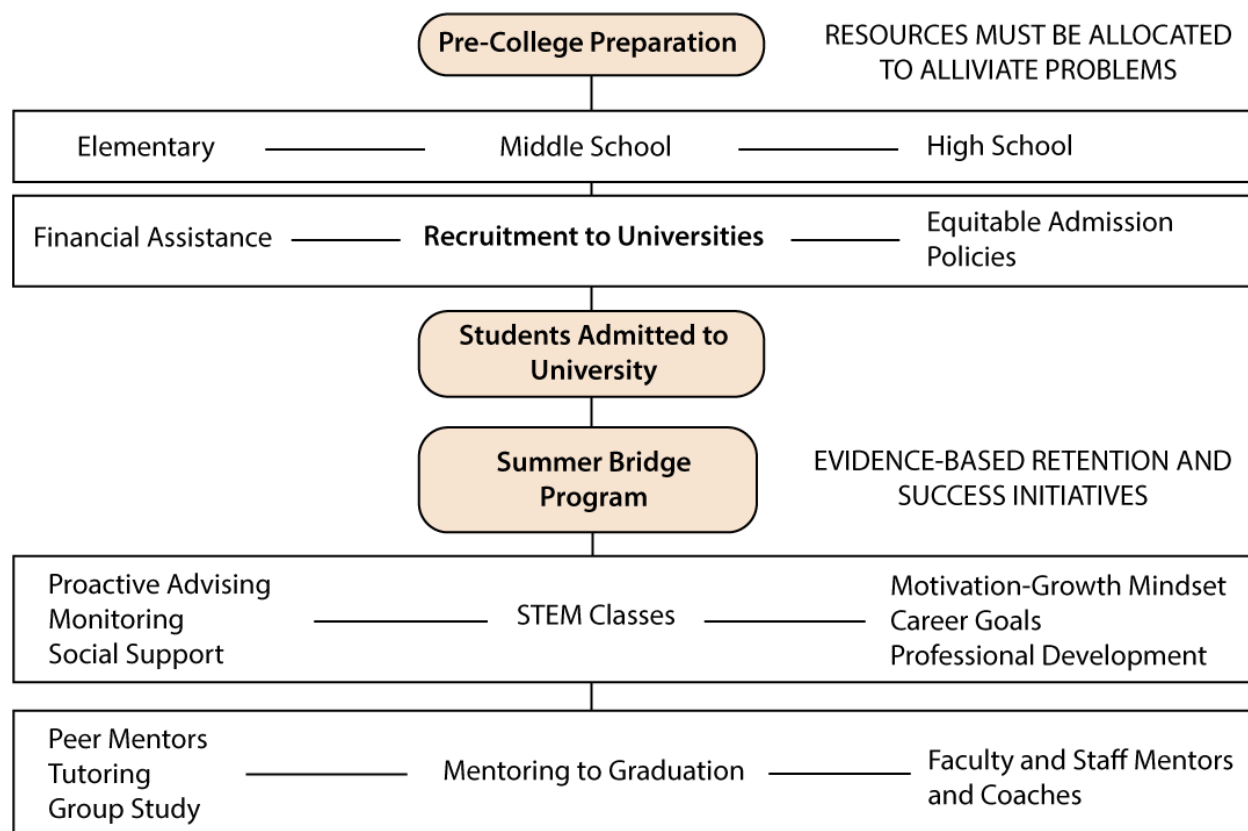


Figure 3. Framework for admission and retention of USP at public universities.

