Retention Strategies for Engineering and Computer Science

High Impact Practices (HIP) during first year in college

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Abstract

The High Tech Education working group of the President's Council on Jobs and Competitiveness (Jobs Council) concluded that an increase in the number of U.S. engineering and computer science graduates is essential to maintain US competitiveness in the world. Accordingly, the National Science Foundation has embarked an initiative to increase the BS graduates in these disciplines by 10,000. However, engineering and computer science majors share the dubious honor of not retaining most of the students entering the programs as freshmen. The problem is much more severe among underrepresented students that make up an increasing fraction of entering freshmen at California State University Fullerton (CSUF). Studies such as the recent work by ASEE (2012) document over 60 strategies and practices to increase retention during the first two years of the undergraduate program. The strategies were divided into three categories: *student-focused strategies and practices; faculty-focused strategies and practices and department-focused strategies and practices.* The College of Engineering and Computer Science (ECS) at CSUF contributed its own practices and findings to the ASEE study, was acknowledged for its work and was recognized nationally by the Wal-Mart *Semillas* grant and *Excelencia's* Growing What Works initiative. This paper examines the causes of poor retention during the first year as well as the successful deployment of high impact practices to improve it. The approach taken by CSUF started with a careful and dispassionate review of student data with the help of the Office of Institutional Research and Analytical Studies. This data based inquiry naturally led to the identification of numerous problems and surprisingly several remedies also. ECS first-year retention has improved between 15 and 20% during the past five years. The approaches, analyses and results of the CSUF experience are expected to be useful to all, particularly for institutions with large populations of first-time college goers or underrepresented minorities.

1. Background

High-Impact Practices are defined as purposeful and effective educational practices which deepen student engagement and learning leading to college student success. [39] Through years of analyzing student gains Kuh found that students who participate in high-impact educational practices have higher student engagement gains than their peers. He recommends that students

receive these high-impact learning experiences in the first year of college. Many of Kuh's high impact learning experiences have been adapted at CSUF.[11] These high-impact practices are positively associated with persistence and GPA, higher rates of student-faculty interaction, increases in critical thinking and writing skills; and higher student engagement overall[2,10,11].

The College of Engineering and Computer Science (ECS) at California State University Fullerton (CSUF), a comprehensive Hispanic-Serving Institution in Orange County, California, implemented an *"Engineering and Computer Science (ECS) Scholars"* program during 2007-10 to increase the retention rates of freshman Latino students in ECS majors. The program integrated curricular and co-curricular educational interventions designed to support students' academic, social and personal transition to college life and increase their achievement, retention and graduation rates. Early results of this special *ECS Scholars* program were powerful, with an average of 81% one-year and 71% two-year campus wide retention rates compared to 73% one-year and 63% two-year campus wide retention rates of all ECS freshman, and serve as the basis for this paper.

The National Science Board (2004) has noted "a troubling decline in the number of U.S. citizens who are training to become scientists and engineers, whereas the number of jobs requiring science and engineering…training continues to grow." Casting that decline in a particularly disquieting light is the fact that significantly fewer U.S. college students are pursuing science and engineering degrees than their counterparts in other countries. As reported in *Rising above the Gathering Storm, Revisited* (2010), the U.S. now ranks 27th among developed nations in the proportion of college students receiving undergraduate degrees in science or engineering. Moreover, there is a large degree of variability in retention and graduation of students by race, ethnicity, and gender. For example, the six-year graduation rate of Asian Americans is 67%, Caucasians, 60%, Hispanics, 44%, Native Americans, 39%, African Americans, 38% and females, 61%[1-12]. In California, about a third of the state's students who intend to pursue engineering and computer science graduates degrees fail to achieve their goal, considerably higher than the 22% attrition rate nationally. While the state is home to more top research universities and high tech industries than any other state, it is significantly under-producing graduates with technical degrees[3].

In order to increase the number of engineering and computer science graduates, the underrepresentation of Hispanic students in engineering and computer science graduates needs to be addressed in California and particularly in Orange County where Hispanics make up 38% and 31% of the population respectively. Projections show that Hispanic students will represent 20% of U.S. high school seniors by 2013, yet they make up only 13% of community college graduates, 10% of university graduates, and 6% of STEM graduates (U.S. Census Bureau, 2012; U.S. Department of Education, 2010c; U.S. Department of Education, 2010d; Taningco et al., 2008). Similarly, low-income students are also seriously underrepresented in higher education and, by extension, STEM majors. For every 100 low-income students who make it to high

school, 65 will graduate, 45 will enroll in college (75% at a community college), and only 11 will earn a college degree.

