Enhancing Retention and Achievement of Undergraduate Engineering Students

Dr. Anant R. Kukreti, University of Cincinnati

Dr. Anant R. Kukreti, Ph.D., is Director for Engineering Outreach and Professor in the School of Energy, Environmental, Biological and Medical Engineering at the University of Cincinnati (UC), Cincinnati Ohio, USA. He joined UC on 8/15/00 and before that worked 22 years at University of Oklahoma. He teaches structural mechanics, with research in steel structures, seismic analysis and design, and engineering education. He has won five major university teaching awards, two Professorships, two national ASEE teaching awards, and is internationally recognized in his primary research field.

Ms. Kristen Strominger, University of Cincinnati - School of Energy, Environmental, Biological and Medical Engineering

Kristen Strominger is the STEM Program Coordinator working under Anant Kukreti on the NSF Type 1 STEP Project in the School of Energy, Environmental, Biological and Medical Engineering at the University of Cincinnati (UC). Kristen completed her master's degree in Higher Education, Student Affairs at Florida State University in Tallahassee, Florida previous to beginning her position at UC in July 2012. She plans, designs, evaluates and modifies programs supported by the NSF Type 1 STEP Grant in the College of Engineering and Applied Science.

Prof. Urmila Ghia, University of Cincinnati
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INTRODUCTION

This paper presents the description and impact of three key strategies that we have implemented for improving retention and student success for engineering undergraduates, as part of a National Science Foundation (NSF) project funded by the Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP). The project targets recruitment and retention of engineering ethnic minorities, women, and economically disadvantaged and/or First Generation college-bound students. The strategies include: cohort building, networking, and pathway to graduate school. Cohort building includes building productive academic relationships among students, between students and faculty, and between students and the university administration. The networking strategies include building and upholding a professional network with all people the students meet within their education and future career field, such as advisors, faculty members from whom they take classes, professors in their major, internship supervisors, employers or administrators, and through volunteer/community activities, seminars/workshops, and conferences. Students should seek out networking opportunities and work on establishing professional relationships beginning in their freshman year and continuing to graduation. Through building their network in academia and the professional world, the students will find themselves with appealing job prospects and opportunities for advanced education. The pathway-to-graduate school strategy is intended to encourage all promising undergraduate students to apply for graduate school and assist them in creating a portfolio which will make them competitive to receive financial support. This strategy enriches the intellectual fabric of the University by developing a mechanism that integrates the experience and expertise of the engineering undergraduate students into the College’s scholarship – such as conducting research and presenting the findings. In this paper the programs implemented for each strategy are presented followed by results documenting the impact of the strategy on retention and student success. Finally, the conclusion section summarizes the highlights of the accomplishments and the challenges faced. This paper will help serve as a resource for others planning similar programs for engineering undergraduate students.

The University of Cincinnati (UC) is an urban, comprehensive, research-intensive, public institution with over 42,000 students. The UC College of Engineering and Applied Science (CEAS) has over 3,000 undergraduate and 650 graduate students, and grants B.S./M.S./Ph.D. degrees in 9 Engineering disciplines (Aerospace, Architecture, Biomedical, Chemical, Civil, Computer, Electrical, Environmental, and Mechanical), a B.S./M.S./Ph.D. in Computer Science, and B.S. degrees in 6 Engineering Technology programs (Architecture, Construction Management, Electrical, Fire and Safety, and Mechanical). All CEAS degree programs are 5-years in duration, because of a mandatory paid cooperative (co-op) education requirement. Through co-op, students alternate semesters of classwork and industry for the middle 3 years, gaining over 1.5 years of full-time work experience. Also, UC’s CEAS includes the ACCEND (ACCELERATED ENGINEERING DEGREE) program, which offers these students the opportunity to complete both a B.S. and an M.S. degree in an engineering major in five years plus a summer. An option for M.S. in Business Administration is also available. Students admitted into the
ACCEND program have Advance Placement (AP) credits in mathematics, science and humanities. The STEP program included students from all 9 Engineering disciplines and 6 Engineering Technology programs.

Three key issues negatively impact student success in engineering; these issues are especially relevant to the target student population addressed in this paper. **Issue I: inadequate academic preparedness from high school.** The target students, by definition, fall into this category. Their ACT scores are 2-4 points below their peer cohort admitted in the CEAS at UC. In addition, on the UC Math Placement Test (MPT), which is used as a basis for first math course placement, the target students typically score below the cutoff for placement in Calculus I, the first course in the engineering math sequence and a prerequisite for Physics I. **Issue II: inability of the students to adapt socially to their new environment**

UC is an urban university with over 30,000 students on its main campus and CEAS has close to 3,000 students. This environment presents particularly unique challenges to ethnic minorities, women, First Generation, economically challenged students, and students from small, rural schools, or from large urban public schools. The target student population is demographically diverse but, relative to direct-admit students, it has a significantly larger population of students that face greater challenges to socialization. **Issue III: incoming students have no prior understanding of the expected workload or level of commitment required of an engineering or engineering technology curriculum.** Students from economically challenged families often must work long hours to cover expenses, have difficulty maintaining good grades, and experience higher dropout rates. Interventions are needed to ease the transition into college, to address cultural conflicts between home and college, and to create a supportive learning environment. The need for cultivating learning environments to support and stimulate undergraduate student learning in engineering and sciences is well established.

The STEP project was funded by NSF in May of 2008. The first cohort (2008-2009) of 20 students started in summer of 2008, and consisted only of ethnic minority students. Since these students were recruited prior to obtaining the grant, their participation in program activities, starting from freshman year, was voluntary. In 2009, we obtained a scholarship grant, Choose Ohio First Scholarship Program (COFSP), from the Ohio Board of Regents (OBR). The grant was leveraged to provide scholarships to deserving Ohio-resident STEP students for five-year undergraduate study, and was expanded to include, economically disadvantaged and/or First Generation college-bound engineering students, in addition to underrepresented (women and ethnic minority) engineering students. **STEP students are either students who participated in the Summer Bridge Scholars Program and continue in CEAS majors or students receiving COFSP and continuing in CEAS majors.** The second (2009-2010) and third (2010-2011) STEP cohorts, started in the fall with 78 and 76 students, respectively, and a majority of them received COFSP awards. Starting from 2009 participation in project activities was made a requirement for continuation. The fourth (2011-2012) and fifth (2012-2013) cohorts, started in the fall with 25 and 19 students, respectively, and consisted mostly (about 90%) of ethnic minority students. Thus, a total of 218 students have participated in the program. The demographics of these students are as follows: (a) **Gender distribution:** 147 (69%) men and 71 (31%) female students; and (b) **Ethnicity distribution:** 108 (70%) ethnic minority, 95 (27%) white Caucasians, 8 (2%) Asian American, and 7 (2%) in “other” category. As of the beginning
of 2012 fall semester, a total of 154 students remain in the STEP Program. The students lost include those who were not meeting grade requirement to stay in CEAS, who left CEAS for another STEM or other degree program at UC, or who left UC. The demographics of these students are as follows: (a) Gender distribution: 99 (63%) men and 55 (37%) female students; and (b) Ethnicity distribution: 75 (68%) ethnic minority, 68 (27%) white Caucasians, 6 (2%) Asian American, and 5 (2%) in “other” category.

We next discuss our three strategies and present their impact on our goals.

**COHORT BUILDING**

Cohort Building includes the following activities: Summer Bridge Scholars Program; cohort course scheduling; and freshman supplemental collaborative learning math and science courses. Each activity is described first, followed by impact assessment results for the strategy as a whole.

**Summer Bridge Scholars Program**

The Summer Bridge Scholars Program is a 7-week residential summer program recommended for all incoming freshmen STEP students. The objective of the program is to create a “learning community” of students and to help them develop the academic and social skills necessary for achieving academic excellence, while at the same time building their self-confidence, strengthening their academic skills, and acclimatizing them to the campus environment. The structure of the courses (Pre-Calculus, Calculus, Chemistry, Physics, and English) taken during the program provides the context in which these gains occur. Students experience the volume and pace of college courses and develop self-confidence to improve their chances of above-average academic performance during the freshman year. It involves learning methods and techniques using cooperative task structures in each Bridge course. In these courses, students work in 4-6 member groups during organized study sessions. Students are required to work collectively toward the common goal of mastering the course material. Classes are 90-minutes long, Monday through Thursday, with Fridays designated for other professional activities, such as company visits. Students can keep their Bridge textbooks for use during the freshman year, and those who pass the Bridge’s English course receive advanced standing for English 101.

