



Living, Learning, and Staying: The Impact of a Women in Engineering Living and Learning Community

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Abstract

A number of studies highlight living and learning communities (LLCs) as a factor contributing to student persistence, particularly in STEM programs.¹⁻³ For several years, the University of Maryland – College Park has housed Flexus: The Dr. Marilyn Berman Pollans Women in Engineering Living and Learning Community. This LLC is solely for first and second year women, who are in vital years of their student development. Flexus provides a space for these women to feel supported, explore different options within engineering, and gain skills that are not taught to the general population. Additionally, every participant in Flexus is required to take a one-credit course each semester and complete a minimum of four service hours.

This paper explores how Flexus has helped improve the experiences of women in engineering majors. In 2013, researchers from the Project to Assess Climate in Engineering (PACE), which is funded by the Alfred P. Sloan Foundation, conducted focus groups with Flexus and non-Flexus engineering students. Researchers combined program evaluation data gathered by the institution with the focus group data collected by the PACE team to illuminate best practices for building inclusive environments for and retaining women pursuing engineering majors.

Findings indicate that providing women with the opportunity to live together within one residence hall and take classes together as part of the Flexus LLC has three main effects. It creates a strong sense of community, provides confidence-boosting professional development, and ultimately helps students stay in engineering. Flexus participants are retained at significantly higher rates compared to non-participants ($p \leq 0.05$). The LLC best practices that have resulted in positive outcomes are discussed as well as lessons learned from program implementation. The size of college campuses can overwhelm students academically and socially, which can affect retention. By creating a small female-only engineering community, these large campuses can begin to feel more like home. Together the women learn to study, socialize, and rely on each other, and Flexus women remain within the School of Engineering at higher rates than their peers.

Introduction

According to 2011 US Census data, 13 percent of engineers were women (www.census.gov). In contrast, 57% of all bachelor's degrees were conferred to women in 2010.⁴ Although women are graduating in higher numbers than their male counterparts, they are still underrepresented in engineering. To meet the ever-increasing demand for engineers, it is imperative that institutions encourage women to major in engineering and graduate with an engineering degree.

There are myriad reasons why women leave engineering such as lack of role models, confidence issues, and the “chilly climate.”⁵ In order to counteract these obstacles and improve retention, institutions should provide opportunities for students to frequently interact with other students, staff, and faculty.⁶ One way to create the desired environment is through building living and learning communities. The purpose of living and learning communities is to create a smaller community within a larger one so that an overwhelmingly large campus becomes more

comfortable.⁷ As students live and study together in a LLC, they are more likely to find their unique niche in a large university.

Living and learning communities are becoming more popular⁸ as an engineering intervention to provide students with a built-in network of other engineering students. These communities, when specifically designed for women in engineering, have the opportunity to provide support for female students in ways that no other intervention can. This is why it is so important to understand 1) whether these communities are working, and to what extent, and 2) which LLC program characteristics have resulted in positive outcomes.

Flexus

At the University of Maryland (Maryland), in the A. James Clark School of Engineering, 22% of the undergraduate student population is female.⁹ In 2007 Maryland along with the generosity of Dr. Marilyn Berman Pollans, took steps to improve the retention of female engineering students by creating Flexus: The Dr. Marilyn Berman Pollans Women in Engineering Living and Learning Community. Flexus is a community designed for first and second year female undergraduate engineering students. The primary goal is to increase these students' retention. Based on the Clark School's retention data, students retained through their junior year are very likely to graduate.¹⁰ A major tenet of Flexus is to provide encouragement and academic support to women during the pivotal early years in engineering. As students are admitted to the School of Engineering, each female is invited to apply to Flexus.

Women involved with Flexus are required to live together in the same residence hall in their first year. Students are encouraged to stay in the same residence hall for the second year, but are not required to do so. It is during their first year that the women are able to forge relationships with each other and form study groups. In addition to study groups, an added benefit to Flexus is the opportunity to take several of their math, science and engineering courses together in a cluster. Taking courses together strengthens community bonds while simultaneously improving retention. Maryland also offers members of Flexus a lounge for additional support and to hold community events. The Flexus lounge is staffed every day with at least one LLC coordinator and/or instructor for students' needs. Students who may require additional support can utilize student tutors, who are often former and more experienced Flexus students. All Flexus students are required to take a one-credit seminar for their first four semesters. This seminar provides the women with an opportunity to:

- Meet mentors and role models from diverse backgrounds within engineering,
- Receive professional and personal development opportunities, which address the unique needs of women in a male-dominated discipline,
- Connect with each other in a safe space,
- Reinforce important technical skills needed to succeed in engineering,
- Develop leadership skills, and
- Participate in an engineering based service-learning project.