2. Need for Improvement of Retention in STEM

The President's Council on Science and Technology's *most recent report* (PCAST 2012) finds that high performing students frequently cite uninspiring introductory courses as a factor in their decision to switch majors. Low performing students with a high interest and aptitude in STEM careers often have difficulty with early courses in mathematics and find little help provided by their universities. Moreover, many students, and particularly members of groups underrepresented in STEM fields, cite an unwelcoming atmosphere from faculty in STEM courses as a reason for their departure. Among the PCAST 2012 recommendations[37] to improve STEM education are 1) improved teaching methods by university faculty to make courses more inspiring; 2) providing more assistance to students facing mathematical challenges; 3) creating an atmosphere of community for STEM learners; and 4) diversifying teaching methods in STEM education. Data show that evidence - based teaching methods are more effective in reaching all students - especially the "underrepresented majority"- the women and members of minority groups who now constitute approximately 70% of college students but only 45% of undergraduate STEM degree recipients. [13-23]

3. Overview of Enrollment and Graduation Data at CSUF and the College of ECS

California State University, Fullerton (CSUF), located 25 miles southeast of Los Angeles in Orange County, is among the largest universities in the nation with a fall 2012 enrollment of 37,677 students. CSUF is the largest of the 23 campuses of the California State University (CSU) in terms of student headcounts, which grants more than 50% of all bachelor's degrees and 30% of all master's degrees in the state. It is Orange County's only four-year, comprehensive Hispanic-Serving Institution and Asian-Pacific Islander-Serving Institution. There is no ethnic majority among its students; 32% of students identify as Hispanic, and more than half come from families in which neither parent graduated from college. Among the first-time freshman entering CSUF in 2011, 40% were identified as low-income, per federal criteria (received Pell Grant) - all factors identified in the literature as contributing to leaks in the STEM pipeline.

CSUF ranks first in California and fourth in the nation in bachelor's degrees awarded to Hispanics[8] and is ranked ninth nationally in the number of baccalaureate degrees awarded to minority students (*Diverse Issues in Higher Education*, 2011).

a. Enrollment and Graduation Data at CSUF

Table 1 shows undergraduate enrollment data and the percentage of students who achieved the dean's list or academic probation in the overall CSUF student population, in all STEM majors and in the College of Engineering and Computer Science (ECS). By the end of the fall 2011

semester, approximately 5% of CSUF's undergraduate student population chose majors in ECS. Just 9% of these students made dean's list, compared to 13.6% across all majors. Moreover, 16% of ECS majors were on academic probation, compared to 7.6% across all majors. Nearly twice as many students make dean's list as those on academic probation university-wide while in ECS, nearly twice as many students are on academic probation compared to the number who achieves dean's list.

Table 1. Undergraduate STEM and ECS Enrollments, End of Fall 2011 Semester

	Undergraduate students	Dean's List	Academic Probation
All University	30,655	13.6%	7.6%
STEM	4,919	9.1%	10.0%
ECS	**1,641** (5.4% of total student population)	**9.0%**	**16.0%**

Table 2 shows CSUF graduation figures, with persistence rates by STEM majors and ECS majors. "Persistence" means that a student initially declaring a major in a discipline completed a degree in that discipline within six years. The persistence rate for all CSUF students was 82% with 53% of STEM majors persisting and 51% of ECS majors persisting. The overall graduation rate for the seven cohorts was 49%, with STEM students again completing degrees at lower rates (38%) and ECS majors at 14%.

Table 2. Undergraduate STEM and ECS Persistence and Six Year Graduation Rates, Entering Cohorts 1998-2004

	Persistence	Six-Year Graduation Rate
All University	80 %	50 %
STEM	61 %	19 %
ECS	60 %	14%

STEM students take more years to graduate than non-STEM students. However, the College of Engineering and Computer Science (ECS) have made significant progress in improving retention and reducing time to degree as discussed in the next section.

b. University Level Retention Efforts at CSUF

In January 2010, a University-wide task force examined the campus' graduation rates for the past 10 years and identified challenges, as well as strategies for addressing the challenges, to increase graduation rates. As a result of its activities, some of the specific changes that occurred are:

- Reexamination and implementation of a more integrated student orientation, academic advising and course registration process.