One of the major objectives of the Summer Bridge course work is to prepare students for their prospective math and science courses taken in the freshman year. To aid in this decision process, the bridge students are required to complete a **math pre-test** prior to arrival at UC, to determine whether they will take Pre-Calculus or Calculus during the Bridge program. This test is not a multiple choice test, but requires the students to present their complete solution steps/process. It is designed and graded by one of the Bridge math instructors. Students are moved between Pre-Calculus or Calculus classes, based on demonstrated skills. The Pre-Calculus Bridge course is designed to prepare students for the Pre-Calculus (Calculus 0) taken in the fall semester of the freshman year. The Math, Chemistry and Physics pre-Bridge courses are designed to prepare students to develop the skills needed to succeed in the corresponding courses taken in the freshman year.
The Summer Bridge Scholars Program starts with a mandatory orientation session, highlighting the goals, objectives, and expectations of the program. It is held on a Sunday, prior to the start of the program, and is also attended by the students’ parents/guardian. Administrative staff and faculty are introduced to the parents and students. Each instructor gives a preview of their course and why they decided to teach in the program. After the orientation, a separate meeting is held with parents to discuss how they can assist in making sure that their student would be academically successful. A unique part of the meeting is the presentation of a five-year plan detailing what their student should be doing as a member of the Summer Bridge Scholars Program and during their undergraduate studies. The goal is to keep the parents involved in the education of their child.

Summer Bridge participants are housed in campus facilities by gender and supervised by a Resident Manager, a member of our administrative staff. The Resident Manager resides in the residence hall, organizes all social activities and monitors each student’s compliance with program rules and regulations. Mandatory study sessions are held Monday through Friday, 6-8 p.m., and are coordinated by the Resident Manager. Our current STEP students assist in the study sessions by making sure that the Bridge students are implementing the collaborative learning process during the study sessions. The Bridge instructors meet with the STEP project team weekly to discuss the progress of students as it relates to academic standing and participation in implementing the cooperative learning process in their respective courses. The Resident Manager provides information on their performance in the study sessions and in the residence hall. These discussions lead to actions taken for particular students who need additional guidance and help.

Since the Summer Bridge Scholars Program was first offered in 1988, several enhancements have been made. First, in 2009 it was decided to invite the Bridge students to participate in a Math College Readiness Program called ALEKS (Assessment and LEarning in Knowledge Spaces). Summer Bridge Calculus 0 students took ALEKS Prep for Calculus program and the Calculus I Bridge students took ALEKS Pre-Calculus program. Students completed part of ALEKS during the summer and finished the rest in the beginning of the fall of their freshman year. ALEKS uses adaptive questioning to quickly and accurately determine exactly what a student knows and does not know in a course. ALEKS then instructs the student on the topics he/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. Of the students who participated in the 2009 ALEKS program, 95.5% of the students successfully (C- grade or better) completed their intended autumn quarter Calculus course, with an average overall GPA of 2.69. Of the students who participated in the 2010 ALEKS program, 100% of the students successfully (C+ grade or better) completed their intended autumn quarter Calculus course with an average GPA of 3.28. Because of the success of ALEKS, it was decided in 2012 that the Bridge students will be required to complete ALEKS during the summer as part of their respective Bridge Calculus course. We compared the students’ scores on UC’s Math Placement Test (MPT) before ALEKS, and after ALEKS and we tracked the success of each individual student. The students who took ALEKS did show a greater improvement than the students who did not take ALEKS, as shown in Figure 1. The students taking ALEKS improved their MPT score by an average of 12% which is equivalent to about 100 points. The second program
enhancement made in the Summer Bridge Scholars Program, was implementation of a course “Introduction to 3-Dimensional (3-D) Spatial Visualization” for the first time in the summer of 2010 and continued since then. Research indicates that engineering students, particularly ethnic minority and women engineering students, have difficulty visualizing in three dimensions\textsuperscript{22}. This cognitive skill is essential for engineering education, but a significant number of these students have not had experience 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 students through a series of modules using a textbook and software.

Beginning with the academic year 2012-2013, all engineering freshman students are introduced to computing in a year-long course sequence called Engineering Models I & II. The goal of this course sequence is to utilize MATLAB, an engineering computing environment, to help students understand math, the role of math in engineering, and prepare them for the use of modern computing tools used in their discipline. Because many students in the STEP program do not have experience with computing or programming prior to enrolling in college, a MATLAB component has been added to the Introduction to 3-D Spatial Visualization course in the 2012 Summer Bridge Scholars Program.

The UC Summer Bridge Scholars Program has been offered for the last 25 years. Significant numbers of the successful Bridge alumni are working for engineering companies located in the Greater Cincinnati and Northern Kentucky areas. A professional development program has been incorporated for current Bridge students utilizing these alumni. The current Bridge students visit area companies where former Bridge alumni are employed and company representatives explain the importance of the Summer Bridge Scholars Program with a special emphasis on the collaborative learning methodology and its relevance to the engineering process. The companies visited each year include the following:

Figure 1: 2012 Summer Bridge MPT Scores Before and After ALEKS
3. Procter and Gamble Health Care Headquarters.

In summary, the Summer Bridge Scholars Program is structured to:

1. Build a self-supporting community of learners to assist each other to achieve academic and career goals.
2. Place students in the appropriate first freshman Calculus course, Calculus 0 or Calculus I, based on Bridge course performance.
3. Increase their MPT Score relative to pre-Bridge by about 10-15% by completing ALEKS during the Summer Bridge Calculus course.
4. Achieve higher grades in their freshman math and science courses.
5. Earn a higher cumulative grade point average for their freshman year.
6. Achieve a higher freshman-sophomore retention rate.
7. Achieve higher five-year degree to completion rates.

It is worth mentioning, that based on our analysis of student degree completion for the last ten years in the UC CEAS, the grade in the first Calculus course is a good indicator of completion of the bachelor’s degree in engineering. Students obtaining a grade of ≥ C+ in the first Calculus course, in general, completed their engineering degree. This data was obtained in an informal study done by the School of Engineering Education in CEAS at UC.

Cohort Course Scheduling

After completing the Summer Bridge Scholars Program, the students enroll in the freshman math and science courses as a cohort. During the last week of the Summer Bridge Scholars 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. Its aim is also to get students to understand that academic excellence needs to be planned, and progress towards goals needs to be assessed. During the exit interviews, the students are given specific information about their placement in freshman year for Calculus and English courses, in which they pre-enroll as a cohort for each class before they leave for home. The instructors made the following recommendations for the 2008 to 2012 Summer Bridge cohorts:

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</tr>
</thead>
<tbody>
<tr>
<td>Total number of students in the cohort</td>
<td>20</td>
<td>22</td>
<td>20</td>
<td>25</td>
<td>19</td>
</tr>
<tr>
<td>No. recommended to take Calc 0 in fall</td>
<td>4 (20%)</td>
<td>5 (23%)</td>
<td>13 (72%)</td>
<td>13 (52%)</td>
<td>13 (68%)</td>
</tr>
<tr>
<td>No. recommended to take Calc I in fall</td>
<td>16 (80%)</td>
<td>17 (77%)</td>
<td>6 (33%)</td>
<td>9 (36%)</td>
<td>4 (23%)</td>
</tr>
<tr>
<td>No. receiving credit for Eng. Comp. I</td>
<td>20 (100%)</td>
<td>21 (95%)</td>
<td>19 (100%)</td>
<td>23 (92%)</td>
<td>17 (90%)</td>
</tr>
</tbody>
</table>
One (1) student, not a U.S. citizen and not supported from NSF funds, is not counted in reporting the statistics. So, 19 students are considered in this Bridge cohort.

One (1) Student had Advanced Placement out of Calc I, so 18 students (in view of Note [1]) are considered in calculating this percentage.

One (1) student was recommended for College Algebra and two (2) students were recommended for Calc II.

One (1) student transferred to College of Business at the end of Summer Bridge Scholars Program. One (1) Student withdrew from Calc 1 and One (1) student was recommended for College Algebra.

It is important to note that the Summer Bridge Scholars Program is not in isolation from the academic year; it is the 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 freshmen, at this time, they register as a cohort for all of their classes, especially in the recommended Calculus course for the fall semester. The course schedules are pre-made as part of the Summer Bridge Scholars Program and consist of an additional collaborative learning course taken for each regular Calculus and Physics freshman course, as described in the following section.

