AC 2011-2827: MATHEMATICS PERFORMANCE AND FIRST YEAR RETENTION OF STUDENTS IN ENGINEERING LEARNING COMMUNITIES

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Mathematics Performance and First Year Retention of Students in Engineering Learning Communities

Abstract

Studies indicate that a number of parameters, including quantitative skills, social integration and academic integration impact student retention to varying degrees. Learning communities are largely designed to address social and academic integration. This paper compares first year retention and performance of Fall 2009 incoming freshmen who participated in one of four engineering learning communities called Freshman Interest Groups (FIGs). The purpose is to begin to develop an understanding of the impact of academic support activities on student retention by evaluating the performance of students in one of the FIGs, called FORCES (Focus On Retention in Cohorts of Engineering Students), compared to students in the other three FIGs and the College of Engineering as a whole. FORCES is funded by NSF's S-STEM (Scholarships in Science, Technology, Engineering and Mathematics) program and targets students in underrepresented groups for recruitment with the broad goals of removing financial barriers and improving student retention.

Recognizing that success in mathematics is critical to engineering student success, key FORCES program elements were designed with a focus on calculus. FORCES scholars were required to demonstrate first fall semester calculus readiness by either earning an acceptable score on the university's Math Aptitude Test (MAT) or by completing "Jump Start Math" (JSM), which consolidates Pre-calculus I and II into an 8-week summer course. The FORCES cohort had to meet participation-based requirements focused on academic success as well.

All 18 students in the FORCES cohort qualified to enroll in Calculus I in Fall 2009. A total of 44.4% (8/18) of FORCES students required JSM during Summer 2009. This was essentially equal to the fraction of students in the Non-FORCES FIGs who were not calculus-ready, which was 43.6% (24/55). Students who enrolled in Calculus I or higher were retained through the first year at higher rates than students in Pre-Calculus or lower. Students earning a C or better in Calculus I were retained at higher rates than students who did not pass Calculus I. Frequency distributions for SAT Math scores were analyzed for correlations with GPA. For students retained through the first year, there was a positive correlation between the two variables (although the correlation for the FORCES cohort was weak). For students who did not persist in engineering, the non-FIG student population data yielded a moderately positive correlation between SAT Math scores and GPA, while FIG data showed a negative correlation indicating that average first year cumulative grade point averages decreased with increased SAT Math scores. There were no statistically significant differences, at the 95% confidence level, in grade point averages among all FIGs; however the percent increase in average cumulative GPA between the first and second semesters was higher for the FORCES cohort (12.4%) than for the others.

Quantitative and qualitative data collected via surveys are being used to evaluate the effectiveness of FORCES components; a preliminary assessment of some of those components is

presented here. Lessons learned during the first year of FORCES implementation are being used to modify the program to improve the outcomes for current and future cohorts.

Introduction

Studies indicate that a number of parameters, including qualitative skills, social integration and academic integration impact student retention to varying degrees.[1,2] This paper compares first year retention and performance of Fall 2009 incoming freshmen who participated in one of four engineering learning communities called Freshman Interest Groups (FIGs). The purpose is to begin to develop an understanding of the impact of academic support activities on student retention by evaluating the performance of students in one of the FIGs, called FORCES (Focus On Retention in Cohorts of Engineering Students), compared to students in the other three FIGs and the College of Engineering as a whole. Specifically, it examines first year performance, as measured by cumulative GPA, and retention among the three groups along with factors that are known and/or believed to contribute to persistence in engineering (e.g. SAT Math scores). It further discusses preliminary assessment results detailing the students' perceptions of FORCES program components.

Literature Review

Learning communities, defined by Lenning and Ebbers as "intentionally developed communities that will promote and maximize learning", may be structured in any of a number of ways and designed to meet one or more of a number of goals.[3] Generally, they are comprised of students who have the same or similar majors and/or interests and some may be "living learning communities", in which students reside in the same dormitories.[4] Living and non-living learning communities benefit students in different ways; however learning communities in general have been found to offer the following student benefits:

- *higher academic achievement,*
- *better retention rates,*
- *greater satisfaction with college life,*
- *improved quality of thinking and communicating,*
- *a better understanding of self and others and*
- *a greater ability to bridge the gap between the academic and social worlds.*[5]

Summer bridge programs, like learning communities, are usually structured to address specific student needs. The overarching aim is to help incoming freshmen successfully transition from high school to college. They often target students who are at high risk of attrition such as first-generation college students and, for engineering and science majors, underrepresented minorities (URMs – ethnic minorities, women and people with disabilities for science and engineering). The literature acknowledges shortcomings in bridge program evaluations, especially with regard to long-term outcomes.[6,7] There are studies documenting the impacts of individual programs; however the results are difficult to extrapolate to others on a broad scale.[8]