Overview of the STEPUP Program

History

In 1994, The University of Florida received funding from the National Science Foundation (NSF) Southeastern University and College Coalition for Engineering Education (SUCCEED) program. These funds were to be used to spearhead college efforts to address poor retention rates among underrepresented students within the major. In particular, students earning lower than a score of 600 on the SAT quantitative portion of the college entrance exam were targeted. The Minority Retention Success program was created as a non-residential program that would target students from underrepresented populations to bolster their strengths in calculus, chemistry, and physics. The program also endeavored to expose these students to other resources such as positive mentors, computer skills, tutoring/study halls, and team or cohort building activities. In 1995, the program was revised to include a residential component to address concerns related to poor class attendance and lack of involvement in other program activities associated with the non-residential format of the program. The combination of the six-week residential program with an eight-month, non-residential program resulted in the creation of the Successful Transition and Enhanced Preparation for Undergraduates Program, or STEPUP. The estimated cost of participation is \$5,200 per student for the entire academic year (this includes summer housing, meal plans, and classes, corporate tours, opening and closing ceremonies, professional development programming and program staff). Corporate sponsorship and donations from alumni are used to cover program expenses and

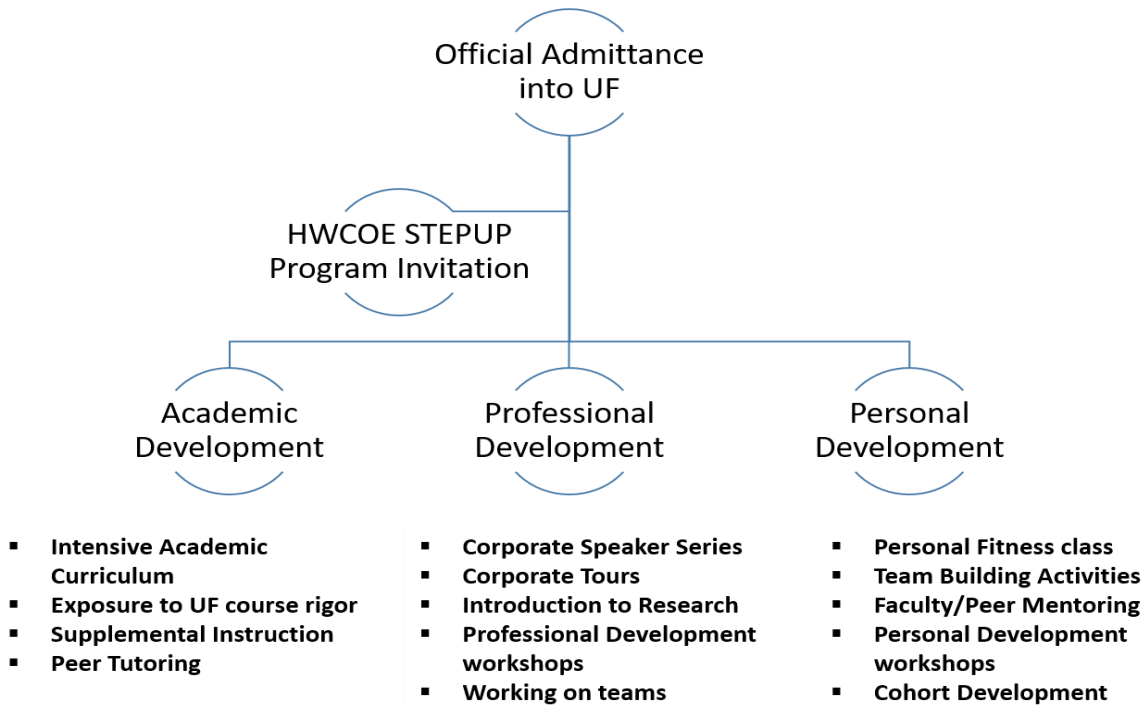
reduce the necessity of passing these costs to student participants. Instead, students selected to participate in the program are charged a nominal application fee of only \$850.00. Application fee waivers are made available to families who are experiencing financial hardship.