Supplemental Cooperative Learning Courses (SCLC)

These courses are first-year SCLC in Calculus 0, I, II and Physics 0, I taken by the students along with the regular course which is part of their curriculum (used to be Calculus 0, I, II, III and Physics 0, I, II in the quarter system prior to fall of 2012). All Bridge students enroll in SCLC. The SCLCs are one-credit courses, and the students meet twice a week for two hours with an instructor dedicated specifically for the course. The students enrolled in SCLCs are provided with additional instruction and time for problem-solving. This instruction requires students to interact in groups of 3-4 to master the course material. It further strengthens the learning community built in the Summer Bridge Scholars Program. The first regular Physics course is Physics I and is taken by the students in the spring semester, thus giving a full one-semester break away from Physics. Based on past feedback, students tend to forget the material learned in Physics as part of the Bridge program, and this impacts their performance in Physics I. To avoid this, a SCLC Physics 0 course is taken in the fall semester. This gives the Bridge students the equivalent of a semester of Physics before they take the actual course. Students repeat the cohort scheduling process for the fall and spring semesters of their freshman year.

Impact of Cohort Building Activities

The impact of the cohort building strategy is documented via two measurements of success, namely, performance in freshman math and science courses, and the D, W and F grade rates in these freshman math and science courses. All comparisons were made with peer students who did not participate in the STEP program (called non-STEP students) and were in the same cohort. When the STEP program was expanded to include economically disadvantaged and/or First Generation college-bound students, in addition to the underrepresented (women and ethnic minority) engineering students, through the COFSP award, not all students in STEP Cohort 2 (2009-2010) and Cohort 3 (2010-2011) participated in the Summer Bridge Scholars Program – these are referred to as non-Bridge STEP students. Some of the non-Bridge STEP and the non-STEP students include ACCEND students. Students admitted into the ACCEND program typically have Advance Placement (AP) credits in mathematics, science and humanities, and so
their sequence of math and science freshman courses is different. The ACCEND students are not included in documenting the impact of the Bridge program.

UC operated in the quarter system up to the end of summer of 2012. Each academic year had four quarters: autumn or fall (October-December), winter (January-March), spring (April-June), and summer (July-August). Because of our mandatory co-op requirement, half of the students were on campus in any quarter, as students went for co-op in either autumn/spring or winter/summer. The required freshman math and science courses offered in the quarter system were: fall – Calculus 0, I and Chemistry I; winter - Calculus I, II, Chemistry I, II, and Physics I; spring - Calculus II, III, Chemistry II, III, and Physics I, II; and summer - Calculus III, Chemistry III, and Physics II. Students do not participate in co-op in the freshman year, and students who started with Calculus 0 in the fall quarter or failed a course got caught up by completing their freshman math and science course requirements by the end of the summer quarter. Starting in fall of 2012, UC converted to semester system with three semesters in each academic year: fall (September-December), spring (January-April), and summer (May-July). The required freshman math and science courses offered in the semester system are: fall – Calculus 0, I and Chemistry I; spring - Calculus I, II, Chemistry II, and Physics I; and summer - Calculus II, Chemistry II, and Physics I. So the two or three math and science courses required in the quarter system have been condensed to one or two courses in the semester system. The data reported to document the impact of the Summer Bridge Scholars Program, Cohort Course Scheduling and SCLC are for STEP Cohorts 1 to 4, who completed their freshman year in the quarter system. STEP Cohort 5, who started in the semester system, have completed only one semester, fall 2012, until now.

The mean course grade point average (GPA) of STEP Cohorts 2 to 4 students who enrolled in the freshman math and science courses is summarized in Table 1. Figure 2 shows this data for only the first math and science courses, as these are a good indicator of success in remaining years to follow. It should be noted that Calculus I is the first required math course for engineering students. But students, who are not prepared, as indicated by the UC Math Placement Test and/or Summer Bridge Scholars Program recommendation, take Calculus 0 as a remedial course in the fall semester and then Calculus I in the spring semester. The data clearly shows that the Bridge STEP students out-performed their peer cohort significantly in the first math course (Bridge/Peer GPA for: Calc 0 = 1.4 and Calc I = 1.2) they took and their grades in science courses were not much different (Bridge/Peer GPA for: Chem I = 0.99 and Phys I = 0.93). Similar is the trend for other math and science courses. Table 1 also shows that the non-Bridge STEP students out-performed their peer cohort in all the freshman first math and science courses. Finally, on the whole the STEP students (Bridge + non-Bridge) out-performed their peer cohort in all the freshman first math and science courses.

Our stipulation is that, in addition to the Summer Bridge Scholars Program, Cohort Course Scheduling and SCLC classes, our STEP Programs to Enhance Retention (PER) also include other programs (Academic Assessment and Monitoring Program, Monthly Socials and Community Engagement Program) as part of the networking strategy. Participation in these programs by the 2008 Summer Bridge students, who constituted STEP Cohort 1, was optional. It was not possible to make it mandatory for these students because they were recruited prior to the start of the STEP grant. Of the 20 Cohort 1 Bridge students, 19 students continued in
College of Engineering, and 1 transferred to the College of Applied Science (at that time the two colleges were separate). Of the 19 engineering students, 10 (52.6%) students participated in all parts of PER, 3 (15.8%) students enrolled in the freshman SCLC classes but did not follow the other retention programs, and 6 (31.6%) did not enroll in the freshman SCLC classes. The performance of STEP Cohort 1 in all the required freshman math and science courses is shown in Figure 3 for the fall, winter and spring quarters. All the courses are grouped to give an overall view of the different comparison groups. As shown in Figure 3, the performance of STEP Cohort 1 in the freshman math and science courses in comparison to their peers varied significantly, and in general was lower than for their peer cohort. We attribute this to varied
level of participation by the students in PER. Also, it should be pointed out that all the non-
Bridge students in STEP Cohorts 2 and 3 were required to participate in the networking strategy
activities and enroll in the Freshman Learning Community Courses (FLCC). UC has
implemented a program called Learning Communities (LC) within the First-Year Experience
(FYE). An LC is a group of 20 First-Year students who share the same class schedule. The
STEP Cohorts 2 and Cohort 3 students, who did not enroll in SCLC, were required to enroll in
UC’s First-Year Experience Freshman Learning Community Courses (FYE-FLCC). Bridge
STEP students were also encouraged to enroll in the FYE-FLCC, if their class schedule could
accommodate these courses. Each LC meets twice per week with its Peer Leader (PL). A PL is
an upper-class student trained by the Office of First-Year Experience to manage the LC and is a
resource for the 20 First-Year students.

Another measure of the impact of the Summer Bridge Scholars Program and SCLC classes
on first freshman Calculus, Physics and Chemistry course performance of STEP students is the
difference in their D, W, and F grade rate compared to the corresponding rate for peer CEAS
students. Historically, Bridge students D, W, and F rate for the freshman math and science
courses has been lower than the peer cohort’s. Table 2 presents the D, W, and F rate for Cohorts
2, 3 and 4 for STEP and peer CEAS (non-STEP) students for the first freshman math and science
courses. As can be seen, the D, W, and F rates for both the Bridge and non-Bridge STEP
students are lower than peer CEAS students; it is significantly lower for the first freshman
Calculus courses, Calculus 0 and Calculus I. This is a significant positive outcome. considering
that the success in the first freshman Calculus course is the best indicator of retention in UC
CEAS undergraduate degree programs.

Figure 3: Comparison of Freshman Math and Science Course Grades of STEP Cohort 1
and Peer (non-STEP) Students

The number above the graph shows the number of students in that category

Figure 3: Comparison of Freshman Math and Science Course Grades of STEP Cohort 1
and Peer (non-STEP) Students
Table 2: Comparison of D, W, and F Grades of the Different Cohorts 2, 3 and 4

<table>
<thead>
<tr>
<th>Cohorts</th>
<th>Course</th>
<th>Percentage of Students with D, W and F Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>STEP Bridge</td>
</tr>
<tr>
<td>Total (2+3+4)</td>
<td>Calculus 0</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Calculus I</td>
<td>16%</td>
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<tr>
<td></td>
<td>Chemistry I</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>Physics I</td>
<td>19%</td>
</tr>
</tbody>
</table>

NETWORKING

The networking strategies include: academic assessment and monitoring program; monthly socials; MentorNet; community engagement program; industry-mentoring program; and E Portfolio. Each of these programs is described next. The networking experiences are designed to help students become more comfortable in their college, the university and their future work environment. These experiences provide the skills for students to work and communicate in small or large groups, and to interact with peers and professionals in ways that will benefit both their academic and professional careers. As such, networking activities are vital to the success of STEP students.