Washington et al. found that at-risk students who participated in bridge programs at eight Texas community colleges and universities enrolled in fewer credit hours of developmental courses than non-participants.[9] Results regarding retention and performance for those students are not yet available (at the time of this writing). A University of New Mexico study showed improved performance on the algebra component of the mathematics placement exam and improved mathematics placement in over 40 percent of students who participated in a summer bridge program for underrepresented minority (URM) students.[10]

A number of internal, external and demographic characteristics affect student retention in engineering. Among the external characteristics, the rigor of engineering curricula is cited as one of the most important factors contributing to student attrition, with calculus being the largest obstacle. According to Li et al., "Among all challenging courses, mathematics seems to be the most difficult and hence the largest stumbling block causing dropouts in the freshman year in engineering schools."[11]

Nicholls et al. recently developed a model to predict STEM outcomes among students based upon data from eighth grade through college graduation. The outcomes evaluated for STEM and STEM-related majors included earning a four-year degree, a sub-four-year degree or no degree. Mathematics and science performance, including ACT and SAT Math scores, were among factors determined to be significant predictors of STEM outcomes. The model correctly predicted STEM outcomes for over 70 percent of the students studied.[12] Burtner found that persistence in engineering was not linked to SAT scores (verbal nor math) among students at Mercer; however first year GPAs were significant.[13]

Background

FORCES is funded by the National Science Foundation's (NSF's) S-STEM (Scholarships in Science, Technology, Engineering and Mathematics) program. It targets students in underrepresented groups for recruitment with the broad goals of removing financial barriers and improving student retention. Key components of the program include a summer bridge course to improve calculus readiness and a learning community to enhance academic and social integration.

The University of Texas at Arlington (UTA) offers learning communities called Freshman Interest Groups (FIGs) to incoming students. One of the FIG requirements is that students take a prescribed set of courses as a cohort. The FORCES cohort comprised a FIG, and as such, required students to enroll in the following courses as a group:

- UNIV 1131 (formerly EDUC 1131) – College Adjustment
- MATH 1426 – Calculus I
- XE 1104 – Introduction to Engineering (all FORCES scholars take the same section regardless of major)
- XE 1105 – Introduction to "X" Engineering (cohorts within different engineering majors)

The College Adjustment course is peer-taught and focuses on skills such as effective study habits, time management, stress management and others relevant to the new college freshman. In order to maintain eligibility for the scholarship, students in the FORCES cohort had to meet participation-based requirements, which included weekly group study sessions and academic and professional development workshops. Most of these requirements were a part of the College Adjustment course, and were documented in the portfolios that the students developed during the first semester.

Recognizing that success in mathematics is critical to success in engineering, key FORCES program elements were designed with a focus on calculus. FORCES scholars were required to demonstrate first fall semester calculus readiness by either earning an acceptable score on the university's Math Aptitude Test (MAT) or by completing a course called "Jump Start Math" (JSM). The MAT assesses students in three areas – algebra, trigonometry and pre-calculus – and is used as a tool to help place students into Calculus I or lower math courses. Jump Start Math is a course that the university's Mathematics Department offers engineering students to help them attain calculus readiness by their first fall semester. It consolidates Pre-calculus I and II into an eight-week summer course.

Two other program elements focused on Calculus as well – tutor-led group study sessions and the Guaranteed 4.0 study skills program. During Fall 2009, the scholars were assigned to study groups comprised of 4-5 members, and received guidance regarding effective group study. Calculus I was the target course for the group study. Tutors were hired to assist with the group study sessions and answer questions as needed. Guaranteed 4.0 provides a step-by-step approach to preparation for classes and improved learning. FORCES scholars attended a six-hour seminar in Fall 2009 (over the course of two evenings) and were provided with all seminar materials (books, notebooks and workbooks) to help them implement the program.

Data Collection and Analysis

SAT scores, grade point averages, demographic data and enrollment data for all three groups of students (FORCES, Non-FORCES FIGs and non-FIG College of Engineering students, denoted as COE) were obtained from the university's Institutional Research office. A total of 373 first-time freshmen declared engineering as their intended major in Fall 2009. Of these, 18 were in FORCES and 55 were in other engineering FIGs.

Analyses were performed to provide a comparison of first year retention (to Fall 2010) and performance of the FORCES cohort compared to the Non-FORCES FIG students and the COE (excluding FIG participants). Grade point averages and SAT Math scores among students retained and those who were not retained were also examined. Statistical significance of differences observed among the groups were evaluated at the 95% confidence level. The data were further analyzed to determine if SAT Math scores correlated with grade point averages and if calculus readiness improved retention.