While Flexus students have a fairly structured academic experience, they have total autonomy with their social activities. A student-elected executive board plans monthly community-building events. The events range from study breaks to tailgates. Recently, an effort has been made by the executive board to formalize a mentoring relationship between the first and second year students.

The participation of Maryland in the Project to Assess Climate in Engineering (PACE) offers a unique opportunity to combine quantitative and qualitative data to understand the effectiveness of a LLC intervention. Taking a mixed methods approach, this paper delves into the kinds of impacts Flexus has had on students in terms of community, professional development, and persistence. The combination of qualitative research data and quantitative evaluation data provide an unprecedented opportunity to understand what the impacts of the LLC have been, while also examining why and how students feel the different program components have been effective. The LLC best practices for building inclusive environments and retaining women pursuing engineering majors are discussed.

Theoretical Framework

Tinto developed a theory of departure from higher education institutions using the concept of integration as a basis for understanding the phenomenon.^{11, 12} This theoretical model provides an excellent lens for understanding the impacts of a women's engineering LLC. Tinto contends that most departures are voluntary and reflect the degree to which an individual's experiences serve to integrate him/her into the social and intellectual life of the institution.^{12, 13} While academic integration is the extent to which a student exhibits a commitment to and engagement in academic activities, social integration refers to the extent to which a student engages in social activities.^{13, 14} Generally speaking, the more satisfying a student finds his/her social and academic experiences, the more likely he/she is to integrate into both social and academic aspects of campus life and persist to degree completion.¹² When an absence of integration exists, this is likely due to incongruence (lack of institutional fit) and/or isolation. Incongruence and isolation may result in students who lack a desire to integrate, have less institutional commitment, and ultimately decide to leave college.¹²

Research on living and learning communities suggests that academic and social integration are key benefits derived from participation in these communities. For example, students in living and learning communities report the following as the most important results from their LLC experiences:

- Experiencing a smooth academic transition to college;
- Feeling a sense of belonging to the institution;
- Demonstrating openness to views different than one's own;
- Learning about others different than one's self;
- Experiencing a smooth social transition to college.¹⁵

Similarly, Tinto writes that as students become active learners, they also become more socially engaged.¹⁶ In order for a living and learning community to be successful, it must promote the full academic and social integration of its students to improve their persistence.

Literature Review

The National Study of Living and Learning Programs has found that one of the best ways to analyze the impact of living and learning communities is to review Astin's inputs-environments-outcomes conceptual model.¹⁷ Essentially, Astin's model states that in order to effectively

observe how a college environment influences student retention (outcome), student inputs must be controlled for and reviewed along with the environment.¹⁸ In the context of living and learning communities, inputs would include student characteristics, such as socioeconomic status and pre-college academic preparedness; the climate in the major and/or in a residence hall could be a measure of environments; examples of outcomes could include GPA and retention.

With regard to student characteristics (inputs), students who choose to participate in living and learning communities report higher average GPAs and SAT/ACT scores, and are more likely to enter college with advanced placement credits than their peers.⁷ During their living and learning experience, students are more engaged in social activities and interact with faculty outside of the classroom.⁶ These interactions lead to higher persistence, more self-confidence, and improved academic performance.¹⁹ Participation also positions students well for early-warning systems, which help staff identify first-year students who may be struggling in their courses. For example, students who receive poor early warning grades, which are reported shortly after mid-semester, can be called in for academic advising and support.¹⁷

The environment of LLCs is designed to result in certain outcomes. Housing students of similar interests together fosters an environment that has both intended and unintended consequences. As mentioned earlier, an intended consequence of LLCs is a sense of community among students of similar interests.¹⁷ Students begin college with similarities such as age, gender, major, and academic abilities. Through a LLC community, students are able to encourage one another during difficult classes and help each other gain a deeper understanding of classroom concepts.²⁰ This type of peer-to-peer interaction provides assistance with students' academic and social integration. Unfortunately, an unintended consequence can be the formation of cliques, or smaller communities within the already small community.