Program Structure

The STEPUP program is planned and coordinated out of the HWCOE Office of Student Transition and Retention (STAR). The STAR office is a unit of the Office of Student Affairs within the College. The main goal of the program is to recruit, motivate, and retain first-year engineering students within the major. The STEPUP program model is a multi-faceted initiative designed to promote the academic, professional and personal (A.P.P) development of freshman engineering students as depicted in Figure 4. The program combines faculty and peer mentoring with team-building, industry involvement, and academic enhancement resources. There are two components to the STEPUP program: a six-week summer residential program and a non-residential fall and spring component. Program support services related to personalized academic advising, faculty & peer mentoring, corporate networking, academic and other student support services continue throughout the entire freshman year. A snapshot of a typical program schedule includes the following classes and/or activities:

- Calculus and Chemistry supplemental workshops,
- A Project Design course,
- An Introduction to Engineering class,
- Introduction to Programming and Coding,
- Professional Development workshops,
- A Personal fitness class,
- A corporate tour and speaker series,
- Team-building activities,
- Study halls and individual tutoring.

STEPUP PROGRAM MODEL



* Diagram of the HWCOE STEPUP Program A.P.P Model

Figure 4. STEPUP program model

Program Recruitment: Admission and Participant Selection Process

To participate in the STEPUP program students must first receive an official letter of acceptance from the University of Florida, Office of Admissions. The Office of Admissions then provides HWCOE a list of student admits who selected engineering as their intended major. HWCOE begins the process of corresponding with all new admits via email, phone calls and letters to congratulate them on their acceptance into the University and welcome them into the College. At this time, students are informed of the diverse student support services provided by the college which includes the STEPUP program and other support services offered through the college. Students electing to apply to the STEPUP program must submit:

- A resume documenting past leadership, organizational and community service experiences,
- A cover letter describing the reason for their interest in the STEPUP program and any personal goal(s) they would like to accomplish as a result of their participation in the program,
- A copy of their high school transcript,
- Two letters of recommendation from either a STEM teacher and/or guidance counselor.

All applications are reviewed and scored to assess each student's:

- foundation in math, chemistry, physics, and other engineering classes,
- Writing abilities based on the quality of the students cover letter,
- Leadership strengths based on resume,
- Letters of recommendation from high school instructors, guidance counselors or other administrators attesting to student’s strengths, academic abilities and personal character.

Applications are reviewed/scored based on the student’s perceived academic ability to successfully manage the rigor and course load required by the STEPUP program. Students admitted into STEPUP are expected to continue their involvement in program activities throughout the entire freshman year. In efforts to extend support services into the sophomore year and beyond, the STAR office is in the process of developing a program called the Ralph A. Morgan “STEPout” program. This program is made possible through the generous support of the Ralph A Morgan family, HWCOE alumni and College donors. The mission of the STEPout program is to foster student professional development through experiential learning activities such as undergraduate research, paid externships and small scholarships in support of studying abroad. The program’s primary focus will be on second-year students, however, all currently enrolled STEPUP undergraduates are eligible to participate.



Figure 5. Diagram of STEPUP and STEPOUT program components

Results: Program Impact on Engineering Student Retention

As previously mentioned, the first two years of the program (1993-1994) served as a pilot for the current program model. The next thirteen years of the program were met with extreme success on nearly all measures. The average trend of enrollment during this time was 54% African American, 40% Hispanic-Latino and 27% Women. The high school grade point averages for students self-selecting to participate in the program prior to 2008 were typically 0.2 to 0.3 points lower than students electing not to participate in the program. In spite of this, the first-year attrition rates for STEPUP participants was only 17% in comparison to 34% for non-program participants [10]. By

the end of their sophomore year, attrition rates for STEPUP participants were only 33% in comparison to 44% percent for both non-STEPUP participants and minority students electing not to participate in the STEPUP program. Although the difference in high school grade point averages was not found to be statistically significant, the higher retention rates of STEPUP students to that of non-program participants is still considered large part due to program participation.