The Pittsburgh Freshman Engineering Survey was administered to students enrolled in introductory engineering courses in Fall 2009 and Fall 2010 to identify attitudes associated with

attrition among the students in each of the three groups. As of the time of this writing, those data have not yet been analyzed.

FORCES students were asked to evaluate the elements of the program in a survey. The survey asked the students to rate the degree to which program components such as Jump Start Math, FIG involvement and others were beneficial to them in terms of meeting their intended objectives and their usefulness in general. Figure 1 is an excerpt from the survey instrument showing questions specific to Jump Start Math and the FIG, the two program elements that are the focus of this study. A four-point Likert scale with responses ranging from "Strongly Disagree" to "Strongly Agree" was used. There was no "Neutral" response; however "Not Applicable" was added so that the survey could accurately capture data in the event that a component was not applicable to the participant (e.g. not all students were required to take JSM). Students were also asked to provide qualitative data regarding their views of the most and least useful components of the program, as well as suggestions for improvements/modifications for future cohorts.

Figure 1. Excerpt from FORCES Formative Evaluation Survey

	SD	D	A	SA	N/A
Jump Start Math helped me to prepare for calculus.	1	2	3	4	
Jump Start Math helped me to prepare for the rigor of college coursework.	1	2	3	4	
The FIG course, covering topics such as study skills, time management, etc., was helpful to me.	1	2	3	4	
The FIG course, covering topics such as study skills, time management, etc., helped me to adjust to college.	1	2	3	4	
My involvement in FORCES is largely responsible for me persisting as an engineering student.	1	2	3	4	

Student Perspectives on FORCES Program Components

Jump Start Math. In Summer 2009, a total of nine FORCES students took the Jump Start Math course, one of whom had placed into calculus but wanted to make sure that he was adequately prepared. Only 22.2% (2/9) of FORCES students who took JSM in Summer 2009 passed Calculus I in Fall 2009; 55.6% (5/9) FORCES students who enrolled in JSM during summer 2009 were retained through the first year.

A survey was administered to the FORCES students who were retained through the first year to assess the impact of various FORCES program elements, including JSM. Of the five retained students who took JSM, 60% (3/5) agreed or strongly agreed that JSM helped them to prepare for calculus. Notably, 80% (4/5) strongly agreed that JSM helped them to prepare for the rigor of college coursework. This is supported by information gained through group discussions with the students. During those discussions, most students stated that they studied very little in high school, and that taking JSM during the summer allowed them to adjust to having to study while taking only one course, helping them to transition to the rigor of a full-time course load.

Freshman Interest Group. Student survey responses indicated that 66.7% (6/9) of respondents either agreed or strongly agreed that the FIG course was helpful to them in general; 77.8% (7/9) agreed or strongly agreed that the course helped them to adjust to college. Several students identified the FIG course and the cohort structure as program strengths. They were asked, "What do you believe are the MOST valuable components of the FORCES program?" Some of the responses were (these are direct quotes from the surveys):

- *That the people that I have met in the program are great friends and study partners, and my association with them was due to the existence of the FORCES program.*
- *The feeling of being a part of an achieving group so that you don't feel alone in college and the friendship that you gain with the other members in the group lets you know that you always have someone to talk to who is on your level.*
- *Your peers. They are one of your main motivations to do well in a class.*
- *Networking – belonging to a group as a freshman.*
- *Being in the FIG class and in the same math classes so we get to know each other and help each other in class.*
- *… having a group of fellow students that are taking similar classes was also important to keep me motivated.*

Tutor-led Group Study Sessions. Calculus I group study sessions in Fall 2009 were facilitated by graduate student tutors who were hired from the university's Student Support Services office, which hires and trains tutors to assist with various courses university wide. Survey results indicated that the students were mixed in regards to their experiences with the group study and tutoring. While the majority (66.7%, or 6/9) agreed or strongly agreed that the group study sessions were helpful, 44.4% (4/9) either strongly disagreed or disagreed that the graduate students' tutoring was helpful and 33.3% (3/9) agreed that the graduate students were helpful. During focus group conversations in Spring 2010 and Fall 2010, the students generally acknowledged the benefits of effective group study but responded negatively regarding the tutoring component. Some students stated that the tutors were not able to communicate effectively; others noted that the tutors were graduate students who had not taken calculus at UTA and felt that tutors who had experienced the rigor of UTA's Math Department could have been more helpful.

Guaranteed 4.0. Based on focus group discussions, many of the students expressed that they found it difficult to implement the program in the calculus class, but found it useful in other courses. Survey results show that while 66.7% (6/9) of students agreed that the Guaranteed 4.0 study skills workshop helped them to improve academically, 88.9% (8/9) either strongly disagreed or disagreed that they were able to implement Guaranteed 4.0 in their mathematics courses. A total 66.7% (6/9) strongly disagreed or disagreed that they were able to implement it in science courses; however 77.8% (7/9) agreed or strongly agreed that they were able to implement it in non-technical courses.