The environment of certain LLCs also encourages other types of non-peer interaction. Faculty and staff members can be involved in activities for a LLC, thereby increasing students' comfort level interacting with them. Research has shown that interactions between students and faculty in living and learning programs are catalysts for increased persistence.^{6, 21} In fact, despite any unintended consequences of LLCs, students who participate in these communities have better retention rates than students who do not belong to such communities.⁷

This study distinguishes itself from other research by delving specifically into the impacts of a women's only LLC in engineering. Examining the effectiveness of such an LLC using both quantitative and qualitative analysis helps unpack the particulars of what contributes to the program's effectiveness. Using Tinto's integration theory as a lens for understanding the impacts of the LLC helps create clear connections between programmatic components and students' integration into campus life, which has been demonstrated as a strong contributor to student persistence.

Data and Methodology

All female students admitted to the A. James Clark School of Engineering are invited to apply to participate in Flexus. While Flexus began in fall 2007, Institutional Review Board approval was secured for research with this group starting with the Fall 2010 cohort as part of a larger National

Science Foundation funded Science, Technology, Engineering and Mathematics Talent Expansion Program (DUE 0969232). Thus, all analyses reported in this paper are for the 2010 cohort forward.

This paper combines data from the internal program evaluation with data from focus groups conducted by an external research study called PACE. The PACE Team and the University of Maryland collaborated to create this research paper. These data sources and methodologies are explained below.

Program Evaluation

From fall 2010 to spring 2013 there have been 142 Flexus students and 319 female students who did not participate in Flexus. Institutional data were used to identify the entering academic preparation for the Flexus students and the non-Flexus students for each cohort from 2010 to 2012. Entry characteristics (Math SAT, Overall SAT, and high school GPA), retention rates, GPA, and total credits applicable for degree have been captured for each cohort of students. Mean scores on items related to academic preparation (i.e., high school GPA, SAT, SAT Math, and SAT Verbal) and academic performance while enrolled (i.e., total credits earned, first semester GPA, second semester GPA, cumulative GPA) were calculated for each group overall, and for each group within each cohort. Independent t-tests comparing Flexus and non-Flexus students on each variable of interest were conducted for the aggregated data as well as the data disaggregated by cohort year.

Using this institutional data, the Flexus and non-Flexus students were compared using a chi-square analysis to determine whether there were significant differences in retention status. This same retention analysis was used for each cohort year (i.e., 2010, 2011, and 2012) to determine whether there were significant group differences within each cohort. The primary categories of interest for the retention analysis were whether students were retained within engineering or were no longer in engineering. In other words, if students had left the university or were currently enrolled at the university in a non-engineering major, they were coded as non-engineering. If students continued within engineering they were coded as such.

In addition, Flexus participants complete questionnaires at the end of each semester with a combination of multiple choice with likert-type scales and free response items. The first and second semester questionnaires ask questions about the immediate impacts of Flexus participation, such as meeting new people, as well as more medium term impacts, such as degree of interest in engineering and certainty and comfort in majoring in engineering. Not all students responded to all the surveys. The response rates for each of the IRB approved surveys was: Fall 2011: 88%, Spring 2012: 78%, Fall 2012: 73%, and Spring 2013: 27%. The lower response rate in Spring 2013 may be due to a change in the personnel who disseminated the questionnaire at the end of that semester.

PACE Focus Groups

The qualitative component of this study is part of a larger mixed methods research project funded by the Alfred P. Sloan Foundation, known as PACE. The PACE study was designed to provide timely feedback to participating schools, such as University of Maryland through customized reports. Quantitative reports summarized 2008 and 2012 quantitative survey data by

question (disaggregated by gender and race), and included comparisons on each question with three anonymous benchmark schools, recommendations for improvement, and raw survey data. Schools also received reports on the 2008 qualitative interview findings. Based on the research results and recommendations in the school report, Maryland created an Action Framework identifying Flexus as an intervention on which to focus to improve their climate.

In spring 2013, PACE conducted focus groups with Maryland engineering students to delve into their attitudes and feelings about the program and provide insights into the “why and how” of program impacts. Focus groups allowed researchers and participants to engage in *conversations with purpose* in order to gain an understanding of engineering student experiences in their own words.²² A semi-structured approach to facilitation fostered and encouraged interactions among participants that explored their feelings and deepened the quality of the output.^{23, 24} Participant responses functioned as cues that sparked ideas and connections from other participants, unlocking and contributing a broader range of perspectives.²⁵

A total of 28 Flexus and non-Flexus women students participated in seven focus groups, which were conducted and audio-recorded at Maryland by a trained PACE team member. Recordings were transcribed for analysis. Focus groups were comprised of students 18 years of age or older, who were invited to participate based on a stratified random sample of currently enrolled engineering majors. For the purposes of this study, four of the seven focus groups were analyzed. Because this paper explores how Flexus has helped improve the experiences of women in engineering majors, analysis focused on the four groups that included current and former Flexus participants. These women ranged in age from 18-30 years old and represented various engineering majors.