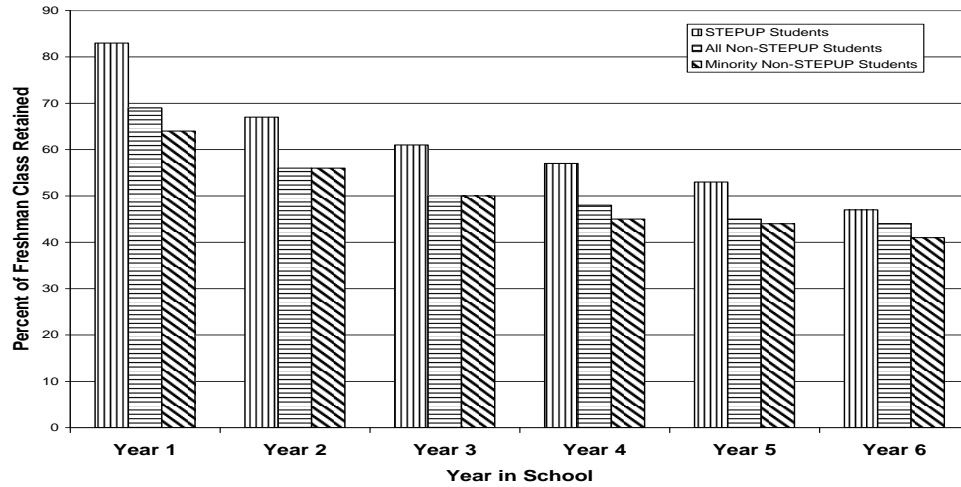


Figure 6: Yearly Percent Retention of STEPUP and non-STEPUP Students Entering as Freshmen from 1996-2007.

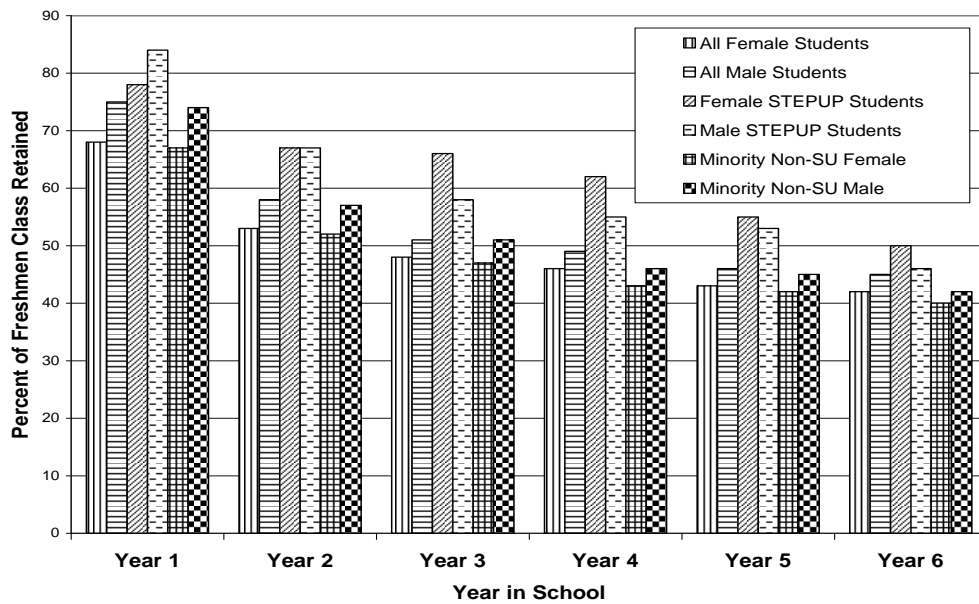


Figure 7: Yearly Percent Retention of STEPUP and non-STEPUP Male and Female Students Entering as Freshmen from 1996-2007.

The retention rates for both male and female STEPUP participants for the academic years of 1996-2007, was higher the first six academic years within the college. More recently, the impact of the program can still be observed through the comparison of African American and Hispanic-Latino

program participants versus non-program participants. The following charts (Figures 8 and 9) present 2-year retention rates of STEPUP program participants in comparison to first-year engineering students electing not to participate in the program.

