Experience: An Examination of Learning Community Models on the Retention, Progression, and Academic Performance of Engineering Students at a Historically Black University

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Introduction

The foundation for learning communities was introduced into higher education over 90 years ago [1]. It is well known that they have a positive effect on measures of student academic performance including retention and graduation rates [2]. Learning communities also have been shown to facilitate both the academic and social transition to college for first-generation students [3]. These characteristics are especially important in the graduation of students underrepresented in science, technology, engineering, and mathematics (STEM) disciplines including women and African-Americans [4].

Different frameworks of learning community models have been developed and various classification types have been reported [5]. These types include linked courses, learning clusters, freshman interest groups, student-type, collaborative and coordinated studies programs. All, which can be implemented in both non-residential and residential forms [6]. In this paper, we examine four learning community (LC) models which were implemented at a large historically black university between 2000 and 2018. These models evolved from a strongly coupled student-type LC, i.e., a student-focused learning community with program activities designed to engage both students and faculty, from 2000 to 2005, to a freshman interest group (FIG) model, i.e., a student-focused designed primarily for first-year students, from 2006 to 2011, and a loosely coupled student-type, i.e. student-focused but with limited faculty engagement, LC from 2011 to 2014. The prior models were all non-residential. A residential FIG model was established in 2015 and is currently in use.

A brief introduction of the university and engineering college is followed by a description of each learning community program. For each program, we describe the various curricular and co-curricular activities which were available to student participants. We also explain the selection process utilized to recruit students into each LC program. As described below, the selection process varied among programs depending on their enrollment capacity and program objectives.

This analysis focuses only on first-time-in-college (FTC) students who were admitted into an engineering major during the summer or fall semester of each cohort year from 2000 to 2017. Summer admits must have continued enrollment into the university the following fall semester to be included in the analysis. For each program, the relative academic performance of the engineering students who participated in the LC program is compared to those engineering students who did not participate. Performance measures which are examined include the (a) mean grade point average (GPA) after the first fall semester, (b) odds ratio of being on academic warning after the first fall semester, (c) graduation rates and odds ratio for students in the first three LC programs, (d) first-year retention rates for the current LC program students, (e) mean time to graduation for students who earned an engineering degree, and (f) odds ratios of graduating with an overall GPA of 3.0 or better.

University and College Introduction

Florida A&M University (FAMU) is one of the top historically black universities in the United States, with a total enrollment of nearly 10,000 students. It has, historically, led the United States in the number of baccalaureate degrees awarded to African American students. The university has strong STEM academic programs, and offers undergraduate and graduate degree programs up through the Ph.D. in several areas of STEM including engineering and physics. Approximately 20% of the undergraduate students at the university are enrolled in a STEM academic program. Although HBCUs only represent approximately 3% of all U.S. universities, between 2006 and 2010, 10 HBCUs ranked in the top 20 in the awarding of bachelor's degrees to African-Americans [7].

The Florida A&M University (FAMU)- Florida State University (FSU) College of Engineering is a unique joint college between FAMU and FSU, a majority graduate research university that started as the Florida State College for Women. Students from each institution take their general education courses (i.e. Physics, Chemistry, Calculus, etc.) at their home campus and all engineering courses at the College of Engineering campus, which is located less than three miles from each institutions' main campus. The College offers Engineering Accreditation Commission ABET-accredited undergraduate degrees in chemical, civil, computer, electrical, industrial and mechanical engineering. This paper will focus on FAMU students from all of these degree programs.

Overview of Florida A&M University Learning Community Models

Learning community models evolved at the university from 2000 to present due to a number of factors including upper administration commitment to the concept and funding source of the program. The primary motive behind each iteration of the LC model was to increase the number of underrepresented minorities (i.e. African-Americans) in a STEM discipline. Experience and financial support also played a fundamental role in the development of each model. The first LC was funded by the National Science Foundation (NSF) through its Historically Black College and University-Undergraduate Program (HBCU-UP) from 2000 to 2005. This was followed with a second LC model again funded by the NSF HBCU-UP program from 2006 to 2011. A third LC model was employed between 2011 and 2015 as funding transitioned to the US. Department of Education Title III program activity. In 2015, the fourth evolution of LC models was introduced at the university which is presently being implemented.