- Identification of bottleneck STEM courses, and new initiatives on how to alleviate the problem, including the use of supplemental instruction utilizing peer leaders.
- Comprehensive analysis and inventory of all advising practices, academic support services and student affairs to identify overlaps and gaps in the system. The information is being used to realign resources to create a more intentional and proactive advising infrastructure so that students do not get lost or drop out of the system.
- Assessment of course registration behaviors of the 2009 class led to identifying students in good standing who had not registered for courses during the first class registration period. These students were contacted by associate and assistant deans, Academic Advising Center staff and Intensive Learning Experience staff to determine why they had not registered and encourage them to do so if at all possible. The primary reason reported for non-registration was financial. The continuation rate in Fall 2010 was 84.3%, more than four points higher than the previous year (80.2%).

A campus-wide academic advising workshop trained 134 participants (74 faculty, 46 staff and 15 students) on the degree audit process, new General Education realignment, probation and disqualification procedures, evidence-based best advising practices, reasons for graduation deferrals, measures to prevent graduation deferrals and advising technologies. 96-98% of respondents agreed that the workshop material was relevant and appropriate and rated it as excellent or above average.

The majority of the CSUF students will be among the first-generation of their family to earn a college degree. The student population is highly diverse (no majority ethnic-race). The university population is predominantly female but the ECS population is majority male by a wide margin. As a regional university, CSUF draws the majority of its student body from the Orange County, Southeast Los Angeles County, Riverside County, and San Bernardino County areas of Southern California (See Table 3). The ethnic and gender mix of entering freshmen at the university is shown in Table 4.

Admission to the university referenced in Tables 3 and 4 is based on the "Eligibility Index (EI)" established by the California State University system. Eligibility index is a composite score obtained by the formula EI = High school GPA* 800 + SAT Mathematics and SAT Critical Reading. For example, a student with 3.2 GPA in high school, SAT Critical Reading score of 500 and mathematics score of 600 will have an EI of 3.2*800 + 500+600 or 3660. (Alternatively, EI=200*GPA+10*ACT score.) Campuses use lower or higher eligibility scores based on local needs, demand and selectivity but the admission standards do not address success in prerequisite courses including mathematics. In the past it was possible for students seeking to be engineering and computer science majors with remediation needs in high school algebra and trigonometry.

The enrollment in the programs within engineering and computer science had been steadily increasing, thanks to the increasing regional and national visibility of the college as well as the success of outreach activities. This has also improved selectivity for entrance. After lagging

behind the university's minimum eligibility index for many years, ECS students have recently edged out the university at large (See Table 5) albeit slightly. One and two year attrition rates for the College of ECS historically exceeded the university rates by a wide margin but, thanks to the recent college-level efforts, the attrition rates are shrinking as shown in Table 6. This results in an increased need for ECS to focus its efforts to improve student outcomes on the freshman and sophomores years in order to begin to make progress in improving its six year graduation rates.

Table 3. Geographical Distribution of Enrollment at CSUF and the College of Engineering and Computer Science[38]

Five Year Trend in Undergraduate enrollments by county of residence	CSUF/ECS	Fall 2008	Fall 2009	Fall 2010	Fall 2011	Fall 2012
Orange	CSUF	48%	48%	52%	53%	53%
	ECS	48%	46%	51%	53%	52%
Los Angeles	CSUF	28%	28%	25%	24%	24%
	ECS	26%	26%	24%	21%	22%
Riverside	CSUF	7%	8%	7%	8%	8%
	ECS	9%	10%	10%	9%	10%
San Bernardino	CSUF	7%	7%	7%	7%	7%
	ECS	6%	7%	6%	7%	7%

Table 4. Enrollment Profile of California State University Fullerton and the College of Engineering and Computer Science[38]

Five Year Trend in Undergraduate enrollments	CSUF /ECS	Fall 2008	Fall 2009	Fall 2010	Fall 2011	Fall 2012
Asian/Pacific Islander	CSUF	22%	22%	22%	22%	22%
	ECS	24%	25%	26%	25%	25%
Hispanic	CSUF	30%	31%	33%	34%	35%
	ECS	31%	31%	32%	33%	33%
White	CSUF	30%	30%	30%	29%	27%
	ECS	26%	26%	26%	26%	24%
Will be among first generation of family to earn a college degree	CSUF	50%	52%	52%	53%	55%
	ECS	50%	51%	50%	48%	50%
Women	CSUF	58%	58%	57%	56%	56%
	ECS	13%	13%	12%	12%	11%

Table 5. Admission Characteristics of Entering Freshmen at CSUF and ECS[38]