When asked about the negative aspects of FORCES, Guaranteed 4.0 was the most common response among the cohort (7/9 respondents). Specifically, they were asked, "What do you believe are the LEAST valuable components of the FORCES program?" Some of the responses were (these are direct quotes from the surveys):

- *I did not like Guaranteed 4.0 for it did not help me with my math and engineering*
- *courses.*
- *Two three-hour DVD lectures about 4.0 program.*
- *The only component I think was least valuable was trying to implement the Guaranteed 4.0 system to calculus. I just think that the system doesn't work with math classes.*

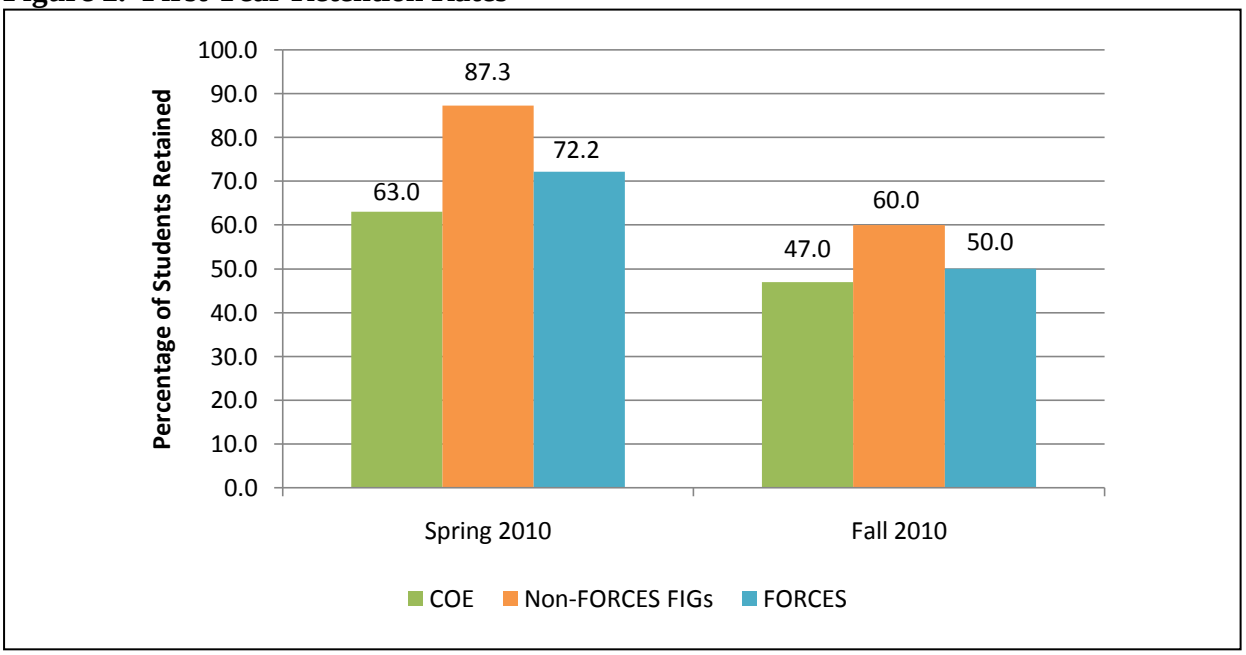
Results and Discussion

General Observations: Retention Rates and Grade Point Averages

Retention rates were determined using Fall 2009 enrollment as a baseline. Students were counted as not being retained if their majors of record as of the beginning of the Spring or Fall 2010 semester were areas outside of the College of Engineering, or if they were not enrolled during those semesters, even if their majors had not changed from engineering.

Figure 2 compares first semester and first year retention rates for the three groups. First semester retention of FIG participants was 9.2% to 24.3% higher than for non-FIG participants (COE). While retention of FIG participants through the first year remained higher than for non-FIG participants, the differences were much smaller (3.0% to 13.0%). In both cases, retention of the Non-FORCES FIG students was higher than all other students. While all three groups experienced decreased retention rates between the first semester (Spring 2010) and first year (Fall 2010), the decrease in COE enrollment (16.0%) was less than for the FIG cohorts (22.2% for FORCES and 27.3% for Non-FORCES).

Figure 2. First Year Retention Rates



As shown in Table 1, average Fall 2009 semester GPAs for students in all three cohorts ranged from 2.34 to 2.57; the differences were not statistically significant at the 95% confidence level.