2000 to 2005: FAMU-Undergraduate Program Project (FAMU-UP)

The first LC model implemented at the university was introduced in 2000 was a strongly coupled student-type LC[13]. It was funded by a new National Science Foundation (NSF) program called the Historically Black College and University-Undergraduate Program (HBCU-UP). Florida A&M University was in the second cohort of HBCU-UP recipients and was awarded a five-year grant. The FAMU program was known as the FAMU-UP and involved both students and faculty but was not primarily focused on first-year students.

Although it was formally called an "Academic Learning Center," the project had many of the programmatic qualities which classify learning communities. Specifically, the program focus was on science, technology, engineering, and mathematics (STEM) majors at the university. Curricular activities, centered on a faculty course development mini-grant program, provided faculty teaching key "gateway" and "bottleneck" STEM courses with funding to infuse the course with innovative teaching methods and learning strategies. Thirty-one STEM faculty participated in the program enhancing 29 courses. Co-curricular activities included (a) summer undergraduate research opportunity program, (b) Stratus peer-to-peer mentoring program, (c) Peer Assisted Learning (PAL) tutoring program, and (d) distinguished scholar seminar series.

All STEM majors were recruited into the project via its various programs. The most popular was the summer undergraduate research opportunity program (UROP) which involved 70 STEM students over the projects lifetime. UROP students received a stipend for their participation. Other popular programs were the PAL tutoring and Status mentoring. In these programs, upperclassmen would tutor and mentor freshman and sophomore students. Additionally, we witnessed a "giving back" philosophy in which freshman students who were recipients of these services became mentors or tutors when they became juniors and seniors. Mentors and tutors were employed by the project and paid an hourly wage.

What also made this program fit into a student-type "learning community" was it was housed within its own facility located on the main campus. This was a large modular unit which became central to all program activities. This unit contained a student computer laboratory, faculty digital media laboratory, tutoring center, conference room, and student meeting space. It was open to all STEM students and faculty. It essentially served as a "clubhouse" for STEM students on campus. It was the realization that students and faculty had organically formed a learning community which led to the next evolution of the learning community model at the university.

Student participation was voluntary as they could pick and choose which program activities they wanted to complete. The FAMU-UP also included non-engineering students from a variety of non-life science STEM fields including chemistry, mathematics, computer science, environmental science and physics. For this analysis, we have only included FTC engineering student who received a financial payment from the program. This payment could have been received for employment as a peer tutor, peer mentor, or student assistant. Or, students also received stipends for participating in the UROP program and travel assistance to attend and present at a student conference.

2006 to 2011: STEM Learning Community at FAMU Program Project

At the time, the NSF HBCU-UP program required the renewal proposals to have a different programmatic focus. Therefore, the second LC, which was also funded by the NSF, was a formal non-residential freshman interest group (FIG) model[1] called the STEM Learning Community or STEM-LC. This LC had both curricular and co-curricular elements. Curricular elements consisted primarily of clustered course schedules. Faculty development opportunities were provided to instructors teaching clustered courses. Co-curricular elements included LC town hall meetings, service-learning projects, undergraduate summer research experiences, book clubs, peer mentoring and tutoring. In addition, social events were also incorporated. All student participants were provided with the financial incentive of a book stipend to participate in the LC.

All STEM students at the university with the exception of life science majors were recruited into the program as first-time-in-college students. The only other eligibility requirement was that a student must be enrolled in a College Algebra or higher course during their first semester at the university. Over the life of the project, over 250 students formally registered in the LC with 65% majoring in engineering.

Students had to “sign-up” to participate in the STEMLC and commit to complete a specific number of activities. All students who met the eligibility requirements were accepted. As described above, for this analysis, we only include FTC engineering students who were formally accepted into the program.

2011 to 2014: Engineering Learning Community

Major changes occurred during the third evolution of the learning community in 2011. First, the second NSF project was winding down, so funding was provided by the university at reduced levels to support the third iteration of the LC program. During the 2011-12 academic year, both programs operated simultaneously with the ELC limited to engineering students only providing a loosely coupled student-type LC model[13]. The ELC was also relocated to a much smaller space approximately one-quarter mile from its original location. These two conditions led to the decision to just focus on engineering students as program participants. We classified this LC model as loosely coupled student type because all of the program activities were co-curricular only. That is, there was essentially no faculty engagement outside of program administrators. The new location did house a small computer laboratory and offered mentoring and tutoring services. But, there were no financial incentives given to student participants.

The third evolution of the LC was open to all engineering students without additional restrictions. Freshman students were especially targeted during the fall semester. Unfortunately, the lack of financial incentives and change in location dramatically impacted student participation.

