

# Work in Progress - Foundations for STEM Success: Implementing National Best Practices in a Liberal Arts College Setting

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**Abstract** - The President's Council of Advisors on Science and Technology has indicated that the US Higher Education system needs to produce more graduates in STEM fields to maintain a competitive position in the global economy. Increasing student retention in STEM majors has been identified as an approach to achieve these objectives. The Foundation for STEM Success (FS<sup>2</sup>) program uses a student-centered approach to academic preparation and learning, and creates a network of supports for first-year students in engineering and computer science majors. The FS<sup>2</sup> project was designed to improve retention and graduation by implementing strategies that contribute to: academic preparation and self-efficacy, particularly in first year mathematics courses; a sense of belonging to a major and social integration within an academic community, and; a belief that the targeted majors contribute to society. These are key factors that affect STEM retention. The FS<sup>2</sup> program is composed of four initiatives: (1) summer bridge program, (2) revised gateway course, (3) peer and faculty mentor/tutoring program, and (4) affinity housing. The FS<sup>2</sup> program is currently in Year 2 and has engaged a total of 213 first year engineering and computer science students. Preliminary results indicate that first year retention is 70% for gateway course participants, 83% for summer bridge participants and 87% for affinity housing participants. This is an improvement over the baseline first year retention of 67%.

*Index Terms* – Affinity housing, Mentoring, Retention, Summer bridge program

## EXPECTED IMPACTS

The FS<sup>2</sup> project elements have been piloted at large public institutions, and this project expands their application and assesses their effectiveness within a smaller Liberal Arts college setting. The project strengthens the infrastructure for providing services for pre-freshman and matriculated students by fostering collaborations between faculty and students and students and their peers. The project is expected to increase the number of engineering and CS graduates and accelerate their progress toward completing their degree and will make significant positive contributions to the STEM

workforce and the new global economy. The results will provide a rich assessment of approaches to retention that can be applied to all STEM disciplines.

## GOALS

The primary goals of this five year project are to, increase first year retention in engineering and CS majors to 80% by Year 3, increase second year retention to 71% by Year 3, and increase the five-year graduation rate to 65% by Year 5. To accomplish the project goals, the FS<sup>2</sup> program implements four initiatives detailed below for first year engineering and CS majors.

### INITIATIVE #1: SUMMER BRIDGE PROGRAM

Summer bridge programs have been shown to overcome the barriers that contribute to student attrition in STEM. These barriers include, misinformation about science curricula, lack of preparation for the academic challenges associated with a degree in the sciences, and the absence of a quality mentoring relationship with a faculty member early in the first year of courses [1].

The Summer Bridge Program is a two-week initiative to improve the preparation of students for college-level studies, particularly first year mathematics. This program also includes career exposure, hands-on activities, seminars, and field trips. The target population for the summer bridge program is students with: low high school grades; and/or low standardized math scores. Participation in the summer bridge program is often a requirement for admission to the college.

The Summer Bridge Program has two goals, (1) to improve student preparation and first-year mathematics placement through a mathematics review, and (2) to excite new students about their chosen majors through activities meant to create a sense of belonging and inform students about career options.

The summer program is taught by faculty from CS, civil, mechanical, and electrical engineering. Three student peer mentors and a graduate student fellow provide additional support, mentoring and oversight of the students. The summer bridge participants live on-campus for the full program in the dorm room assigned to them for the fall semester, to ease their transition into college life. At the end of the Summer

Bridge Program students retake the Math Placement Exam and have the opportunity to move up one math course if they show sufficient improvement.

### INITIATIVE #2: REVISED GATEWAY COURSE

The Introduction to Engineering gateway course serves as a first-year experience for engineering students course is a required course for all incoming engineering students. As part of the FS<sup>2</sup> project, the gateway course has been expanded to include CS majors and has been revised to include a collaborative team-building design project. This interdisciplinary design project offers first year students with valuable experience working in teams on a hands-on practical problem.

First-year experiences, in particular overview freshmen seminars that introduce and orient STEM students to college-level studies, are a best practice for enhancing skills in the sciences and engineering, strengthening peer learning, and improving retention. Students develop relationships with one another, faculty, and the community; a sense of personal responsibility for academic progress; and an appreciation for education culture, diversity, and tolerance [2]. Studies have shown that participation in a first-year experience leads to improved academic performance throughout a student's college career [3]-[5]. The retention benefits are also clear. Numerous studies have shown that first-year experiences allow students to forge tighter bonds with their classmates and create a community of learners that increases persistence and graduation rates [6]. The retention effects of these experiences are most pronounced for high-need students, including Hispanics and first-generation students [7].

The expanded gateway course is team taught by faculty from civil and mechanical engineering, electrical engineering, and computer science. The course is structured as writing-intensive lectures, labs, and a weekly recitation. Additionally, students learn to use the tools of their major in their discipline specific labs, such as computer-aided design software or programming development platforms.

Students meet one per week for an interdisciplinary recitation, where students are placed into interdisciplinary teams and work on a hands-on design project. The design project incorporates multiple engineering and CS concepts, and emphasizes teamwork. The primary focus is on knowledge and comprehension of basic concepts within the context of a real-world application. The courses culminated in a design competition that includes a judged poster session and design demonstrations.