Academic Assessment and Monitoring Program

Gardner\textsuperscript{23} and Tinto\textsuperscript{24} suggest that faculty/professionals-student interaction outside the classroom positively affects retention. They provide opportunities for building community and capacity through academic/social networks. This program activity is structured keeping this in mind. An academic undergraduate degree Program Advisor is identified for each STEP student, and the students are required to meet with this advisor during the pre-advising week (7\textsuperscript{th} week of the semester) to discuss progress towards degree and to plan their course schedule. Each advisor completes an Academic Progress Report Form for student records. Additionally, each STEP student is assigned a STEP Mentor to monitor student’s matriculation in the college. Students meet their STEP Mentor at least once every semester and submit a minimum of two course progress reports from the instructor for each course taken. The STEP academic advising process is also built around three touch-points to provide all students with key opportunities to develop, review, and act upon a learning plan for degree completion. In the first freshman quarter (now semester), the students submit a reflective essay documenting their professional career aspirations and its relationship to the college education they have planned to pursue. They revisit this essay at the beginning of the pre-junior (3\textsuperscript{rd}) and senior (5\textsuperscript{th}) years.

The instructors provide feedback to students on their performance, often with specific recommendations on what can be done to improve their class standing. While the primary purpose of instructor progress reports is to provide students the feedback they need to be successful in the classroom, the progress reports also play a key role in networking. The reports require that students interact with their instructors and this interaction provides an opportunity for students to develop long-term relationships with their instructors. Key future benefits of developing a relationship with their instructors are future undergraduate research opportunities...
and recommendation letters. Also, STEP students thus learn to take a more active role in their education.

The STEP Mentor meetings facilitate discussion on instructor reports, course work, special opportunities for community engagement, and personal and academic concerns. STEP Mentors can make recommendations for students to take certain actions to improve their grades, co-op opportunities or housing/roommate issues. The STEP Mentor learns the short- and long-term goals of their student advisees through the reflective essays. Once those goals are known, the STEP Mentor can steer students to appropriate information or resources that may help student achieve his/her goals. As such, the STEP Mentors are in a position to connect the advisee to faculty who have professional, research, or service interests compatible with the student’s interests.

The STEP Mentor documents recommendations in a Student Consultation Form during the semester meeting. The form requires responses to the following: 1) Has student met with her/his instructor(s)? 2) Has student met with her/his academic Program Advisor? 3) Issues/Topics Discussed, and (4) Recommendation(s). The STEP Mentor and the student agree on recommendations to continue or enhance academic or professional development and the students sign this form.

**Monthly Socials**

STEP socials provide the experiences that make students better prepared to navigate both the academic and professional worlds. The monthly socials bring students together to meet representatives from the university faculty and industry to discuss academic strategies for success; career trends; to learn about co-op opportunities; to investigate undergraduate research experience options; to explore graduate school and how to prepare for it; and to connect with each other. Socials bring students together to: interact with individuals and groups – improving their communication skills. Each monthly social has a theme and a guest speaker or group of speakers for a panel discussion. Each year, about eight socials are held, and 60%-70% students attend, since some of the students are on co-op assignments. Students are often given a leadership role to choose the social’s theme and invite speakers, and this requires further interaction with fellow students and/or industry representatives. The students are asked to write a brief reflection on each monthly social attended.

**MentorNet Program**

The MentorNet Program was originally added for majority women and is supported by UC funds. MentorNet is now open to all STEP students. It is an e-mentoring network that matches student protégés studying in STEM fields with mentors from industry and academia. A strong, though not exclusive, focus is placed on providing support to women and underrepresented students within these fields. We also have an excellent opportunity to recruit mentors from our strong alumni network, industry partners, and faculty. Once students are paired with a mentor, they typically communicate with their mentor via email and interact frequently with the MentorNet website (http://www.mentornetwork.net/). Incoming freshman students in the STEP program are required to register for MentorNet, and sophomores through seniors are encouraged
to continue, but it is not a requirement for them. Our experience has been that, once the students join MentorNet in the freshman year, they see its advantages, and continue with it.

**Community Engagement Program**

The purpose of this program is to demonstrate the need for becoming participating agents who provide service to both their university and community. The students are required to perform 15 hours of voluntary service for each semester they enroll at UC for classes (was 10 hours per quarter in the quarter system). Several structured K-12 outreach programs are made available for the community engagement program (summer academies, tutoring program and STEM clubs organized by the CEAS Emerging Ethnic Engineering (E³) Program; and Gifted Girls Program, Science Career Fair and Summer Camps organized by the Society of Women Engineers; and many more). Students document each experience in a *Service Learning Activity Hours Report Form* and also write a reflection on their community engagement experience for the semester.

**Industry-Mentoring Program**

The industry-mentoring program provides an opportunity for students to interact with engineering professionals. The key outcomes of this mentoring program are the professional development of the student, increased student awareness, readiness, and disposition towards engineering careers, and educational training needed. It provides an opportunity to the student to experience the various work environments and opportunities, and make informed decisions on their career choice, and to gradually build an education portfolio to best market themselves for it. Two programs are offered: corporate mentoring program, and the paid industrial cooperative program, and these are described below.

*Corporate Mentoring Program:* The CEAS Emerging Ethnic Engineering (E³) Program and General Electric (GE) Aviation have developed a mentoring program for ethnic minority engineering students. At the end of the freshman year, Summer Bridge students who take SCLC and are on-track are candidates for this program. The mentors arrange to meet with their student on a regular basis during the academic year to make sure that the student is participating in 1) the GE social functions planned for the students and 2) the STEP retention program. The students 1) maintain consistent communication with their mentor, 2) provide their mentor with all information related to their academic progress and status, and 3) participate in all activities planned by the GE mentors. The E³ Director, who is a Co-PI in the STEP grant, and the GE mentors meet quarterly to discuss the progress of the program. Each year, about 6-9 GE Mentors participate and each mentor is assigned one student who stays with the mentor until graduation.

*Paid Industrial Cooperative (Co-Op) Program:* All STEP students are placed in co-op paid jobs by the UC’s Division of Professional Practice (DPP) during the sophomore, pre-junior and junior years. Students document each experience. Mentorship is provided by DPP faculty (one for each degree program) to guide them to appropriate paid co-op jobs to suit their career aspirations. In preparation for the co-op placement in the sophomore year, students enroll in a one credit hour course, *Introduction to Cooperative Education*, in the spring semester. This course is designed to acquaint students with cooperative education and the Professional Practice
Program. It prepares students to maximize learning from the co-op experiences; understand the educational and career related skills needed for a successful engineering career; acquaint students with co-op performance expectations; develop the behaviors and attitudes appropriate for a professional environment; and assist in the development of the strategies (e.g., resume preparation) and necessary skills (e.g., interviewing, employer-employee interaction, etc.) for effective participation in the employment process. At the co-op job, a student has an assigned supervisor. Both the supervisor and student evaluate the co-op experience, instruments for which were developed by DPP. Additionally, at the end of the co-op assignment, the STEP student documents the co-op experience in a Co-operative Education Report Form which is countersigned by the co-op supervisor. Many of the participating co-op supervisors are former UC students, and have first-hand knowledge of what is needed to graduate and succeed in the undergraduate engineering degree program. Students find it easy to relate, share and take advice from these industry supervisors.

E-Portfolio

As the STEP project evolved, it was decided to utilize electronic portfolios to enable STEP students, faculty, and staff to track and manage program requirements, academic progress, degree progress, program participation online, and encourage accountability. The main purpose of the E-Portfolio for faculty and staff is early intervention when a student is struggling in a course, degree program or in completing the requirements of the program. The STEP Faculty Mentors are able to review student progress prior to meeting with the students. The main purpose of the E-Portfolio for the students is the ability to track their participation online, and have access to documentation for use at any time for interviews, application to graduate school or any other use. Program requirements tracked in the E-Portfolio include: updated resumes; signed program contracts; instructor course progress reports; academic Program Advisor progress reports; STEP Mentor student consultation reports with recommended actions and follow-up; community engagement service-learning activity hours reports; and co-operative education reports. The E-Portfolio also archives the reflective essays prepared by the students documenting: professional career aspirations and their relationship to their college education at the beginning of freshman, pre-junior and senior year; and special programs attended (orientation, monthly socials, special seminars, MentorNet, REU, etc.).