Data was analyzed using NVivo 10 qualitative data analysis software and incorporated a focused coding method.²⁶ Questions focused on intervention impacts provided a lens for code generation, as well as for the notation of themes.²⁶ This led to organizing and grouping data by theme and relationship to other data, moving from general to specific themes and vice versa, to understand the phenomenon being studied.²⁷ Throughout the process, patterns, themes, and regularities were identified, along with contrasts, paradoxes, and irregularities. Analytic memo writing was used during the analytic process to help interrogate, systematically explore, and make sense of the data.²⁷

Results

This section describes selected results from the program evaluation and focus groups. The program evaluation results focus on differences in student characteristics and retention, as well as quantitative analysis of Flexus participant experiences. The focus group results describe student perspectives on the impacts of the program, especially around sense of community, professional development, and persistence.

Program Evaluation

Student data for the most recent cohorts (Fall 2010, Fall 2011, and Fall 2012), were combined to compare students’ entering characteristics and retention. There was only one statistically significant difference between Flexus and non-Flexus students. As shown in Table 1, Flexus

participants are retained at significantly higher rates compared to non-participants ($p \leq 0.05$). The participants were similar to non-participants on other entering characteristics (Math SAT, SAT, and high school GPA), and current academic achievement in terms of cumulative GPA and total credits taken (Table 1).

Table 1. Entering characteristics and retention of Fall 2010-2012 cohorts^a

	N	Math SAT	SAT	HS GPA	Retained through Fall 2013	Cum GPA	Total Credits
Flexus	142	695 (53.68)	1359 (99.55)	4.23 (0.39)	91%*	3.32 (0.48)	74 (30.73)
Non-Flexus	319	705 (54.12)	1372 (99.38)	4.26 (0.36)	81%	3.31 (0.49)	79 (29.08)

^a Means reported with standard deviations in parentheses

* $p \leq 0.05$

To examine the impact of time on the retention rates, the cohorts were analyzed separately, and one year, two year, and three year retention rates were examined for Flexus participants and non-participants for each cohort. Table 2 contains a summary of the percentage of Flexus and non-Flexus women retained in engineering after one, two, and three years for each cohort. There is a significant difference in retention rates for the 2010 cohort after two and three years. After three years, Flexus participants were retained in engineering at a rate of 94% compared to 78% for non-Flexus participants ($p \leq 0.05$). For the other cohorts (2011 and 2012), students participating in Flexus are retained at higher rates, but chi-square analyses find no statistically significant differences, likely due to the small sample sizes and the fact that not enough time has passed (Table 2).

Table 2. Retention of Fall 2010-2012 cohorts

		N	Retained After		
			1 year	2 years	3 years
2010 Cohort	Flexus	46	98%	96%	94%
	Non-Flexus	103	92%	82%**	78%*
2011 Cohort	Flexus	34	94%	82%	
	Non-Flexus	120	92%	77%	
2012 Cohort	Flexus	62	94%		
	Non-Flexus	97	87%		

** $p \leq 0.02$

* $p \leq 0.05$

In addition to student retention data, students were asked to complete end of semester evaluation questionnaires to assess their perspectives on the program. Selected results of the first and second semester questionnaires are shown in Tables 3 and 4.

At the end of the first semester of participation in Flexus, 76% of participants rated their experience as good or excellent while 18% rated it as average. By the end of the second semester,

the results were even stronger: 92% rated their experience as good or excellent while 8% rated it as average (Results not tabled).

Results on the first semester student questionnaire indicate that on average, 90% of students strongly agree or agree that they met other engineers through Flexus, were well-informed about engineering because of Flexus (87%), and felt connected to other students in the Flexus community (73%) (Table 3). In addition, approximately 80% of students indicated that living with other students in the residence halls has been positive or very positive (Table 3). Since beginning the program, about 47% of students felt slightly more comfortable in their decision to major in engineering, and about 52% indicated that their interest in engineering slightly increased since beginning the program. Refer to Table 3 for a breakdown of student questionnaire responses after one semester in Flexus.