Table 1. Comparison of Grade Point Averages

Average GPAs			
Group	**Fall 2009**	**Spring 2010**	**% Difference**
COE	2.41	2.63	+9.13
Non-FORCES FIG	2.57	2.57	0.00
FORCES	2.34	2.68	+14.52

Although the differences were not significant, the GPAs for the students retained in the FORCES cohort were on average 3.1% higher than those of the other two groups.

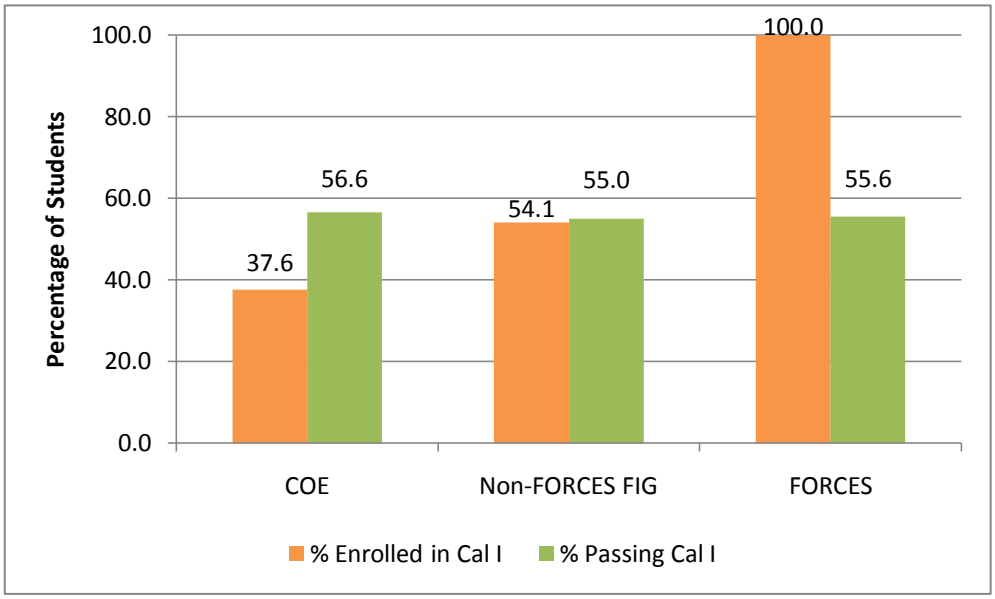
Calculus Readiness and Performance

All 18 students in the FORCES cohort were calculus-ready by their first fall semester of enrollment, Fall 2009. Each earned calculus placement either by successfully completing Jump Start Math or by achieving an acceptable score on the Math Aptitude Test. By comparison, only 56% and 43% of Non-FORCES FIG and COE students, respectively, were enrolled in Calculus I or higher during their first fall semester. Forty-four percent of FORCES students (8/18) required JSM during Summer 2009. An additional student who qualified for Calculus I took JSM as a pre-calculus refresher course. The fraction of FORCES students who required JSM was equal to the fraction of students in the Non-FORCES FIGs who were not calculus-ready, which was also 44% (24/55). By comparison, 57% (171/300) of non-FIG COE students were not calculus-ready in Fall 2009.

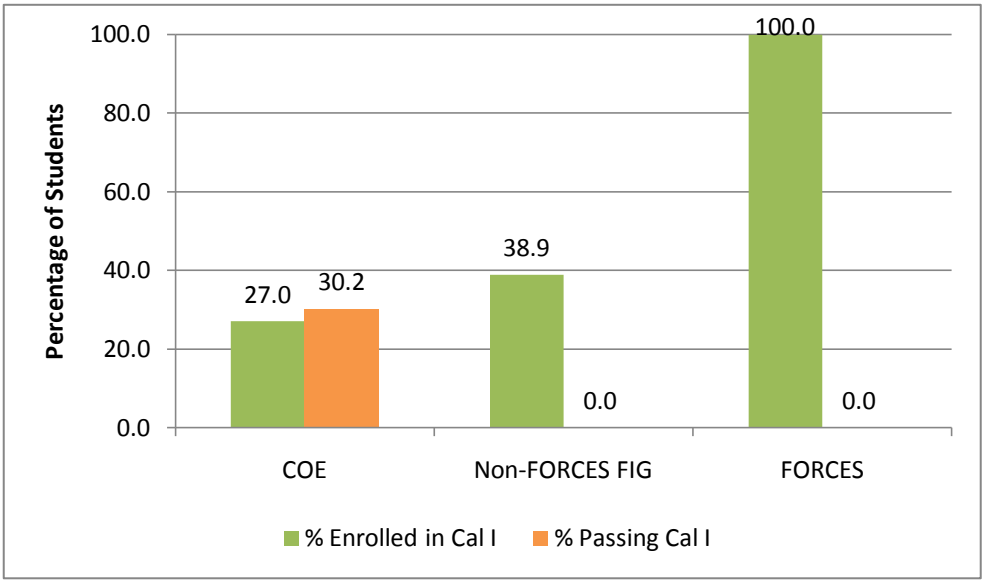
While all FORCES students enrolled in Calculus I, there were a number of students in the other two groups who enrolled in Calculus II or Calculus III. Figure 3 compares Calculus I performance of the students who were retained or not retained through the first year in each of the cohorts. Grades of C or better were deemed passing; students who earned grades of D, F or withdrew from the course were counted as not having passed the course. Although the fraction of retained students (Figure 3 (a)) in each of the groups who enrolled in Calculus I varied widely (from 37.6% for COE to 100% for FORCES), the pass rates were essentially the same for the three groups (around 55%). For students who were not retained (Figure 3(b)), there was also wide variation in the fraction enrolled in Calculus I (from 27.0% for COE to 100% for FORCES); however 30.2% of COE students who left engineering within the first year passed Calculus I, while none of the FIG students who left the program passed the course. For comparison, the pass rate for all students enrolled in Calculus I in Fall 2009 was 35.7%.