Currently, the Program Coordinator oversees student completion of the E-Portfolio requirements manually, but in the future, reports and documents will be submitted electronically instead of a PDF format. The E-Portfolio is intended to be utilized as an advising and early warning system. In the future, the instructor reports will be completed electronically and submitted to the student’s E-Portfolio directly. In the situation when the instructor checks the box that indicates that the student is not performing satisfactorily, an alert email will go to the STEP Faculty Mentor and the Program Coordinator. The STEP Faculty Mentor will review all progress reports, and work with the student and faculty to take corrective action, and document the recommendations agreed upon with the student in an online STEP Student Consultation Report Form for the student’s E-Portfolio. The grant Program Coordinator will check the online document submissions to confirm completion and then interact with the student if items are missing, and inform the instructor(s) of the recommendations.
Impact of Networking Activities

Each year, an external evaluator collects retention data and conducts a student survey to assess program satisfaction and impact. The student survey is the primary source used to evaluate the impact of the networking strategy. This section presents the spring 2012 survey results for advising, progress reports and monthly socials activities. In response to the questions, “The quarterly meetings with my STEP Faculty Mentor were helpful in providing me personal support” and “The quarterly meetings with my STEP Faculty Mentor were helpful in providing me academic support,” 77% of the students responded that they had a positive relationship with their STEP Mentor. This statement had the highest mean response, 4.08/5.0. In response to the question, “The required Instructor Course Progress Reports facilitated a positive relationship with my teachers,” 65% of the students responded positively to this statement. The student’s response to the question, “The Monthly Socials were informative,” received the lowest rating, with a mean response of 2.69/5.0. Most probably the students see this as an added burden to their regular coursework and other educational obligations.

PATHWAY TO GRADUATE SCHOOL

Educators recognize that undergraduate research motivates students to apply to graduate school - ethnic minorities and women groups in engineering must become an integral part of such a technical workforce. Research experience for undergraduates (REU) fosters the pursuit of an undergraduate degree\(^\text{25}\); increased interest in pursuing graduate education\(^\text{26, 27}\); and gains in skills by REU alumni over comparison groups (in conducting research, acquiring information, and speaking effectively)\(^\text{28}\). REUs develop career pathways, increasing minority retention\(^\text{25}\) and the pursuit of graduate degrees\(^\text{29}\). In view of these observations, two REU programs, Summer REU and Academic Year (AY) REU, the associated Research Training Program, and a Research Forum are offered each year in the STEP project. The programs expose the students to the broad range of interdisciplinary research being conducted in the College, and provide them an opportunity to consider graduate study.

Baccalaureate degree graduates of CEAS at UC either pursue career opportunities in industry, government and other professional avenues or an advanced graduate degree in Engineering, Business Administration, Law, Medicine, etc. The mandatory co-op program in UC CEAS is structured for professional career opportunities upon graduation. The pathway to graduate program, described in this section, is structured to prepare the students for graduate school and obtain competitive financial support and/or graduate fellowships.

Summer REU Program

This is an 8-week full-time in-residence (June-July) program for 12 students/year (8 UC and 4 from other institutions) in which teams of 3 students pursue research, each under the mentorship of a Faculty Mentor and a Graduate Student Mentor. Student selection is based on the following process: an online application, an online review and rating, and final rating and selection. To prepare the selected students for the research, reading material is sent four weeks prior to their arrival. Participants receive a stipend of $1,250/month plus $1,800 to cover costs for room, board, and travel. The Summer REU Program is supported by NSF funds. Priority is
given to women and minority students. Each REU team produces three deliverables: Technical Paper/Report, Display Poster, and PowerPoint Presentation, which are presented on the last day of the program and juried by external professional judges.

Prior to the start of the program, the faculty mentors and graduate mentors attend a workshop on building fruitful mentor-mentee relationships. On the first day of the project, the project personnel collectively discuss with the REU teams the nature and scope of the REU projects, expectations, deliverables, and general lab safety rules, the lab facilities, and introduce graduate students, faculty and staff. On the first day of the REP program, the student participants attend an orientation session which outlines the expectations and responsibilities of the participants. On the third day, each REU participant team presents a plan outlining the objectives, research tasks, and time-line for their project. This way the students understand and identify the research process upfront, and set a timeline for tracking research progress. Weeks 2-7 are primarily devoted to conducting the research and presenting interim progress reports. At least one field trip connected with each REU research project is planned for the REU participants. Every alternate Friday afternoon, each team submits a biweekly written report and gives an oral PowerPoint presentation in which each student participates. This approach promotes team work, and provides an opportunity to each student to lead the discussion. When the projects are nearing completion, using the biweekly reports, each student team is assisted in writing a technical paper/report and preparing a display poster. Each team gives a final 1/2-hour PowerPoint presentation, which, along with the technical paper and poster, is judged by an invited panel of four external judges. The judges also select the “Best Project” considering both the report and presentations.

The primary goal of the STEP REU program is to introduce undergraduate students to, and encourage them to pursue, careers in research. A REU website (http://www.eng.uc.edu/reu/) has been developed to inform students outside UC about the program, to present summaries of research projects completed, and elicit communication from REU alumni. All past REU students are asked to fill a Web-based Tracking Form every year up to 5 years beyond participation. Internal and external evaluation of the project is provided by participants and judges. The students complete a pre-site survey documenting their prior exposure to research and two post-site surveys on the last day. The first survey asks specific questions to assess their satisfaction with the REU-site research programs. The second survey includes questions which probe students’ perceptions about research as a potential career option, about themselves as a researcher, or about the role of research in improving quality of life. Feedback on the effectiveness of the whole REU program is obtained from the judges, who fill out a scoring rubric evaluating: 1) each team’s technical paper, 2) each student’s presentation skills; and 3) each team’s poster.

**Academic-Year (AY) REU Program**

In the AY-REU Program, a student pair works for 18 weeks during two quarters (now 14 weeks during a semester in the semester system) under the mentorship of a Faculty Mentor, and each student is paid $1,500/quarter ($2,000/semester in the semester system). In the quarter system, approximately 20 UC students were selected each year to work for two quarters on 10 research projects submitted by the engineering faculty. In the semester system, approximately
14 UC students work for one semester on 7 research projects submitted by the engineering faculty. University of Cincinnati provided matching funds to execute the STEP AY REU Program. The recruitment and process to operate the AY-REU program is similar to that described for the Summer REU Program. The deliverables and their evaluation are also the same as for the Summer REU Program.

**Research Training Program**

The first and the second weeks in the Summer REU Program and the first month in the AY-REU Program are mainly devoted to seminars specially structured to educate the students on the content of the research topic to be pursued, train them on the use of the laboratory facilities, related software and statistical analysis techniques, and procedures to test, analyze, interpret, and report their research results. Separate targeted seminars are conducted by each research Faculty Mentor, which include lab safety training.

A series of research skills training workshops are also held to train the participants to become proficient disseminators of research - written reports, papers, posters, and oral presentations. Each year, the following seven interactive workshops are provided: Safety Training; Technical Writing and Presentation; Online Literature Search; Project Documentation (Photography and Video Recording); Statistical and Uncertainty Analysis; Poster Making; and Public Speaking and Communications.

An enrichment training seminar series introduces the role of interdisciplinary research in modern society, the scientific research process, and the opportunities it creates. The following four seminars are organized: Ethics in Engineering Research; Research in an Academic Setting; Taking Research from Lab to Real World; and Graduate Education Opportunities and Application Process.

The students are asked to prepare a reflective write-up for each seminar and workshop following a prescribed format. The Summer REU Program seminars and workshops are videotaped and made available on the project website. For the AY REU Program, each seminar is offered twice in the year to accommodate the alternating co-op assignments of the students. If, for special reasons, an AY-REU Program student is still unable to attend at least one session of a seminar, he/she is permitted to view the Summer REU Program video to complete the assignment.

These seminar and workshop series and the REU experience have been integrated into a course, ENFD 403: REU Research Program Workshops/Seminars. The course is available to all CEAS students. The course objective is: Students will acquire training in various aspects of the research process, including research dissemination, ethical responsibility and conduct. The course goal is: Students will develop an ability to conduct research on a topic of their interest, and share the outcomes of their research with the relevant technical community. All AY-REU Program students are required to register for the course, and the credits are kept variable, from zero to 3 credit hours, depending on the registration requirements for the students’ majors. At UC, the undergraduate students pay a fixed tuition fee for up to 18 credit hours per term, and are charged extra fees for credit hours in excess of this limit. For the ENFD 403 Course, we adjust
the number of credits for each student, so as to not exceed this limit, and the students do not have to pay any extra tuition fees for registering for this course. The course grade is based on attendance and class performance, as measured by: reflective write-up of seminars and workshops; progress reports; and final deliverables (paper/report, poster and presentation).