### INITIATIVE #3: AFFINITY HOUSING

The affinity housing initiative created a living/learning community (LLC) of students majoring in engineering or CS, with Resident Advisors who are also STEM majors. The affinity house has been dubbed the "iTEC LLC" for Innovations Through Engineering and Computing. The iTEC LLC is based on the Quadrangle Engineering and Sciences Living and Learning Community at the University of Colorado-Boulder [8]. The iTEC LLC provides peer support

outside the classroom, and directly address the need for social integration into the engineering and CS community. Student success and persistence in college has been shown to be tied to their social integration with peers and students are more likely to accomplish difficult tasks when engaged with individuals facing similar challenges [9].

The iTEC LLC activities are intended for students living in the iTEC LLC but available and advertised to all engineering/CS freshman students and open to sophomore students as well. Activities consist of professional development sessions, nightly mentoring/tutoring in the iTEC LLC dormitory and community building activities. Specific activities have included a guest lectures, tours of local companies, and internship advice from upper classmen and recent alumni.

### INITIATIVE #4: ADVISING, TUTORING, AND MENTORING PROGRAM

Faculty and peer mentoring are best practices as recognized by the National Research Council, especially for first-generation students and groups underrepresented in STEM [10]. The close personal relationship that develops between mentor and student can be one of the most important factors in determining the overall academic success of STEM students, and the quality of student/faculty interactions is key to student engagement and learning [11][12]. Multiple studies underscore the importance of peer relations, in particular peer mentoring, during the undergraduate experience [5][13][14]. The integration of academic and social support systems is especially important for students from groups underrepresented in science [15].

As part of FS<sup>2</sup>, the Advising, Tutoring, and Mentoring (ATM) program was designed and launched. Each year, the FS<sup>2</sup> leadership team selects peer mentors from top performing, upper-division students in engineering and CS. These peer mentors help new students build their aspirations and academic confidence by welcoming and orienting them to the campus and its culture, and sharing with them their own academic/personal experiences and coping strategies.

A formal tutoring schedule for topics critical to first year students (i.e. mathematics, programming, physics and chemistry) is developed each semester. The peer mentors serve as tutors for the program and they are required to complete peer tutor training in accordance with tutoring standards for the College.

### DISCUSSION OF PRELIMINARY RESULTS

The FS<sup>2</sup> project is currently in its second year and has engaged a total of 215 first year engineering and CS students as well as 20 upper division peer mentors. Table I shows the demographic breakdown of the two FS<sup>2</sup> cohorts. The 2015/16 cohort is slightly larger however the demographics are very similar. Both cohorts are predominantly male, roughly a quarter are underrepresented in engineering, and nearly a third are 1<sup>st</sup> generation college students.

TABLE I  
COHORT DEMOGRAPHICS AND PRELIMINARY RETENTION DATA

Cohort Year	Cohort Size	Male	Female	Under-represented	1st Generation
2014/15	101	88 (87%)	13 (13%)	22 (22%)	27 (27%)
Retained FA15 ==>	77	67	10	15	20
	76%	76%	77%	68%	74%

2015/16	114	93 (82%)	21 (18%)	32 (28%)	35 (31%)
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Underrepresented students includes women, hispanic and african american students.

Table I also shows the number and percentage of student within the 2014/15 cohort retained after one year. The baseline first year retention was defined as the average retention for the combined civil, electrical and CS majors over a ten year period from 2002 to 2011. Mechanical engineering was not included in this baseline retention value because it is a new major and data was not available.

Table II indicates the number of students participating in the Summer Bridge, iTEC LLC and the Gateway initiatives and the percent participation in the cohort (shown in parenthesis). To date 86 students have participated in the iTEC LLC and 29 students have participated in the summer bridge program. Virtually all students in the cohorts participate in the gateway course. Participation in the iTEC LLC has increased from 31% of the 2014/15 cohort to 48% of the 2015/16 cohort due to the implementation of an opt-out approach. Participation in the Summer Bridge remains below 15% for each cohort. Table II also shows the retention rates by participation in these initiatives and indicates that Summer Bridge and iTEC LLC participants were retained at rates of 83% and 87%, respectively.

TABLE II  
INITIATIVE PARTICIPATION AND PRELIMINARY RETENTION DATA

Cohort Year	Cohort Size	Summer Bridge	iTEC LLC	Gateway
2014/15	101	12 (12%)	31 (31%)	100 (99%)
Retained FA15 ==>	77	10	27	76
	76%	83%	87%	76%

2015/16	114	16 (14%)	55 (48%)	110 (96%)
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**PRELIMINARY CONCLUSIONS**

Based on data from the first two years of the project, first year retention rate after implementation of the FS2 initiatives is 76% which is higher than the baseline retention rate of 67%. The retention rate for the male, female and 1<sup>st</sup> generation students mimics the overall cohort rate of 76%. Underrepresented students were retained at a slightly lower rate of 68%.

The retention rate for the students who participated in the Summer Bridge program and the iTEC LLC was 83% and 87%, respectively, noticeably higher than the overall retention rate of 76% and representing a significant increase over the baseline retention of 67%. It should be noted that due to the small sample size in the summer bridge program,

the retention rate of 87% is not statistically accurate, and further study is required.

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