Entry Characteristics Trend for First-time Freshmen: *Five-Year trend*	CSUF/ECS	Fall 2008	Fall 2009	Fall 2010	Fall 2011	Fall 2012
Eligibility Index	CSUF	3542	3611	3620	3719	3742
	ECS	3479	3509	3631	3707	3743
Needed Math Remediation at Point of Admission	CSUF	37%	35%	32%	24%	23%
	ECS	22%	21%	13%	13%	13%

Six year graduation rates for ECS cohorts lag the university rates by a large margin. While six-year graduation rates of the university are approximate 50%, rates for students initially entering as ECS majors are near 30% (Table 7). The ECS first-time freshman cohort of over 300 students impacts the overall university rate by being 10 percentage points in an overall rate of 100 points. The failure to graduate students who entered as ECS majors in six years or less from an engineering program or from any other university programs thus draws down the overall university rate by approximately one percentage point. ECS outcomes lower the university six-year graduation rates of male students by two percentage points. All of this points to the need for focused attention to retention of freshmen students within ECS.

Table 6. Retention Rates of Entering Freshmen at CSUF and ECS[38]

First-time Freshman One- and Two-year Retention Rates by Cohort Entry Term: *Five-Year Trend*	CSUF/ECS	Fall 2007	Fall 2008	Fall 2009	Fall 2010	Fall 2011
One-Year Retention rate	CSUF	79%	80%	84%	85%	88%
	ECS retained at CSUF	68%	71%	83%	81%	85%
	ECS retained as ECS major	52%	52%	69%	69%	71%
Two-Year Retention rate	CSUF	70%	73%	79%	78%	
	ECS retained at CSUF	59%	62%	78%	72%	
	ECS retained as ECS major	34%	40%	49%	51%	

Examination of graduation rates for entering ECS cohorts reveals students who entered initially seeking ECS majors are unlikely to graduate with ECS degrees. Fifteen percent of the ECS majors entering as first-time freshmen in Fall 2006 ultimately graduated with a degree in ECS.

Twenty three percent of the students from the initial Fall 2006 ECS cohort earned a degree in six years or less from a major outside of ECS.

The retention and graduation rates of first time ECS majors are most impacted by the first year attendance. So, it became apparent that efforts for increased contact with ECS freshmen during the first year of college attendance and during the first semester classes they take (See Table 8) need to be undertaken. Remediation in mathematics was another challenge. So, ECS altered the first year experiences of its entering class starting with wholesale changes to its new student orientation and first year experiences available to its students.

Table 7. Six Year Graduation Rates for Entering Freshmen[38]

Five Year Trend First-time Freshman Six-year graduation rates by Cohort Entry Term	CSUF/ECS	Fall 2002	Fall 2003	Fall 2004	Fall 2005	Fall 2006
Six-year graduation rates	CSUF cohort (includes ECS majors at entry)	49%	52%	51%	50%	51%
	ECS major at entry earned degree in any major including ECS at CSUF	32%	40%	34%	31%	38%
	ECS major at entry earned degree in ECS major	11%	15%	14%	11%	15%

Table 8. First Semester Courses Taken by First Time Freshmen[38]

Course attempted by ECS first-time freshmen in year one Fall (% of ECS freshmen)	Fall 2008	Fall 2009	Fall 2010	Fall 2011	Fall 2012
Remedial math	17%	17%	10%	10%	10%
Pre-calculus	57%	58%	65%	65%	57%
Calculus	12%	11%	16%	21%	28%
Computer Science	29%	27%	29%	34%	39%
Engineering	30%	13%	30%	39%	37%
At least one Engineering or Computer Science course	59%	41%	58%	73%	76%

4. Specific Efforts for Improving ECS Retention in the First Year

As mentioned above, the retention during first year was addressed using a variety of approaches. They included ECS Scholars Program using an opportunistic Title V grant, a scaled down effort using a *Semillas* Award obtained in 2009, academic adjustments by reordering choke points in the curriculum to a later, more mature, stage, improved connections and advising during new student orientation, creating affinity groups such as 'Women in Engineering,' peer mentoring programs, and intervention approaches during probation and disqualification due to low grades. Also, efficient utilization of support services from campus forums such as Freshman Programs, the University Learning Center (ULC) and Center for Academic Support in Engineering and Computer Science (CASECS) is also part of the retention strategy. While every one of these strategies contributes in some meaningful way in helping a few students succeed during the first year, the combined impact of these high impact practices continues to be substantial.

a. ECS Scholars Program Title V - Integration of Services

The Engineering and Computer Science (ECS) Scholars program is a learning community (LC) based model that integrates interventions from four different entities at CSUF: Title V Retention Programs, the University Learning Center (ULC), the Center for Academic Support in Engineering and Computer Science (CASECS) and the Freshman Programs. Service allocation and delivery is coordinated by a Student Services Professional (SSP). The *ECS Scholars* program launched in the fall 2007 semester focuses on the academic success of Latino *first-time freshmen* (FTF) in engineering and computer science. Students participate in this program during the fall and spring semesters of their first year. As mentioned earlier, this program integrated interventions designed to support Latino student's academic, social and personal transition to college life and ensure success. Program staff and services provided by the program are tailored to be culturally relevant to ECS Latino students.