Research Forum

Each year, in Spring, UC holds a week-long REU Poster Forum, which includes poster presentations, an awards banquet, a distinguished guest lecture, “People’s Choice Awards,” and GRE preparation sessions. All UC STEP REU participants are required to make one presentation in an organized student group meeting (e.g., a Professional Society Student Chapter Meeting, First-Year Experience and Learning Community Meeting, UC Research Forum, etc.), which is documented and reported by an advisor. Additionally, all UC STEP REU participants are required to participate and present a poster at the UC Research Forum, if they are on campus.

Impact of REU Programs

Number of Students Impacted: During the STEP Project years, the Summer REU Program has been offered in 2009, 2010, 2011 and 2012 (4 years), and the statistics for the students are as follows. The total number of REU participants is 46 [14 students in 2009, 12 each in 2010 and 2011, and 8 in 2012]. Of these, 20 were men (43.5%) and 26 women (56.5%). The men consisted of 11 white (23.9%), 7 minority (15.2%), and 2 (4.4%) Asian American. The women consisted of 7 minority (15.2%), 17 white (37%), and 2 (4.3%) Asian American. The total ethnicity distribution included 28 white (60.9%), 14 minorities (30.4%), and 4 (8.7%) Asian American. The total underrepresented participants were 33 (60.9%), whereas the goal was just 33%. Looking at the education placement, 9 students have finished their B.S. degree and 37 are in school - 33 in B.S. engineering degree programs (2 expected to graduate in spring 2013), and 4 in graduate engineering programs (3 in M.S., and 1 in Ph.D.).

The AY-REU Program has been offered in AY 2009-2010, 2010-2011 and 2011-2012 (3 years), and the statistics for the students are as follows. The total number of AY-REU participants is 54 for the three years (16 students in AY 2009-2010, 22 in AY 2010-2011, and 16 in AY 2011-2012). Of these, 35 were men (64.8%) and 19 were women (35.2%). The men consisted of 22 white (40.7%), 12 minority (22.2%), and 1 Asian American (1.9%). The women consisted of 6 minority (11.1%), 9 white (16.7%), 3 (5.5%) Asian American, and 1 (1.9%) in other category (mixed race). There were 31 whites (57.4%), 18 minorities (33.3%), 4 Asian American (7.4%), and 1 (1.9%) in other category (mixed race). The total underrepresented participants were 31 (57.4%).

Student Satisfaction: The post-program Project Satisfaction Survey Questionnaire indicates that the participants were pleased with the overall organization of the programs. The students appreciated the opportunity to work with the faculty mentor and the graduate student mentor as a team. Their interaction with the graduate students gave them an idea of life as a graduate student, and all REU participants were highly satisfied with their graduate student mentor. Almost all participants indicated that their technical writing skills improved significantly due to participation in the REU project, and that the skills workshops helped improve their presentation
skills and their report-writing skills. The students also got exposure to journal papers, how to read and understand them, and to use the information in preparing their final technical research paper. All believe that the requirement for intermediate deliverables forced them to work under strict deadlines, and helped to keep their work on schedule. The participants also stated that they got a first-hand experience in how research is conducted and reported in graduate school. Some of them were appreciative that they were able to gain this understanding early in their educational career, and get good exposure to research which they would have otherwise not gotten as undergraduate students. The main strength of the REU program, according to the participants, was the wide variety of the projects made available for the two REU programs, their pace, and the challenges the projects posed to them. All of the participants were satisfied with the REU programs as a whole, and all of them stated that they will recommend the programs to their peers.

Judges Evaluations: The judges evaluated each deliverable on a 4-point scale (4 = Excellent, 3 = Very Good, 2 = Good and 1 = Fair) in the following general categories: Content, Organization, Clarity, Quality, and Presentation. The overall average judges' score over the last four Summer REU Programs is 3.39/4.00. Similarly, the overall average judges' score over the last three AY-REU Programs is 3.28/4.00. Overall the judges commended the high quality of work produced by the REU participants and the confidence with which the students made their presentations and defended questions asked.

OVERALL IMPACT OF OUR STRATEGIES

Retention and Graduation

For retention, the following annual targeted incremental retention goals were set for the STEP program students as they progressed from freshman to senior year: 1) 76% from freshman to sophomore year; 2) 86% from sophomore to pre-junior rear; 3) 93% from pre-junior to junior year; and 4) 100% from junior to senior year. The success of the program can thus be ascertained by the attainment of these goals. The retention of the Bridge and all (Bridge + non-Bridge) STEP students is presented in Table 3 and Table 4, respectively, for all the cohorts in the program as of fall of 2012. The numbers in the white cells are the actual head count numbers whereas the numbers in the grey cells of the tables are projected using the targeted retention rates set as the goals of the program. One of the main objectives of the STEP Program, through the Summer Bridge Scholars Program and the Supplemental Collaborative Learning Courses (SCLC), is to promote student success in their first year. Table 3 shows that first-year retention, not including Cohort 1, is on average 88.7%, which is 12.7% higher than the goal set for the program for the freshman year. Cohort 1 is not included in this calculation, as the participation of Cohort 1 students in the program was not a requirement for participation and following the Summer Bridge Scholars Program their participation was significantly less. Students who began the STEP program with Summer Bridge in fall 2008 were given the opportunity to participate in the Programs to Enhance Retention (PER) during the academic year, but less than half chose to participate. The PER include: Summer Bridge Scholars Program, SCLC, Academic Assessment and Monitoring Program, Monthly Socials, MentorNet, and Community Engagement activities. Eight (8) of the incoming 19 students participated in the full PER and, at the end of the first term, their GPA was 3.00, while the non-participating students average GPA was 1.63.
Table 3: STEP Bridge Student Retention as of Fall 2012

<table>
<thead>
<tr>
<th>Cohort # (Starting Year)</th>
<th>Freshmen to Sophomore</th>
<th>Sophomore to Pre-Junior</th>
<th>Pre-Junior to Junior</th>
<th>Junior to Senior</th>
<th>Graduation #</th>
<th>Graduation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># Start Fall</td>
<td># Return Fall</td>
<td>Retention</td>
<td># Start Fall</td>
<td># Return Fall</td>
<td>Retention</td>
</tr>
<tr>
<td>Cohort 1 (2008-09)</td>
<td>20</td>
<td>30.0%</td>
<td>6</td>
<td>100.0%</td>
<td>8</td>
<td>100.0%</td>
</tr>
<tr>
<td>Cohort 2 (2009-10)</td>
<td>22</td>
<td>90.9%</td>
<td>20</td>
<td>75.0%</td>
<td>15</td>
<td>80.0%</td>
</tr>
<tr>
<td>Cohort 3 (2010-11)</td>
<td>20</td>
<td>100.0%</td>
<td>20</td>
<td>85.0%</td>
<td>17</td>
<td>93.0%</td>
</tr>
<tr>
<td>Cohort 4 (2011-12)</td>
<td>25</td>
<td>88.0%</td>
<td>22</td>
<td>86.0%</td>
<td>19</td>
<td>93.0%</td>
</tr>
<tr>
<td>Cohort 5 (2012-13)</td>
<td>18</td>
<td>76.0%</td>
<td>14</td>
<td>86.0%</td>
<td>12</td>
<td>93.0%</td>
</tr>
<tr>
<td>Average Retention</td>
<td>71.3%</td>
<td>87.0%</td>
<td>87.0%</td>
<td>100.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Projected Retention</td>
<td>105</td>
<td>76.0%</td>
<td>80</td>
<td>86.0%</td>
<td>69</td>
<td>93.0%</td>
</tr>
<tr>
<td>CEAS Average Retention</td>
<td>73.0%</td>
<td>85.0%</td>
<td>94.0%</td>
<td>99.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[1] Students in Cohort 1 were not held to the same requirements of the program as later cohorts, due to the timing of the funding and student selection