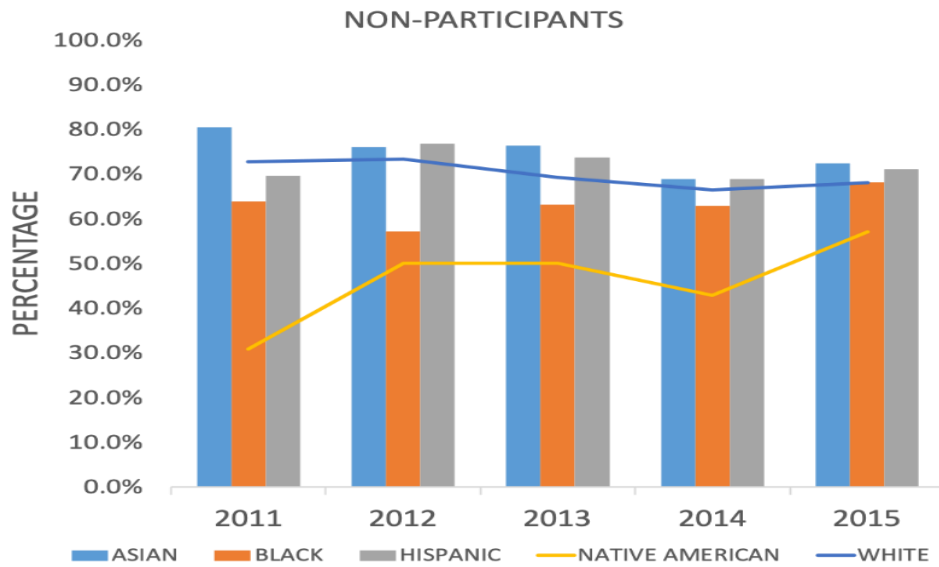


Figure 8. Two-year retention rates of non- program participants by cohort year.

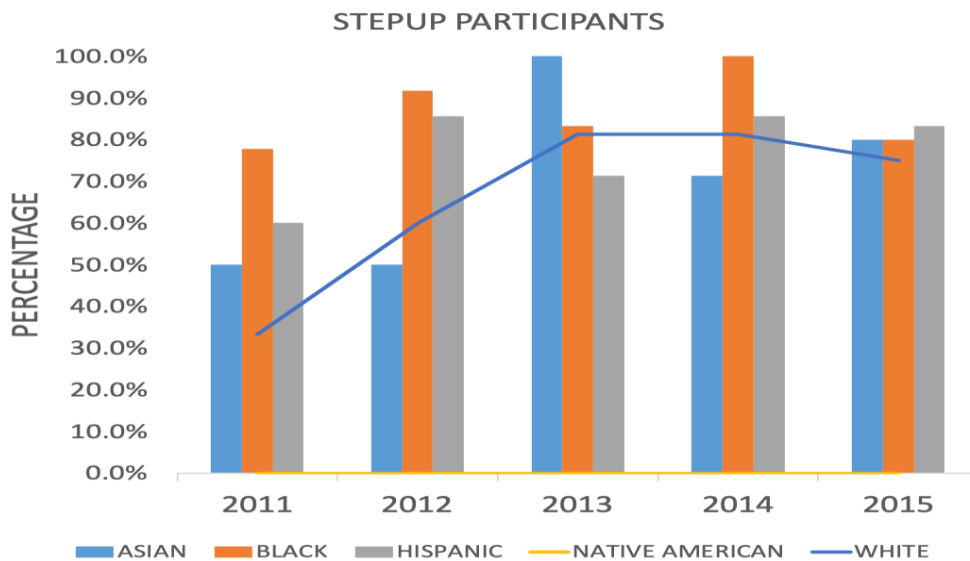


Figure 9. Two-year retention rates of STEPUP participants by cohort year.