Program Activities

ECS Scholars is an elective program; participants experience a smooth transition to college life by maximizing campus resources, opportunities for individual and community development, and on-going interaction with faculty, staff, and peers from the College of ECS. The ECS Scholars LC offers rewarding and unique benefits centered on the following aspects:

- Develop friendships and connections with students and faculty within the College of ECS. Students are block scheduled and placed in a Freshmen Year Seminar (FYS) course each semester of their first year (1 unit in the fall and 2 in the spring semester) with an instructor who holds a Ph.D. in Engineering or Computer Science.
- Receive specialized academic advisement for general education and major coursework under the guidance of a full-time academic advisor.

- Receive supplemental instruction and one-on-one tutoring in core classes (math, science, engineering and computer science courses) in specialized Freshmen Interest Groups lead by trained upperclassmen.
- Service-learning experience related to their field of study; students must complete 20 hours at government or non-profit organizations.
- Receive counseling on transitional issues from a student service professional who is a co-instructor in both sections of the FYS courses.
- Mid semester grade check (early intervention) to connect academically at-risk students with university or college level support services to help them succeed in their classes.

b. Excelencia in Education Wal-Mart Semillas Grant– *Scaled Down Integration of Services*

In early 2009 the Title V grant (with annual allocation of $160,000) ended but ECS received a smaller funding of $50,000 from the Excelencia in Education Foundation from their Wal-Mart *Semillas* grant. One of the outcomes observed that has paved the way to offer variations of the ECS Scholars program with limited funding, was the opportunity to restructure portions of the ECS Scholars program. The program was eventually mainstreamed at the conclusion of the grants with the Assistant Dean leading the efforts and most of the advising, tutoring and mentoring services channeled through CASECS.

During the fall 2010 semester 26 students participated in the learning community. By block scheduling the students, it was possible to offer study groups and bring them together in two courses, University 100 and Engineering 100 (EGGN 100). This activity is to be one of the most important components for student success and is identified as one of the high impact educational activities for student success. According to their ASEE paper, Unnikrishnan and Lopez state the following: "*Learning Communities have three integral components: shared knowledge, shared knowing, and shared responsibility. Connecting courses so that they appear to be related promotes the networking of ideas and elevates thinking to a higher level (shared knowledge). Enrolling participants in the same classes induces social interaction and enhances intellectual interface, and allows students to care for the development of each other's learning (shared knowing). Lastly, students who participate in LCs learn to become responsible for one another and become "mutually dependent" so that advancement is done as a cohesive unit with each member making contributions to the group (shared responsibility)*[18-19]*."* A total of 129 ECS first-time full-time students participated in the programs for three academic years in 2007, 2008, and 2010. Data in the tables 9 and 10 indicate that those who were in the ECS Scholars Program had a higher persistence rate. One year retention rate of ECS Scholars freshmen was 71%, while only 58 % of all ECS freshmen had been retained for one year. Similarly, two-year retention rate of ECS Scholars was 10% higher than that of all ECS freshmen. Therefore, student involvement in a small learning community sharing knowledge and academic goals was found to be an effective educational intervention to improve freshmen retention, particularly for underrepresented students.

c. University Learning Center

The ULC provided study groups for remediation courses such as Math 40, Math 125 and Math 150A Calculus I. These courses had been identified as choke points where ECS students struggle and often fail. In addition to the study groups, the ULC offered tutoring in English, chemistry, computer science and provided study skills workshops. The workshops included, time management, note taking, and test taking strategies.