[2] 2 students from the original Cohort 1 returned to CEAS

[3] 1 student has left STEP in Fall 2012


[5] 1 student left STEP at the end of Summer Bridge 2012

Table 4: STEP Total Retention as of Fall 2012

<table>
<thead>
<tr>
<th>Cohort #: (Starting Year)</th>
<th>Freshmen to Sophomore</th>
<th>Sophomore to Pre-Junior</th>
<th>Pre-Junior to Junior</th>
<th>Junior to Senior</th>
<th>Graduation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># Start Fall</td>
<td># Return Fall</td>
<td>Retention %</td>
<td># Start Fall</td>
<td># Return Fall</td>
</tr>
<tr>
<td>Cohort 1 (2008-09)</td>
<td>20</td>
<td>6</td>
<td>30.0%</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Cohort 2 (2009-10)</td>
<td>59</td>
<td>64</td>
<td>86.4%</td>
<td>49</td>
<td>76.6%</td>
</tr>
<tr>
<td>Cohort 3 (2010-11)</td>
<td>75</td>
<td>70</td>
<td>93.3%</td>
<td>59</td>
<td>84.3%</td>
</tr>
<tr>
<td>Cohort 4 (2011-12)</td>
<td>25</td>
<td>21</td>
<td>84.0%</td>
<td>18</td>
<td>93.0%</td>
</tr>
<tr>
<td>Cohort 5 (2012-13)</td>
<td>14</td>
<td>14</td>
<td>76.0%</td>
<td>12</td>
<td>93.0%</td>
</tr>
<tr>
<td>Average Retention</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Projected Retention</td>
<td>198</td>
<td>150</td>
<td>76.0%</td>
<td>169</td>
<td>86.0%</td>
</tr>
<tr>
<td>CEAS Average Retention [6]</td>
<td>73.0%</td>
<td>85.0%</td>
<td>94.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[1] Students in Cohort 1 were not held to the same requirements of the program as later cohorts, due to the timing of the funding and student selection
[2] 2 students from the original Cohort 1 returned to CEAS
[3] 12 Transfer Students and 7 Replacement Students were added to Cohort 2 in Fall 2010
[4] 1 student left STEP in Fall 2012
[5] Out of 78 students total (Bridge + Non-Bridge + Transfer Students + Replacements)
[7] 1 student left STEP at the end of Summer Bridge 2012
The impact of the STEP program is clear; it provides support for progress towards graduation. Graduation of these students will then lead to UC graduates as professionals who represent the university and the college globally. The projected graduation rates for the program, assuming the retention rates proposed as the goals of the project, will be above the university average (59% for students seeking bachelor’s degrees starting in 2005) for Cohorts 2, 3, 4 and 5 for all STEP participants on average (see Table 4). Cohort 2 will graduate with a 61.5% graduation rate, assuming 100% retention from junior to senior year. Cohort 3 will have a 69.3% graduation rate, assuming 93% retention from pre-junior to junior year, and 100% from junior to senior year. Cohort 4 will have a 63.2% graduation rate, and Cohort 5 will have 69.1% retention rate, assuming the goals set for the program.

**Academic Success**

One of the main objectives of the STEP program, through the Summer Bridge Scholars Program and the SCLC, was to promote student success in their first year. In this respect, academic success highlights include: positive impact of ALEKS on MPT scores during the Summer Bridge Scholars Program (Figure 1) and better performance in the first freshman math and science course, particularly to the corresponding cohort peer group (see Figure 2). MPT Scores increased an average of 13% after completion of ALEKS during the 2012 Summer Bridge Program, as shown in Figure 1. STEP students who participated in ALEKS with 20 hours or more of use increased their MPT score on average by greater than 100 points.

The **Engineering and Applied Science Entrance Program (EASE)** was started at UC in fall of 2010 to provide access to engineering and engineering technology degrees to students who do not qualify for direct admission to a degree program in CEAS. EASE students are given one calendar year to achieve the necessary math and science GPA and overall GPA needed to transfer to a degree program. EASE students follow the same curriculum as direct-admit students. However, they enroll in specific sections of the college-wide introductory freshman courses that are designed to give them additional support through tutoring. In fall 2010, 147 (20% of total) students were admitted to the EASE program, which grew to 161 (21% of total) students in the fall of 2011, and currently (fall of 2012) has 141 (18% of total) students. The EASE program enrollment exceeds the first-year enrollments in any one of the individual engineering and technology and computer science degree programs in CEAS. The ACT score of EASE and Bridge students is 2-4 points below the lower threshold for direct admission to a program (average ACT for EASE = 23.9, Bridge = 25, and Peer = 27.8). In addition, based on the UC MPT, which is used as a basis for first math course placement, EASE and Bridge students typically score below the cut-off for placement in Calculus I, the first course in the engineering math sequence and a prerequisite for Physics I [average MPT for EASE = 690.3, Bridge = 792.4 (after completing ALEKS during Bridge, which increased on the average by about 100 points from that prior to Bridge), and Peer = 811.8; cut off for Calculus I placement = 700]. Thus, EASE students are used as the comparison group for Bridge students in the STEP program as both groups of students have similar high-school academic preparation. In many cases, both Bridge and EASE students enter the university with weaker academic preparation than the majority students who directly enter degree programs or the Freshman Engineering Program (FEP) in CEAS for undecided students that provides otherwise well-qualified students the information they need to decide on a major within the first year. The end of their freshman
year, GPA and the D, W, F grades received in the freshman year math and science courses are compared for the STEP and EASE students in Figures 4 and 5, respectively. The STEP and Bridge students received higher GPAs at the end of their freshman year compared to the EASE students (Figure 4). Also, the percentage of STEP and Bridge students receiving D, W, F grades in the first-year math and science courses is lower than the EASE students (Figure 5).

Participation in PER activities has also enhanced the cumulative GPA of the STEP students in comparison to their peers. The last three columns of Table 5 compare the GPA of STEP Bridge, STEP non-Bridge and non-STEP peer students. A ratio of greater than 1.00 indicates that the respective STEP student cohort had a higher GPA than their peer counterparts. STEP Cohort 1, which had not participated in all the PER programs from the very beginning, and obtained a GPA that varied between 80% and 98% level of their peer and obtained a GPA that varied between 80% and 98% level of their peer. STEP Cohort 2 performed same or better than their peer, and obtained a GPA that varied between 100% and 119% level of their peer. STEP Cohort 3 performed much better than their peer, and obtained a GPA at about 106% to 114% level of their peer. STEP Cohort 4 has performed a little lower than their peer and obtained a GPA at about 90% level of their peer. No specific reason can be identified for this slightly lower performance by Cohort 4. Thus, participation in all PER activities does have an impact on students’ overall academic performance as measured by cumulative GPA. In Table 5, the results for Cohorts 2, 3 and 4 also indicate that the STEP non-Bridge students performed better than the STEP Bridge students (average performance varied between 85% and 91% level for the Bridge, and between 102% and 104% level for the non-Bridge cohorts, relative to their peer cohort).

Interest in Graduate School

One objective of the STEP program is to increase the number of minority students and women enrolled in graduate school. The Summer and Academic Year REU Programs included in the STEP project impact student progress towards graduation, interest in research and graduate school, research support for faculty, and create research publications to enhance UC as an institution for research. Since none of the STEP cohorts have actually graduated as yet from their undergraduate degree programs, no results are available documenting how many STEP students have gone to graduate school. However, we do have some data to report for the seniors who participated in our Summer REU Program: 9 students have finished their B.S. degree and 4 (44%) of them are in graduate engineering programs (3 in M.S. and 1 in Ph.D.). Also, a March 2012 survey of STEP participants indicates that 25% of participants intend to attend graduate school in engineering, 6% plan to attend graduate school in a STEM discipline other than engineering, and 2% plan to attend graduate school in a non-STEM area. Thus, a total of 33% of the STEP students have indicated an interest in pursuing graduate education upon finishing their B.S. degree.