Students who enrolled in Calculus I or higher were retained through the first year at higher rates than students in Pre-Calculus or lower (see Table 2). The Non-FORCES FIGs retained the largest fraction of students overall; however, the COE cohort showed the largest difference between the retention of students enrolled in calculus versus those who were not (58.1% versus 38.6%).

Figure 3. Comparison of Calculus I Enrollment and Pass Rates



(a) Calculus I enrollment and pass rates for students retained to Fall 2010.



(b) Calculus I enrollment and pass rates for students not retained to Fall 2010.

Table 2. Retention of Calculus Students versus Students in Pre-Calculus and Lower

				≥ Cal. I		< Cal. I	
	Total Students	**Number ≥ Cal. I**	**Number < Cal. I**	**Number Retained**	**Percent Retained**	**Number Retained**	**Percent Retained**
COE	300	129	171	75	58.1%	66	38.6%
Non-FORCES	55	31	24	23	74.2%	14	58.3%
FORCES	18	18	0	9	50.0%	N/A	N/A

First year retention rates among students enrolled in Calculus I or higher were compared to those for students enrolled in Pre-calculus or lower to determine if calculus readiness improved retention. A one-tailed test was used to evaluate the following hypotheses:

- H_0 (p(RC) = p(RNC)): Calculus readiness does not improve retention (i.e. observed differences in first year retention occurred by chance)
- H_1 (p(RC) > p(RNC)): Calculus readiness improves first year retention

The probabilities are summarized in Table 3. For the COE cohort, the null hypothesis was rejected at the 95% confidence level (z=3.36); however, the null hypothesis was accepted for the Non-FORCES FIG cohort (z=1.24).

Table 3. First Year Retention Probabilities based on Calculus I Enrollment

	p(≥Cal I)	**p(RC)**	**p(<Cal I)**	**p(RNC)**	**z**
COE	0.43	0.58	0.57	0.39	3.36
Non-FORCES FIGs	0.56	0.74	0.44	0.58	1.24
FORCES	1.00	0.50	0.00	N/A	N/A

p(≥Cal I) = probability of a student being enrolled in Calculus I or higher
p(RC) = probability of students enrolled in Calculus I or higher being retained
p(<Cal I) = probability of students being enrolled in courses lower than Calculus I
p(RNC) = probability of students enrolled in courses lower than Calculus I being retained

Note that none of the FORCES students were enrolled in Pre-Calculus or lower during the first fall semester, so there were no differences to observe for that cohort. It is also noteworthy that despite the interventions implemented with the FORCES cohort beyond those that are a part of the FIG course (e.g. tutor-led group study targeting Calculus I), the first year retention was lower for this cohort compared to their counterparts who enrolled in Calculus I or higher during Fall 2009.

Conditional probabilities were calculated and evaluated using one-tailed tests at the α=0.05 significance level to determine whether or not Calculus I performance improved first year retention. The results are summarized in Table 4. In each case, the null hypothesis (earning a grade of C or better in Calculus I does not improve retention) was rejected, thus indicating that passing Calculus I does improve retention.