Table 9 *In-ECS* Retention Rates

First-Time Freshmen ECS SCHOLARS in ECS (2007, 2008, 2010 Cohort)[38]

Cohort Year (Fall)	# of ECS Scholars	1-year Retention	2-year Retention
2007	59	40 (68%)	28 (47%)
2008	44	31 (70%)	23 (52%)
2009*	n/a	n/a	n/a
2010	26	20 (77%)	16 (62%)
Total	**129**	**91 (71%)**	**67 (52%)**

* ECS Scholars Program was not available for 2009 cohort

Table 10 *In-ECS* Retention Rates
First-Time Full-Time Freshmen ALL in ECS (2007, 2008, 2010 Cohort)[38]

Cohort Year (Fall)	# of ECS Cohort	1-year Retention	2-year Retention
2007	325	170 (52%)	110 (34%)
2008	353	184 (52%)	141 (40%)
2010	331	229 (69%)	168 (51%)
Total	**1009**	**583 (58%)**	**419 (42%)**

d. Freshman Programs

At CSUF "**Freshman Programs**" is an entity on campus that promotes college success by providing learning communities designed to ensure first-year students' successful transition from high school to higher education. Its curriculum and services create a foundation for academic

achievement, campus involvement and community engagement. Freshman Programs promotes student retention through academic success, campus involvement and community engagement.

Freshman Programs facilitated the following for the ECS scholars program: (1) enrollment in a Freshmen Year Seminar (FYS) Course that is vital to academic planning, orientation, and transition to CSUF; this seminar offers further integration into areas of Engineering and Computer Science via a Service Learning component, (2) coordination of block-scheduling of participants (3) professional development for FYS Course instructors; and (4) assessment of all professional development programs as well as peer evaluations for instructors.

e. Women in Engineering

In 2012, ECS received funding from the Engineering Information Foundation to support a "Women in Engineering" learning community project. Nineteen, out of 58 entering first-time freshman female students, are participating in the learning community during the Fall and Spring semesters of AY 2012-13. A tutor and a mentor for this community were hired and female role models have been invited to interact with the group. Field tours such as the one to the Disneyland Resorts were arranged to witness the work done by female engineers in nonconventional venues.

f. Creation of an Undeclared Engineering Option

It has been observed at CSUF that about 25% of the entering freshmen in engineering may not be ready to declare a major largely due to a lack of information regarding difference between the disciplines within engineering. Some students may be genuinely torn between two disciplines they like equally. In the past, these students were advised to choose one of the available majors with the understanding that they could transfer to a different major later. However, such transfer occurred rarely; instead students left the college altogether when they became disenchanted with the initial choice. Today, all undeclared majors are required to take *EGGN 100 Introduction to Engineering* where they are introduced to the various branches of engineering. Early indication is that the retention rate among undeclared freshmen is high; formal evaluation of the data is still in progress.

g. EGGN 100 Introduction to Engineering

The College of Engineering and Computer Science has allocated resources to offer a 3 unit introductory course, EGGN 100. ECS Scholars were required to register for this course which is part of the block scheduled courses. This course was team taught by selected untenured faculty members with a reputation as excellent teachers.

Students who are enrolled in the course will have a general understanding of four engineering disciplines including Civil Engineering, Electrical Engineering, Computer Engineering, and Mechanical Engineering to gain hands-on experience of engineering tools and to work

collaboratively in team projects. Faculty-Student interaction has consistently been found as a strong correlate of successful learning[26-34]. According to Vygotsky's "Zone of Proximal Development Theory (1978)", learning can be enhanced when students work in collaboration with more capable peers[35-36]. In EGGN100 classes, students are able to interact with peers, faculty, and graduate students who are more capable peers.

ECS Freshmen who take EGGN100 course are more likely to return to ECS major in 2nd year (see Table 11 and Table 12)[38]. In 2010, 73% of freshmen who took EGGN100 persisted in the engineering major, whereas 68% of freshmen who did not take the course returned to ECS in 2nd year. The difference in 1-year retention is more salient for 2011 cohort, indicating that 81% of 2011 freshmen cohort returned to ECS in 2nd year.

Table 11. The Effects of EGGN 100 on 1-Yr Retention of ECS Fall 2010 Freshmen Cohort[38]

inECS Status	EGGN100		Total
	NOT taken	taken	
Changed Major/Dropped Out	104	8	112
In ECS Retained	**221**	**22**	**243**
Total	325	30	355

In ECS Status	EGGN100		Total
	NOT taken	taken	
Changed Major/Dropped Out	32.0%	26.7%	31.5%
In ECS Retained	**68.0%**	**73.3%**	**68.5%**
Total	100.0%	100.0%	100.0%

Table 12. The Effects of EGGN 100 on 1-Yr Retention of ECS Fall 2011 Freshmen Cohort[38]

In ECS Status	EGGN100		Total
	NOT taken	taken	
Changed Major/Dropped Out	99	5	104
In ECS Retained	**230**	**21**	**251**
Total	329	26	355