Discussion

As part of any discussion related to underrepresented student populations (USP) and best practices in the form of student support services that promoting their success, it is essential to look at the

entire spectrum of the education process to gain a more holistic view. This includes their K-12 experiences, university admission, and transition and retention into the college/university. Diversity in education is linked to our nation's gross domestic product (GDP) and gross national product (GNP). The by-product of our unified educational opportunity for all citizens is in the nation's economic and technological strengths. In order to increase the number of engineers needed for our economy we must adequately prepare USP in foundational courses such as algebra II, pre-calculus, calculus and chemistry at the K-12 level. USP students must be encouraged, counselled, and prepared at the K-12 level to complete these foundational courses if they aspire to pursue STEM as a major at a top tier university such as the University of Florida (or other top tier university). At the university level, higher education practitioners must be committed to performing on-going and reflective strategic planning for continuous improvement of their student support services and programs.

Planning, Assessment and Continuous Improvement for the STEPUP program

Prior to the start of the summer residential program, students are required to complete a calculus and chemistry pre-test. These tests assess student foundational skills and establish a baseline of student knowledge in the subject areas. This test is administered again (post-test) at the end of the summer program to assess student improvement and knowledge gains. In addition, weekly pre and post-tests are used in the classroom to better assess the impact of class lectures and assignments. This practice will provide program staff with additional data to be used to assess student strengths and areas in need of improvement while summer the program is still in operation.

Program assessment will continue throughout the fall and spring semester in the form of student surveys, feedback from program mentors, informal feedback from program participants and a review of student academic performance each semester. Data gained from continuous improvement practices are used by the STAR office to assess the need for updates/revisions to the program model, program materials, marketing strategies, etc. For example, as of date, continuous improvement efforts have resulted in several enhancements and revisions to the STEPUP program model (as depicted in Figure 5) including:

- The addition of an Introduction to Research class intended to expose students to college faculty, their research endeavors, engineering research methodology and research programs available for first-year students,
- The addition of a Personal Fitness class promoting the benefits of exercise on student academic performance, and countering mental and physical health decline,
- Personalized learning through online tutoring software in chemistry and calculus,
- The creation of the "STEPout" program in efforts to improve student engagement in experiential learning activities,
- A project design centered model (2019) that will require students to demonstrate their ability to apply the principles of calculus, chemistry and physics learned in the classroom.

Issues affecting growth and efficacy

Assessment and continuous improvement efforts have also assisted identifying programmatic challenges that may contribute to program shortcomings related to identified goals and objectives. These issues include:

Funding for bridge programs and their expansion

The STEPUP program is funded in large part by sponsorships from engineering corporations and donations from university alum. In 2007, (in large part due to the national recession), for the first time since its inception, the STEPUP program began experiencing funding issues that have continued until this day. A reduction in alumni donations and corporate sponsorships has led to a decrease in program size from a capacity of 50 students down to 30-35. HWCOE faces an on-going challenge related to sustaining funding for the program.

Program Diversity and Participant Recruitment issues

A steep decline in the admissions rates for African American began during the academics years of 2007-2013. According to university and media resources, during this time period the enrollment of African American students at UF decreased by at least 50%. The drastic drop in African American admits poses a steep diversity challenge for the University at large, and for STEPUP program recruitment efforts specifically. For example, from 2007 to 2013 the rate of program participation for African-American students dropped from 18 to 6 (or approximately 33%). To put this in perspective, on average, the University of Florida can receive well over 40,000 applications for a typical freshman class of 6460 students. From this freshman cohort, as many as 25% or more select engineering as their intended major with as few as 4% to 5% this population comprising Black or African American students.