Additionally, in this cohort, we are considering students that participated in the Engineering Concepts Institute (ECI) summer bridge program, which has been around for over 30 years. The ECI scholars were required to spend 3-5 hours a week in the ELC computer laboratory in the fall and spring semesters. The summer program prepares students for the successful completion of their first year as an engineering student. During the summer, ECI scholars are provided with an upperclassman peer mentor, learning skills and tools necessary to become effective and efficient engineering students. The students take both math and science preparatory classes during the six-week period.

A variation of the program in 2014 required the students to be FAMU summer admitted students and participate in courses toward graduation. In this paper, we will only include FTC engineering students who participated in the ECI summer program as ELC participants.

2015 to Present: Engineering Living-Learning Community

A new university president prompted the fourth and current evolution of learning communities at the university. She had been hired from an institution which had success with living-learning communities. Concurrently, the university was building a new residence hall. With the enthusiastic support of the new president, a number of campus wide living-learning community was formed. Initially, a STEM Living Learning Community (LLC) was formed with engineering students consisting of a separate subset producing a residential FIG LC model[6]. However, after two years, an independent Engineering Living Learning Community (LLC) was established.

The Engineering LLC, housed in FAMU Village, seeks to facilitate engagement with fellow students and faculty in order to foster a sense of community. Students live on the same floor in the same residential hall and are registered in the same math courses. They attend meetings that cover a range of topics and have guests from industry and engineering departments. Additionally, there are mandatory study hours that have to be completed each week. Students can utilize any of the tutoring labs on campus, peer-assisted study sessions (PASS) or for the convenience of the Engineering LLC students there are learning-assistants staffed in the community room on their floor of the residential hall.

The students are recruited from first-time-in-college freshman through an application process. Students are offered the opportunity to participate in the LLC when they sign up for housing at FAMU. There are between 20 - 45 students selected each year based on available residential bed space and applicant pool. An effort is made to ensure that a variety of student profiles are selected. In other words, it is not just the top academic students that are selected. Students in the Engineering LLC first math course range from College Algebra to Calculus II.

Findings

This analysis examines the persistence and academic performance of first-time-in-college (FTC) engineering students who participated in one of the Learning Community (LC) programs compared to a group of non-LC engineering students from the same admissions cohort. An examination of the relative performance in several metrics between the LC engineering students and their non-LC counterparts is compared. To increase the sample size for each comparison, each LC program is analyzed as a single cohort of students.

Performance metrics include first fall semester mean GPA, and for students graduating with an engineering degree: mean overall GPA at graduation and mean time to degree. The relative odds of being placed on Academic Warning after a student's first fall semester is also estimated. For students earning a degree, odds ratios are found for earning a degree in any major and a degree in engineering.

The RStudio integrated development environment was used to perform the statistical analysis [8]. All statistical tests were conducted with an alpha=0.05. A standard t-test is used to compare means. For the odds ratio estimate, the Fisher's Exact Test for Count Data from the R-"stats" package is used[8]. The cohen.d function from the EffSize package estimates the effect size for all t-tests[9]. This is a measure of the strength of the difference between means and we use $d \leq 0.2$ for a small (S) effect, $0.2 < d \leq 0.8$ is considered a medium (M) effect, and $d > 0.8$ is a large effect [9]. The statistical power is also estimated using the "pwr" package in R using default values for all non-required parameters [10].

A comparison of means is considered "significant" if the p-value < 0.05, effect size is estimated at Medium, and the statistical power is greater than 0.7 For the odds ratio estimate, the results are "significant" if the estimated confidence interval does not include the value '1' and the statistical power is greater than 0.7. For both tests, these results are indicated with an asterisk, i.e., *, in the tables below.

LC Program Student Statistics

The number of students by cohort years and LC program are given in Table 1. Additionally, the table provides the high school profile of the average student in each cohort LC model. All first FTC students who declared an engineering major during the summer or fall semester of each cohort year have been included in the analysis. The engineering totals do not include students who participated in the LC Program. Although, we are not examining gender differences in this analysis. This data is provided on the table as background information. With respect to race/ethnicity data, historically, the African-American population in engineering at the university has averaged 90% or higher over these years. It should be noted that the FAMU-UP program had a higher percentage of female students and the most competitive high school GPA and test scores of any LC model.