Comparing the STEP versus peer students for each cohort, there were mixed findings about statistical significance of the results. We lacked statistically significant evidence that there was a difference in mean GPA comparing the STEP and Peer students (p-value = 0.8391) for Cohort 1. For Cohort 2, there was marginally statistically significant evidence that, on average, GPA for STEP students was higher than GPA for Peer students (p-value = 0.0671). For Cohort 2, on
Figure 4: End of Freshmen Year Mean GPA Comparison of STEP to EASE for Cohort 3 (2010-2011) and Cohort 4 (2011-2012)

Figure 5: Percentage of Students who Received D, W and F Grades in Calculus, Chemistry and Physics Courses in Year 1 by STEP and EASE Students in Cohort 3 (2010-2011) and Cohort 4 (2011-2012)
Table 5: Cumulative Year-End GPA Comparison of STEP Bridge, STEP Non Bridge and Peer (Non-STEP) Student Cohorts

<table>
<thead>
<tr>
<th>Cohort (Start Year)</th>
<th>Year</th>
<th></th>
<th>Mean Cumulative GPA</th>
<th></th>
<th>Cumulative GPA Comparison</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>STEP Bridge</td>
<td>Non-Bridge</td>
<td>Total STEP</td>
<td>Peer (Non-STEP) Bridge</td>
<td>Non-Bridge + Peer</td>
</tr>
<tr>
<td>1 (2008-2009)</td>
<td>1</td>
<td>2.48</td>
<td>0</td>
<td>2.48</td>
<td>3.06</td>
<td>0.81</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2.65</td>
<td>0</td>
<td>2.65</td>
<td>2.94</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2.74</td>
<td>0</td>
<td>2.74</td>
<td>3.16</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>2.88</td>
<td>0</td>
<td>2.88</td>
<td>3.27</td>
<td>0.88</td>
</tr>
<tr>
<td>2 (2009-2010)</td>
<td>1</td>
<td>2.68</td>
<td>3.19</td>
<td>2.97</td>
<td>2.68</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2.69</td>
<td>3.31</td>
<td>3.12</td>
<td>3.11</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2.93</td>
<td>3.34</td>
<td>3.30</td>
<td>3.21</td>
<td>0.91</td>
</tr>
<tr>
<td>3 (2010-2011)</td>
<td>1</td>
<td>2.33</td>
<td>3.31</td>
<td>3.07</td>
<td>2.89</td>
<td>0.81</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2.53</td>
<td>3.43</td>
<td>3.32</td>
<td>3.04</td>
<td>0.74</td>
</tr>
<tr>
<td>4 (2011-2012)</td>
<td>1</td>
<td>2.72</td>
<td>0</td>
<td>2.72</td>
<td>3.03</td>
<td>0.90</td>
</tr>
<tr>
<td>Average for 2, 3 &amp; 4</td>
<td>1</td>
<td>2.58</td>
<td>3.25</td>
<td>2.92</td>
<td>2.91</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2.61</td>
<td>3.37</td>
<td>3.22</td>
<td>3.08</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2.93</td>
<td>3.34</td>
<td>3.30</td>
<td>3.21</td>
<td>0.91</td>
</tr>
</tbody>
</table>

STEP students was higher than GPA for peer students \( (p\text{-value} = 0.0671) \). For Cohort 2, on average, STEP students’ GPA was 0.1427 GPA points higher than for peer students. For Cohort 3, there was statistically significant evidence that, on average, STEP students’ GPA was higher than GPA for peer students \( (p\text{-value} = 0.0033) \). For Cohort 3, on average, STEP students GPA was 0.22 GPA points higher than peer students’ GPA. For Cohorts 4, we lacked statistically significant evidence that there was difference between average GPA for STEP and peer students \( (p\text{-values} = 0.1309) \). It is noted that the power of the t-test to find a difference between the two groups (STEP and peer) may not be strong as the number of students in a particular STEP cohort is much smaller than the number of students in the corresponding peer cohort (therefore the confidence intervals for mean GPA for STEP is wider, making it harder to find a statistically significant difference between the two groups).

**CONCLUSION**

The key implementation strategies for improving retention and student success in the STEP Project are: Cohort Building; Networking; and Pathway to Graduate School. These strategies have proven successful in improving first-year success and retention, and are projected to improve graduation rates for the demographic groups supported by the project.

The success highlights of the STEP program include: Summer Bridge performance was used to place students in the first freshman Calculus course, either Calculus 0 or Calculus I; a “structured” freshman year including cohort course scheduling of regular and SCLC freshman Calculus and Physics courses; positive impact of ALEKS on MPT scores during the Summer Bridge Scholars Program (scores increased by 13%, which is equivalent to about 100 points); student retention on average is exceeding program goals; the first year GPA is greater for STEP Bridge students than for students in the comparison group; the freshman course performance is
greater than for students in the comparison group; and early participation in REU fosters the persistence to pursue an undergraduate degree and gains in skills in conducting research, acquiring information, and communicating effectively.

The STEP program at the University of Cincinnati is coordinated by one full-time grant Program Coordinator (supported 33% by NSF funds and 67% by university funds), one part-time student as the IT coordinator (supported from NSF funds), and 3 engineering faculty members (2 supported less than 4.5% by NSF) and 1 full-time administrative staff member (receiving no support from NSF) serving as the STEP Mentors.

Several challenges have been faced in the implementation for the STEP program. The first challenge has been recruitment for the Summer Bridge Scholars Program, as the current financial and academic support given by the program is not enough to draw students to participate, particularly minority students. An important element of the strategy must include a financial aid package that is competitive.

The second challenge is coordinating student participation in various programs by the Bridge and non-Bridge STEP students. The level of self-commitment by these two groups does not appear to be the same. The level of immersion in cohort building experienced by the Bridge students is different than that for the students who do not participate in the Summer Bridge Scholars Program. The cohort building and learning community creation occurs in the Summer Bridge Scholars Program as the students live together for seven weeks prior to their freshman year, and study as cohorts during the required evening/night study sessions. The Bridge cohorts study together in their freshman year as they take the SCLC in math and science besides their regular courses. Thus, the Bridge students form a social and academic learning community for a longer time, and it is guided and supervised. On the other hand, the non-Bridge STEP students, who do not participate in the Summer Bridge Scholars Program, form a learning community as part of the Freshman Learning Community Courses (FLCC) they are required to enroll in. The FLCC is more of a social network of students with similar academic interests, and is different from the learning community formed in the Summer Bridge Scholars Program and continued in the SCLC. An E-Portfolio system has been implemented for the purpose of enhancing student participation in the program. The E-Portfolio allows students, faculty and staff to track student participation in real time online. This encourages students to take responsibility for their participation in the program, which then impacts their success at the institution.

Since majority of UC engineering students (about 94.6%) come from Ohio, and many from the surrounding school districts in Cincinnati and Northern Kentucky, the third challenge is to increase the yield from this group of students for the STEP project. The major ethnic groups in the school districts from Greater Cincinnati and Dayton, from where a majority of our engineering students come, are white and African-American, with an average of 64.7% white and 25.1% African-American (69% in the two largest districts, which are Cincinnati Public Schools (CPS) and Dayton School District). The Hispanic population varies from 9%-3%. We recruit from 5 school districts from Northern Kentucky - majority (86%) students in these targeted school districts are economically disadvantaged and First Generation college-bound. High-School students from grades 10-12 from these school districts need to be better prepared for college entrance tests (ACT/SAT), and these students need assistance with completing
college applications in a timely manner (we observed that many minority students who were qualified for the COFSP award were not considered since they had not submitted a completed application by the December 1 deadline set by UC). To address this challenge, during September-November each year, we plan to conduct ACT/SAT and college application preparation workshops for local area students, particularly minority students.

The lessons learned from the STEP program are: the prior un-proctored MPT Score varied from the proctored MPT score for pre-Bridge; and the creation of the E-Portfolio has enabled advising and tracking of student progress in the program online and encouraged accountability. The E-Portfolio was not proposed in the original NSF proposal, but was added as its need became apparent. During early conversations about using an E-Portfolio system, the university had expressed its intent to adopt an E-Portfolio system for all undergraduates. The adoption did not happen, but the STEP committee took the project, hired a student to create the system from scratch during 2011-2012, beta-tested it with a subset of the STEP students, and launched it fully in fall 2012. Creating a new program with your own staff allows for immediate adaptation, but also puts the E-Portfolio at the mercy of the creator’s abilities. Thus far, the student staff member has not had any issue creating the components requested, but future needs may outgrow the programming abilities of the E-Portfolio’s creator. Educating students, faculty, and staff regarding the E-Portfolio is in progress, and changes for the second semester are anticipated to increase user frustration. Once the format and functions are established, however, this will be minimized. The student feedback for the E-Portfolio has been very positive, as illustrated from following student statements:

“The list of all of the requirements enables better organization.”
“The E-Portfolio makes the student the driver – whatever is required is ultimately your responsibility.”
“Viewing all I have done allows me to see how I have grown since college.”
“Having the touchpoint essays online keeps goals in line and we can see how they change.”

The feedback from the STEP Mentors has also been very positive, as illustrated from following mentor statements:

“Easy to see all information at once.”
“More accessible information makes discussion and follow up with students easier.”
“Students take ownership of completing the requirements instead of waiting to be told.”
“Elimination of paperwork and possibility of a lost student file.”

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