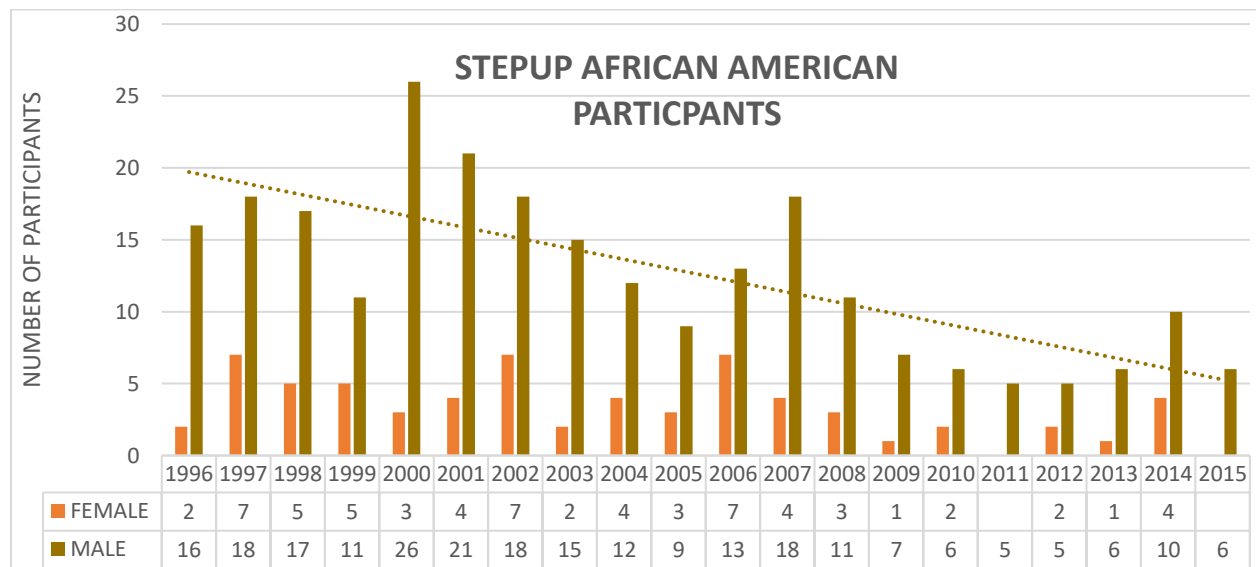


Figure 10: STEPUP African American Male and Female Students Entering Program Participants from 2000-2015

Figure 10 shows a steady decline in the number of African American students participating in the STEPUP program. The most significant drop off occurs between the years of 2009 to 2013 directly correlating to the time span for African American student decreased admission rates. The HWCOE

has no input regarding UF student admissions. As result, the STAR office has been forced to approach this challenge from all angles which include revising program marketing and recruitment strategies, creating/supporting K-12 engineering pipeline programs, exploring resources to provide additional scholarships to program participants, etc.

Conclusion

This paper examined the various K-12 and college/university factors that impact USP success in undergraduate engineering programs. It proposes the STEPUP program model as one method universities can use to promote their success. The program is not in the least bit perfect. However, it's past success and effectiveness on USP retention are worthy of being noted. Our nation's ability to overcome challenges related to USP K-12 preparation, admission into higher education and successful attainment of the engineering degree is well within reach with a tad bit of creativity and innovation on behalf of educational institutions and higher education practitioners.

References

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APPENDICIES

CHALLENGES FACING UNDERREPRESENTED STUDENT AFTER COLLEGE/UNIVERISTY ADMISSION

In addition to challenges related to gaining admission into a college/university, underrepresented student populations (USP) can face additional challenges long after the admission process has been completed: A list of these challenges include:

- Exceptionally high stress levels associated with successful transition into the college/university, as well as, pressures related to academic performance,
- Feelings of isolation and/or a lack of “belonging” within the college/campus setting (ESP. First Generation students). This may pose negative effects on student confidence and perception of self-efficacy,
- Assistance avoidance behaviors related to asking for help both inside and outside of the classroom. Utilizing campus support services if efforts to avoid association with negative stereotypes historically attribute to their cultural, ethnic, or gender group (11).
- Perceptions of isolation which result in USP students becoming less involved in extracurricular and other campus activities,