In ECS Status	EGGN100		Total
	NOT taken	taken	
Changed Major/Dropped Out	30.1%	19.2%	29.3%
In ECS Retained	**69.9%**	**80.8%**	**70.7%**
Total	100.0%	100.0%	100.0%

h. Supplemental Instruction

Even though the ECS frowns on additional credit hour burden created by the supplemental instruction, such extra instruction has proven to be one more item in ensuring student success in gatekeeper courses [40]. Some students benefited by supplementary instruction especially in mathematics.

i. CASECS (Center for Academic Success in Engineering and Computer Science)

The Center for Academic Support in Engineering and Computer Science (CASECS) is an academic support program designed to recruit, retain and graduate students. CASECS serves educationally disadvantage students, to the extent possible by law, emphasizes participation by students from groups with low eligibility rates for four-year colleges. Some of the features of the program include:

1. Building a support community among students with similar career goals
2. Constructing the bridges necessary to establish a mentor-protégé relationship between faculty and students
3. Expecting excellent performance by students

j. Freshmen Advising: Bucking Against the Campus Culture of *General Education First*

One of the quickest ways of discouraging an engineering or computer science student is through advising the student to take all general education courses first. Such advice was very common until relatively recently because the campus culture promoted wanderings of undeclared freshmen. Once the student takes all general education courses without simultaneously progressing in technical courses or foundational courses in mathematics and science, the student finds himself or herself unable to take courses or an adequate number of courses for lack of prerequisites. This practice has essentially stopped by the intervention of ECS administration and the constant dialog it has with Freshmen Programs as well as the staff of New Student Orientation.

k. New Student Orientation (NSO)

ECS NSO Model

With the goal of establishing a connection from the beginning and allowing first-time freshmen to “experience” their major earlier in their academic career, ECS collaborated with the Academic Advisement Center and the New Student and Parent Programs and added an innovative component in 2010 to the summer NSO sessions. The afternoon session of the NSO is now held in the ECS labs. The students, grouped by major, spend an afternoon with their department chair, faculty members and administrators. Activities include lab tours, academic advisement where general education and major requirements are presented along with how to register for classes.

The interactive NSO sessions have resulted in an increased level of interaction between faculty and student, allowed students to "experience" their major earlier in their academic career, increased the level of peer interaction among students within the College and created opportunities for students to immediately "connect" with their future instructors and advisors.

Placement in correct Math course

Many freshmen are quite gullible and naïve about course selections especially when they are first generation college goers. There have been many instances where students with transferable AP scores in mathematics (AB or BC) are placed inappropriately in pre-calculus courses since scores are not available at the time of orientation. Sadly, some of these instances are not minor clerical errors. So, ECS welcome letter now includes specific directions about mathematics placement and avoiding a second serving of pre-calculus while waiting for advanced placement scores.

Math Qualifying Exam (MQE)

Many students with good mathematics skills arrive for NSO without expecting a 'test.' They invariably failed to make the cut when asked to take the MQE that is administered during new student orientation. The scores in such "gotcha" tests meant little but low scores forced AP students into pre-calculus courses. ECS instituted coaching for the MQE examination by sharing tips for taking the test. Information on the MQE is also provided on the checklist sent to students and is also covered during NSO. The MQE scores are becoming more reliable as a result.

Chemistry Placement Exam (CPE)

Students failed to reach the cut-off threshold if they arrived without reviewing high school chemistry and are then placed in basic chemistry courses that totally upset their curricular flow. So, ECS includes information about CPE in the checklist that is sent to accepted students.

5. Further Thoughts

As can be seen from the discussion above, a number of individual high impact strategies have resulted in a cumulative improvement in the retention of first time freshmen in the College of Engineering and Computer Science. However, the gains in the first year retention have not been matched by similar gains in the second year, a critical gap in improving graduation rate. At the present time, the College is contemplating on a program with the following well-defined objectives: 1)increase the number of students obtaining baccalaureate degrees in ECS at CSUF; 2) reduce the time to graduation for ECS students; 3) continue to improve the retention of freshman students; and 4) increase retention of sophomore ECS students. The targeted goals are ambitious; however, they are based on the proven results of first year retention. These goals are depicted in tabular form in Table 13.