Table 4. First Year Retention Probabilities based on Passing Calculus I

	p(Cal I)	p(PC)	p(RPC)	p(NPC)	p(RNPC)	z
COE	0.32	0.45	0.70	0.55	0.43	2.58
Non-FORCES FIGs	0.49	0.41	1.00	0.59	0.56	2.55
FORCES	1.00	0.28	1.00	0.72	0.31	2.63

p(Cal I) = probability of a student being enrolled in Calculus I
p(PC) = probability of students being enrolled in Calculus I and passing Calculus I
p(RPC) = probability of students passing Calculus I being retained
p(NPC) = probability of students being enrolled in Calculus I and not passing Calculus I
p(RNPC) = probability of students not passing Calculus I being retained

SAT Math Scores

Table 5 compares average SAT Math scores among students who enrolled as first time freshmen in Fall 2009, and among those retained in Spring and Fall 2010. There were no statistically significant differences in the scores (at the 95% confidence level) among the cohorts or in the scores among those retained through the first year versus the original group; however with the exception of the Non-FORCES FIGs, average scores among students who were retained through the first year were higher than the baseline (Fall 2009) scores.

Table 5. Comparison of SAT Math Scores

	All	Retained	
Group	**Fall 2009**	**Spring 2010**	**Fall 2010**
COE	594	605	607
Non-FORCES FIGs	606	613	596
FORCES	574	586	596

Table 6 shows the frequency distributions of SAT Math scores for the students retained in each of the cohorts. Students lacking SAT Math scores were excluded from the analysis. A total of 55.6% of retained FORCES students had SAT Math scores between 601 and 650. This was the largest fraction of students in any score range among any of the cohorts.

The frequency distributions were analyzed for correlation with first year cumulative grade point average. SAT Math scores and grade point averages were standardized by dividing each value by the standard deviation of the data set. Table 7 summarizes the regression results for each of the groups. SAT Math scores showed strong correlation with grade point averages for the non-FORCES students, but not for the FORCES students. This may be attributable to the small sample size of the retained FORCES cohort compared to the other two. In each case, the standard errors of the estimates indicate that the regression models have merit.

Table 6. Frequency Distributions for Students Retained through the First Year

	COE			Non-FORCES FIG			FORCES		
SAT Range	No.	%	Cum. %	No.	%	Cum. %	No.	%	Cum. %
<450	1	0.7%	0.7%	2	6.1%	6.1%	0	0.0%	0.0%
450-500	14	10.4%	11.1%	2	6.1%	12.1%	2	22.2%	22.2%
501-550	21	15.6%	26.7%	6	18.2%	30.3%	0	0.0%	22.2%
551-600	29	21.5%	48.1%	6	18.2%	48.5%	1	11.1%	33.3%
601-650	30	22.2%	70.4%	11	33.3%	81.8%	5	55.6%	88.9%
651-700	24	17.8%	88.1%	4	12.1%	93.9%	1	11.1%	100.0%
701-750	14	10.4%	98.5%	2	6.1%	100.0%	0	0.0%	100.0%
751-800	2	1.5%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%
>800	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%
Total	**135**	**100.0%**		**33**	**100.0%**		**9**	**100.0%**	

Table 7. Regression Results for Retained Students

Group	Standardized Equation	r^2	S_y	$S_{y/x}$
COE	y = 0.5966x + 0.092	0.93	0.86	0.25
Non-FORCES FIGs	y = 0.4922x + 1.1733	0.95	0.60	0.17
FORCES	y = 0.3041x + 3.8196	0.36	0.72	0.37

This analysis was also performed for students who left engineering majors during the first year. COE student population data yielded a moderately positive correlation, while the other two cohorts showed a negative correlation indicating that average first year cumulative grade point averages decreased with increased SAT Math scores among students who left engineering within the first year (Table 8). The FORCES cohort showed a strong negative correlation between the two variables.

Table 8. Regression Results for Students Not Retained

Group	Equation	r^2	S_y	$S_{y/x}$
COE	y = 0.1216x + 3.5613	0.58	0.38	0.52
Non-FORCES FIGs	y = -0.2343x + 3.4659	0.46	0.38	0.32
FORCES	y = -0.6145x + 6.5079	0.87	0.85	0.35

Although not evaluated specifically in terms of retention, frequency distributions for SAT Math scores were developed for students enrolled in Calculus I during Fall 2009 (Table 9). Because of the small numbers of students involved, data for all three groups of students were combined. Students passing Calculus I had higher average Math SAT scores than students who did not pass the course. The majority of students passing Calculus I had scores in the rage of 601-700 (36.8% in the 601-650 range and 26.3% in the 651-700 range), while the majority of students not passing had scores in the 551-700 range (29.6% in the 551-600 range, 25.4% in the 601-650 range and 18.3% in the 651-700 range). Interestingly, the Math Department allows some students to enroll in Calculus I without taking the MAT if they have earned an SAT Math score of 600 or above

within the past five years. Over half of the students in our dataset who did not pass Calculus I earned a 600 or higher on the math portion of the SAT. (Engineering students are required to take the MAT).