- Financial challenges faced by First-generation and other USP students resulting from family economic hardships. This may significantly increase the likelihood of the student having to work part-time/full-time while attending college. This can further reduce the opportunities for campus engagement directly impacting a student's college experience on both an academic and a social level" (1).
- Family related financial challenging may impact the student's college selection/choice. For example, first-generation college students are significantly more likely to attend a university within fifty miles of their home and significantly less likely to live on-campus during their freshman year.
- Student financial challenges contribute to first-generation and USP students being less likely to enroll full- time in a four-year institution, and less informed about ways to obtain financial aid and student loans.
- On average, first-generation college students obtain lower grade point averages and higher dropout rates than their peers by the end of their first year in college. Those that do graduate are least likely to attain their degree on time". (5).

STEPUP 25 SUMMER PROGRAM SCHEDULE - DRAFT

Week 1 thru 6 -

	Monday	Tuesday	Wednesday	Thursday	FRIDAY	SATURDAY	SUNDAY
Time	Column1	Column2	Column3	Column4	Column5	Column6	Column7
8:00am	PROJECT DESIGN (Lecture)	PROJECT DESIGN (Lecture)	PROJECT DESIGN (Lecture)	PROJECT DESIGN (Lecture)	CORPORATE ENGAGEMENT TOURS		
8:30am							
9:00am	CHEMISTRY WORKSHOP	CALCULUS	CHEMISTRY WORKSHOP	CALCULUS			
9:30am							
10:00am						FITNESS COURSE (Recreative)	
10:30am							
11:00am	CHEMISTRY WORKSHOP	CALCULUS	CHEMISTRY WORKSHOP	CALCULUS			
11:30am							
12:00pm							
12:30pm	LUNCH	LUNCH	LUNCH	LUNCH			
1:00pm							
1:30pm							
2:00pm	Project Design Lab	Project Design Lab	Project Design Lab	Project Design Lab			
2:30pm							
3:00pm							
3:30pm	INTRODUCTION TO RESEARCH	INTRODUCTION TO CODING	INTRODUCTION TO RESEARCH	INTRODUCTION TO CODING			
4:00pm							
4:30pm							
5:00pm	INTRODUCTION TO AGRICULTURAL AND BIOLOGICAL ENGINEERING	INTRODUCTION TO INDUSTRIAL AND SYSTEMS ENGINEERING	INTRODUCTION TO AGRICULTURAL AND BIOLOGICAL ENGINEERING	INTRODUCTION TO INDUSTRIAL AND SYSTEMS ENGINEERING			
5:30pm							
6:00pm	DINNER	DINNER	DINNER	DINNER			
6:30pm							
7:00pm	CONCEPTUAL MAKER SPACE SESSIONS	CONCEPTUAL MAKER SPACE SESSIONS	CONCEPTUAL MAKER SPACE SESSIONS	CORPORATE ENGAGEMENT SESSION			
7:30pm	CORE CONCEPT REVIEW	CORE CONCEPT REVIEW	CORE CONCEPT REVIEW				
8:00pm	DESIGN TEAM MEETINGS	DESIGN TEAM MEETINGS	DESIGN TEAM MEETINGS				
8:30pm	TUTORING	TUTORING	TUTORING				
9:00pm	CLASS ASSIGNMENTS	CLASS ASSIGNMENTS	CLASS ASSIGNMENTS				
9:30pm							
	Residence Hall Curfew @ 11pm		Residence Hall Curfew @ 11pm	Residence Hall Curfew @ 11pm	Residence Hall Curfew @ 11pm	Residence Hall Curfew @ 11pm	Residence Hall Curfew @ 11pm