Table 1: Total number of students by Cohort Years and Comparison groups

Comparison Group		Engineering		LC Programs				
Cohort Years	LC Program Name	# of Students	% Females	# of Students	% Females	Average HS GPA	Average ACT Math	Average SAT Math
2000-2005	FAMU-UP	599	25%	42	52%	3.76	24	608
2006-2011	STEM-LC	615	21%	165	24%	3.28	23	556
2011-2014	ECI/ELC	371	20%	69	27%	3.37	22	527
2015-2017	LLC	293	28%	93	30%	3.39	22	555

Academic Performance Measures

a) First Fall Semester Mean GPA

The first fall semester mean GPA for each group is given in Table II. The LC program Mean GPA column gives the mean fall semester GPA for engineering students who participated in the LC Program indicated by the row name. The non-LC mean GPA column provides this same information except for non-LC program engineering students. For example, the FTC engineering students who participated in the STEMLC had a mean GPA of 2.66 compared to a mean GPA of 2.16 for those FTC engineering students who entered the university from 2006-2011 and did not participate in the STEMLC. A similar interpretation should be used for all of the remaining tables in this section.

As Table II shows, LC program participants regardless of model performed better than their engineering peers across all LC program types. This is consistent with similar results reported in the literature [13]. This metric is an early indicator of how well a student is making the transition from high school to a university environment. The LC programs help reinforce the desired characteristics of an "ideal" engineering student through the activities they offer to participants. Please note that the LC model with the highest first semester GPA is FAMU-UP, which also has the highest high school GPA profile and test scores. The STEM-LC and Engineering LLC, which had similar student profiles has 0.5 higher first semester GPA than engineering students that did not participate in an LC program.

Table II: Fall Semester Mean GPA

LC Program	LC Program Mean GPA	Non-LC Mean GPA
FAMU-UP	3.43*	2.48
STEMLC	2.66*	2.16
ELC/ELC	2.73*	2.36
LLC	3.01*	2.55

* indicates $p<0.05$, cohen.d >0.2, and stat power >0.7

b) First Fall Semester Academic Warning Odds Ratio

Another measure to determine how well an FTC student has made the transition to a university academic program is whether or not they received an "Academic Warning" after their first fall term. Students are placed on warning if their overall grade point average (GPA) is below 2.0. Students must raise their GPA above 2.0 by the end of their next semester or risk being placed on academic probation. Table III shows the percentage of students and the odds ratio of being placed on academic warning after the first fall semester between the various groups. In this case, an Odds Ratio less than 1 is "better" for LC participants since it implies that the LC program student would be less likely to be placed on Academic Warning than the student's non-LC program counterpart.

As seen in the table, all LC program students were less likely to be placed on Academic Warning after their first fall semester except the ECI/ELC students. These students were just as likely to be placed on Academic Warning as non-ECI/ELC students. As described above, this program model was employed during the three-year transition from the STEMLC to the current Engineering LLC. It had the least number of program activities and opportunities for students to make connections with peers or engineering faculty and staff.

Table III: Academic Warning Percentage and Odds Ratio

LC Program	LC Program Academic Warning %	Non-LC Academic Warning %	Odds Ratio
FAMU-UP	0%*	24%	0.00
STEMLC	17%*	36%	0.37
ECI/ELC	23%	26%	1.29
LLC	7%*	23%	0.23

* indicates confidence interval does not include 1 and stat power >0.7

B. Retention and Graduation Measures

a) Graduation Rates and Odds Ratio

Table IVa and IVb shows graduation rates and odds ratios for students in the FAMU-UP, STEMLC, and ECI/ELC programs and their equivalent non-LC program engineering peers. Table IVa shows these metrics for students who graduated in any degree major while

Table IVb presents this information for students graduating with an engineering degree. Participants in both the FAMU-UP and STEMLC programs were more likely to graduate and more likely to graduate with an engineering degree compared to non-LC program students. The lower graduation rates for the ECI/ELC group are partly due to some students in that group not yet to reaching the mean number of semesters to graduation as described below.

With respect to graduating with an engineering degree, students in all three LC programs performed better than their non-LC peers. These results are again consistent with some published results [11].

Table IVa: Graduation Rates and Odds Ratio of students who graduated in any major.

LC Program	LC Program # of Grads	LC Program Graduation Rate (Any Degree)	Non-LC # of Grads	Non-LC Graduation Rate (Any Degree)	Odds Ratio
FAMU-UP	35*	83%	286	48%	5.45
STEMLC	81*	49%	229	37%	1.62
ECI/ELC	22	32%	96	26%	1.34

Table IVb: Graduation Odds Ratio of students who graduated with an engineering degree.