Table 3. First semester student questionnaire responses^a

Question	N	Response Categories				
		1	2	3	4	5
By joining Flexus, I met other engineers. ^b	72	0%	1%	9%	19%	71%
I am well informed about engineering. ^b	30	0%	0%	13%	57%	30%
I am well informed about the Clark School. ^b	72	0%	3%	15%	60%	23%
I feel well connected to the other students in the community. ^b	30	10%	3%	13%	23%	50%
Compared to your interest in engineering at the beginning of the semester (program), how would you rate your present level of interest? ^c	72	0%	4%	45%	49%	3%
Compared to the beginning of the semester, how comfortable do you feel in your decision to major in engineering? ^c	72	1%	9%	42%	38%	9%
How does your understanding of the social relevance of engineering compare to the beginning of the program? ^c	30	0%	0%	47%	47%	7%
How has living with other students in the community in Easton Hall affected you? (Skip if you did not live in Easton Hall). ^c	24	0%	4%	17%	17%	63%

^aPercentages may not add to 100% due to rounding

^bThe scale was 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree

^cThe scale was 1=much lower, 2=lower, 3=about the same, 4=higher, 5=much higher

^dThe scale was 1=very negative, 2=negative, 3=not much, 4=positive, 5=very positive

Results on the second semester student questionnaire indicate that students felt even more positively about their experiences as a result of Flexus participation than they did after just one semester. On average, 87% of students strongly agree or agree that they felt connected to other students in the Flexus community (73% after first semester) (Table 4). In addition, 100% of students indicated that living with other students in the residence halls has been positive or very positive (80% after first semester) (Table 4). Since beginning the program, about 59% of students felt slightly more comfortable in their decision to major in engineering, and about 62% indicated that their interest in engineering slightly increased since beginning the program (Table 4). Finally, there was a very large increase in the percentage of students who indicated that their understanding of the social relevance of engineering was higher or much higher compared to the

beginning of the program (75% after second semester compared to 54% after first semester) (Table 4).

Table 4. Second semester student questionnaire responses^a

Question	N	Response Categories				
		1	2	3	4	5
I have a strong understanding of the field of engineering. ^b	39	0%	0%	13%	44%	44%
I am well informed about the Clark School. ^b	25	0%	0%	4%	40%	56%
I feel well connected to the other students in the community. ^b	39	0%	5%	8%	41%	46%
Compared to your interest in engineering at the beginning of the semester, how would you rate your present level of interest? ^c	39	0%	0%	39%	54%	8%
Compared to the beginning of the semester, how comfortable do you feel in your decision to major in engineering? ^c	39	0%	3%	39%	49%	10%
How does your understanding of the social relevance of engineering compare to the beginning of the program? ^c	39	0%	0%	26%	54%	21%
How has living with other students in the community in Easton Hall affected you? (Skip if you did not live in Easton Hall). ^c	19	0%	0%	0%	21%	79%

^aPercentages may not add to 100% due to rounding

^bThe scale was 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree

^cThe scale was 1=much lower, 2=lower, 3=about the same, 4=higher, 5=much higher

^dThe scale was 1=very negative, 2=negative, 3=not much, 4=positive, 5=very positive

On the questionnaire each semester, students were asked to comment on the greatest strength of the Flexus community. The majority of these comments (an average of 64% of questionnaire respondents in fall 2011, spring 2012, fall 2012, and spring 2013) were related to the sense of community that is created among the participants. Exemplars include:

- *Living with people in the same classes has been beyond beneficial.* -Fall 2011
- *That almost everyone lives together and is able to build strong friendships with people who have similar goals.* -Fall 2011
- *The camaraderie on our floor.* -Fall 2011
- *Giving us information that would be harder to access if we were not in it and creating a sense of community with other engineers.* -Spring 2012

Similarly, when asked what their favorite part of Flexus is, the majority of the comments (64% to 84% of questionnaire respondents in fall 2011, spring 2012, fall 2012, and spring 2013) were also related to the community and living with others taking the same courses.