Table 9. Frequency Distributions for Students Enrolled in Calculus I during Fall 2009

	Passing Calculus I			Not Passing Calculus I		
SAT Range	**No.**	**%**	**Cum. %**	**No.**	**%**	**Cum. %**
<450	0	0.0%	0.0%	1	1.4%	1.4%
450-500	2	3.5%	3.5%	5	7.0%	8.5%
501-550	5	8.8%	12.3%	7	9.9%	18.3%
551-600	5	8.8%	21.1%	21	29.6%	47.9%
601-650	21	36.8%	57.9%	18	25.4%	73.2%
651-700	15	26.3%	84.2%	13	18.3%	91.5%
701-750	8	14.0%	98.2%	5	7.0%	98.6%
751-800	1	1.8%	100.0%	1	1.4%	100.0%
>800	0	0.0%	100.0%	0	0.0%	100.0%
Total	**57**	**100.0%**		**71**	**100.0%**	

Conclusion

Both first semester and first year retention of students in the engineering FIGs were higher than for non-FIG participants. Students who enrolled in Calculus I or higher were retained through the first year at higher rates than students in Pre-Calculus or lower; however, results of one-tailed z-scores were mixed with regard to the impact of calculus readiness on student retention. Calculus readiness improved retention in the COE cohort, but not in the Non-FORCES FIG cohort (α=0.05). All FORCES students were calculus ready by their first fall semester of enrollment, so no comparison could be made for that group. Consistent results were obtained when evaluating the impact of calculus performance on retention. In all cohorts, earning a grade of C or better in Calculus I was shown to improve first year retention (α=0.05).

Larger fractions of FIG students were calculus-ready compared to students who did not participate in FIGs. For the Non-FORCES FIGs, this may be partially attributable to self-selection; students who opted to participate in learning communities were likely those who took a more pro-active approach to their education, and hence were more likely to be prepared for calculus. This is a hypothesis that needs further exploration. FORCES FIG students were required to be calculus ready by the first fall semester of enrollment, which was accomplished either by completing JSM or by earning an acceptable MAT score.

There were no statistically significant differences in the SAT Math scores (at the 95% confidence level) among the cohorts or in the scores among those retained through the first year versus the original group; however average scores among students who were retained through the first year were higher than the baseline (Fall 2009) scores (the Non-FORCES FIG cohorts was an exception to this. For students retained through the first year, there was a positive correlation between the two variables (although the correlation for the FORCES cohort was weak). For students who did not persist in engineering, the non-FIG student population data yielded a

moderately positive correlation between SAT Math scores and GPA, while FIG data showed a negative correlation, indicating that average first year cumulative grade point averages decreased with increased SAT Math scores. The FORCES cohort showed a strong negative correlation between the two variables.

Assessment of the FORCES program performance in many cases supported or further informed the retention and performance data analyses. Members of the cohort consistently identified the FIG component as a strength, and the data reflect that FIG participants in general were retained at higher rates and performed better than non-FIG participants. Evaluation of elements relative to calculus readiness and performance show that modifications are needed if these components are to have the intended impact. General findings and lessons learned are summarized below.

- Jump Start Math was viewed by the students as useful in terms of preparing them for the rigor of college coursework and in helping them to prepare for calculus; however, students who took JSM did not show improvements in GPA, calculus performance or retention compared to other students. Alternatives are currently being explored to remove the negative grade consequences of JSM so that students earning a C or lower in the course will not have it adversely impact their GPAs going forward.
- Most students agreed that the group study sessions were beneficial, but were mixed regarding the tutoring component. A large fraction of students (44.4%) rated the tutoring component as negative, and cited issues specifically related to the tutors as reasons for doing so. The group study and tutoring component is now being facilitated by students from the Fall 2009 FORCES cohort who performed exceptionally well in calculus at UTA and who have excellent communication and strong interpersonal skills.
- While students believed the Guaranteed 4.0 workshop helped them to improve academically, the vast majority (88.9%) stated that they were not able to implement it in calculus. Efforts are underway to identify other resources that can help to improve calculus performance.
- Apart from those described in this paper, additional efforts to improve student outcomes included weekly meetings with JSM students to monitor progress and "reality checks" during seminars and meetings to warn students in advance of the higher level of rigor, expectations and study requirements for college work versus what they experienced in high school. The students always seemed to believe that they were doing "okay" and largely could not relate to the concept of failure, as they had not yet experienced failure nor the consequences thereof.

This study was designed to begin to develop an understanding of the impact of academic support activities on student retention by evaluating the performance of students in FORCES compared to students in other engineering FIGs and the College of Engineering as a whole. Only a few factors related to student retention and performance in engineering were explored; future studies will include analyses of other factors such as student attitudes related to attrition as well as correlations between SAT Math scores, grade point averages and retention beyond the first year. A tool designed to measure both student motivation and maturity would be very useful in conjunction with performance and student attitude data in helping to identify students who are at risk for attrition.

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