LC Program	# of LC Program Graduates (Engineering Degree)	# of non-LC Program Graduates (Engineering Degree)	Odds Ratio
FAMU-UP	34*	145	13.2
STEMLC	43*	63	3.08
ECI/ELC	15*	35	2.66

* indicates confidence interval does not include 1 and stat power >0.7

The mean number of semesters to an engineering degree for STEMLC participants (12.6 semesters) was significantly better than non-STEMLC students (14.1 semesters), where one year is equivalent to three (3) semesters. There were no significant differences in this mean between FAMU-UP/ELC and non-FAMU-UP/ELC students.

b) Engineering LLC Retention Rates

Since the first class of Engineering LLC have yet to reach the 4-year graduation milestone, we compare their year-to-year retention rate to measure the relative effectiveness of retaining students at the university and within an engineering major. Table V compares the first-year, second-year and third-year retention rates to non-LLC engineering students retained in engineering. The rate is considered "significant" based on the definition provided above.

Table V: 1st, 2nd, and 3rd year Retention Rates for Engineering LLC and non-LLC engineering students

	Retention in Engineering Major			
Cohort Type	N	Year 1	Year 2	Year 3
LLC Engineering	94	91%	58%	50%
Non-LLC Engineering	293	60%	40%	25%

c) Graduating with an Overall GPA of 3.0 or better.

Table VI gives the percentage of students and odds ratio of graduating with an overall GPA of 3.0 or better. This achievement has important implications of the quality of student produced with respect to graduate school opportunities and engineering job placement. The analysis suggests that only the FAMU-UP program participants performed significantly better than their non-LC peers in this measure

Table VI: % of students with an Engineering Degree and overall GPA ≥ 3.0 at Graduation

LC Program	LC Program GPA ≥ 3.0 Percentage	Non-LC GPA ≥ 3.0 Percentage	Odds Ratio
FAMU-UP	79%*	48%	4.1
STEMLC	51%	27%	2.8
ECI/ELC	66%	34%	3.7

* indicates confidence interval does not include 1 and stat power >0.7

Summary

We have provided a top-level overview of the relative performance of engineering students at a historically black university who have participated in several learning community models over an almost 20-year time span. These models have evolved over time from its initial implementation to the current living-learning model which has become well integrated into the culture of the university. The reason for each change either resulted from either funding or administrator support changes. The student profile and level of support was provided in this paper to provide other universities the ability to choose a LC model that fits their own student profile, funding sources, building space and administrator support.

Table VII provides a summary of the common features of the various LC programs. It should be noted that no one LC feature played a role in the respective success, but a conglomerate of features in each model. The LC models had several common features including tutoring, meetings and physical community space. Conversely, there are several important differences such as paid participation, faculty development of courses, and a residential requirement. A summary chart of the program features is provided below. The aspects of the LC models that played a more significant role in the models student participation are the aspects of the peer mentors; determining the “right” location of the community space; and the program participation incentives.

It is clear from the fall semester measures of mean GPA, academic warning odds ratio, and retention rates that each LC model gave FTC engineering students an academic "head-start" compare to their peers. This result should help justify their continued university support for future engineering students. However, it is not clear if LC programs devoted to only first-year students are sufficient to bring them all the way to degree completion. While LC students in both the STEMLC and ECI/ELC programs did outperform their non-LC peers in most graduation measures, it was in the multi-year FAMU-UP program in which FTC engineering students with the highest high school profile appeared to show the best overall performance.

As a result, we have implemented a second-year program for current LLC students and are developing a multi-year strategy which will provide engineering students with a series of well-defined programs from their first-year to graduation. These activities will utilize the most successful program features we have identified from our experience in managing learning communities including access to a community space, peer academic and social collaborations, financial incentives, and faculty involvement.

Table VII: Common Features of the LC Programs

LC Program	Tutoring	Peer Mentors	Meetings/ Seminars	Social Events	Undergrad Research	Paid Participation	Residential	Community Space	Faculty Development
FAMU-UP	✓	✓	✓		✓	✓		✓	✓
STEMLC	✓	✓	✓	✓	✓	✓		✓	✓
ECI/ELC	✓	✓	✓					✓	
LLC	✓		✓	✓			✓	✓	

✓ = This feature is included in the LC program.

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