Table 13. Expected Retention and Graduation Outcomes[38]

Cohort year	Total Head Count of Freshmen	Persist to 2nd year	Persist to 3rd year	Persist to 4th year	Grad in 4 years	Enter 5th year	Grad in 5 years	Enter 6th year	Grad in 6 years	> 6 years to grad
		85%	70%	65%	35%	30%	50%	60%	60%	5%
2013	550	468	385	358	**193**	165	**275**	330	**330**	28
2014	600	510	420	390	210	180	300	360	**360**	30
2015	600	510	420	390	210	180	300	360	**360**	30
2016	650	553	455	423	228	195	325	390	**390**	33
2017	650	553	455	423	228	195	325	390	**390**	33

In other words, the following are the aspirations of ECS:

1. **Increase the number of ECS graduates who complete STEM baccalaureate degrees within six years by 60%.** There are currently 496 freshmen in the 2012 cohort. Of the expected 550 freshmen in the 2013 cohort, 330 (60%) will be on track to graduate within six years. In the fall 2005 cohort, only 35 of 328 freshmen (10%) were on track to graduate within six years.
2. **Reduce time to graduation. Increase by 44% the number of students graduating within five years and increase by 34% the number of ECS students graduating within four years**. Of the 550 expected freshmen in the 2013 cohort, 193 (35%) students will receive their degree within four years and an additional 82 students for a total of 275 (50%) will graduate within five years. In the fall 2005 cohort, only 22 (6%) of 328 students graduated within five years and only 5 (1%) of 328 students graduated within four years.
3. **Increase freshman retention by 35% annually.** In each year of the project, 85% of freshmen will enter the sophomore year. Of the 550 entering freshmen in 2013, 468 (85%) will continue to the second year. In the fall 2005 cohort, 164 (50%) of 328 students continued to the second year.
4. **Increase sophomore retention by 42% annually**. In each year of the project, 70% of sophomores will enter the third year. Of the 550 entering freshmen in 2013, 385 (70%) will continue to the third year. In the fall 2005 cohort, 95 (28%) continued to the third year.

This is an ambitious plan that is rooted in growth with quality. It is labor intensive and therefore too expensive for a public university like CSUF to unilaterally implement. With this plan in mind, ECS is actively seeking external funding for implementation. When such efforts become successful, the college will be able to deploy a multifaceted full-press court towards recruitment and retention of high school seniors and shepherd them through the freshmen and sophomore

years. Well-advised students who are in sync with the curriculum seldom drop out of the program if they have gone beyond the sophomore year.

6. Conclusions

Attrition at the end of freshmen year has been a well-known problem as well as a national scourge in technical education. The problem is significantly more pronounced in engineering and computer science disciplines. While increasing entrance requirements may be one approach, such an option may not be feasible for public universities with mandated admission criteria and a mission to accommodate access. The problem is exacerbated in these universities such as CSUF where the entering freshmen are in large number first generation college goers with modest means. In the past, there was less focus on university wide graduation and retention efforts but it was a matter of survival for ECS. The college unilaterally embarked on an aggressive retention initiative a few years ago and this investment is returning yield handsomely now.

As one can see from the results of the paper, no single solution exists for the complex problem of attrition. Supplementary instruction may benefit a few, a nurturing environment and special attention may help another group, peer mentoring suits another and so on. It has been shown in this paper that by deploying a number of activities during the freshmen year, significant improvement in retention can be achieved. *In short, in the absence of the elusive magical silver bullet to obliterate the offending target, it was found that a collection of BB gun pellets can do just as well.* Thus the many little steps and data driven approaches taken within engineering and computer science, have found to be highly successful.

The College of ECS efforts recognized that a problem existed and that all ECS faculty, staff, and leaders had to be engaged to find solutions. The college did not accept the *status quo* excuse that the rigor of the program was too great for the students and therefore, high attrition was inevitable. Instead, it focused on the causes of student drop out and created relatively small common sense remedies for the problem. Despite funding reductions over the past decade to California public education, the ECS efforts have flourished.

What has been achieved to date is an inclusive, transferable model of effective learning communities with the support of administrators, faculty, staff, and students—one that can be expanded to other four-year institutions throughout the country, amplifying its effectiveness and increasing the number of U.S. students who earn baccalaureate degrees in STEM majors and enter successful and productive STEM careers. Furthermore, since these ideas are tested in an environment where 32% of the students are Hispanic, many strategies are directly transferable to HSI institutions.

The College of Engineering and Computer Science is currently embarking on adapting the success it has had with first year students and extending them to ensure success for second year students. Specifically, the project that is being envisaged will: 1) significantly improve advising,

peer mentoring and community building opportunities; 2) improve learning (and therefore student success) in pivotal mathematics and other introductory courses; 3) improve undergraduate student engagement and leadership opportunities; and 4) institutionalize STEM student learning communities with a few more block-scheduled classes.

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