- *I loved living with fellow engineering students and clustering the classes.* -Fall 2011
- *The community among students and the stress on professionalism* -Fall 2011

- *Community of women engineers, bonding activities, and tutoring/mentorship both in class (by professors) and out (by Flexus second year students and SEEDS Mentor). - Spring 2012*
- *[G]ain a network of friends in engineering. -Fall 2012*

Students were asked about the influence their participation in Flexus had on their thinking about engineering. The majority of responses (71% of Fall 2011 and 59% of Fall 2012) indicated that their participation had a positive influence. For example, one student said: *“It made me more confident in my choice to study engineering because I know I have such a strong support system behind me”* (Fall 2011). One student even said that without Flexus, she probably would have dropped out of engineering. This might be because *“Flexus helped me see the bigger picture in engineering, which can be hard with all of the details and hardships of the course load”* (Fall 2012). Eight students indicated that they had a strong interest in engineering to begin with and that interest had not changed because of their participation in Flexus.

In the end of semester questionnaire, students are asked if they would recommend Flexus participation to new female engineering students. After just one semester of participation, 93% of the 2011 cohort indicated they would recommend participation in Flexus to new incoming first year engineering students. By the end of the first year (after two semesters), 100% of the 2011 cohort indicated they would recommend Flexus to new students.

Focus Group Results

Most students who participated in the PACE focus groups described Flexus as a positive experience that they would do again. They also expressed that it is a program that they would and do recommend to others. Flexus participants described how the program helped them develop a sense of community and belonging, provided them with valuable professional development, and motivated and supported them to persist in engineering and pursue an engineering-related career after graduation. Quotes are identified by the focus group code.

Sense of Community

Overall, there was a strong sense of community among the Flexus women, which started to develop as soon as students got to campus. One alumni of the program described it as a “good base for starting in engineering.” Students talked about how Flexus helped them get oriented to the campus, campus resources, and their courses, and how it connected them with people who could and did help them, including peers, various staff, and faculty, as this woman explains:

I didn't know anyone at all from my town or anyone that came here and so I was kind of by myself, and it really presented you with this group of women engineers that had the same classes as you. And then the faculty relationships that you can build through the program are great, and I've continued to use those faculty members and staff members from the program to help me with other things—recommendations and stuff like that... And [every] semester there was a requirement of how many events you'd volunteer at. So an engineering event like the Women in Engineering Dream Conference or the Girl Scout Engineering Saturdays and things like that the Flexus students would volunteer to work at—

and the advisers and staff were always at those events too so you got to work with them on a different level.

Focus Group D

This was the case with both current and former program participants, with one woman stating, “We still refer to ourselves as Flexus girls.” Many students described this community as helping them feel reassurance, support, and a sense of belonging, as this student illustrates:

[As] I've gotten into the upper level, [knowing] that you have a group of people that you can study with and that you study well with, that has really been key. Even if you don't study with them, just a group of friends that are going through the same thing, it's key for your sanity.

Focus Group C

Some students attributed the sense of community primarily to living together in the same residence hall, and for many students, living with others on a floor was a key part of what made it a great experience. Upperclassmen described how they continue to live with friends they met through Flexus. This conversation provides an example:

Female 1: I think that the most helpful part [of Program] was the first few days that we moved in. I lived on the floor...Those first few days when you're like, "I don't have any friends, I don't know anyone here"...We came in a few days early, which I think helped, too. It was before all of the regular people moved in. I think that just having that time to get to know some people before everybody else got there and it was even more overwhelming. I think that that was one of the most helpful things for me because there were people in my same situation going into engineering, probably really scared. I think that knowing that they were going to be on my floor and in my classes made it really helpful.

Female 2: I'd definitely say living with a whole floor or half a floor [of] engineering girls that are taking the same classes as you was really helpful. I know me and [Student Name] are still roommates. Our other roommate [was] in Flexus. Our roommate next year is going to be in Flexus. I know a bunch of other girls who still live with their Flexus friends.

Female 3: I still live with all mine.

Female 2: Yeah. We became really close really fast, obviously, because we lived together. I think it was just nice to be surrounded by people who had the same course load because you couldn't be friends with [business] or psychology majors who were going out every night because they have homework due once a week, but we have homework due three times a week and tests and projects. That was really nice, not being tempted.

Female 3: I definitely think that that was a huge pro of the program.

Focus Group F

The clustering of classes for Flexus participants was also very helpful. Students described the important role that taking the same classes together played in developing a sense of community and support. One student explained:

[Coupling] your classes I thought was great, especially the first semester, because I don't know how I thought I was going to get to the math building for my first class on the very first day of classes. But there was this huge group of Flexus girls that all met at the front door to walk down together, so I just kind of like hopped on the Flexus train and walked to class. People always refer to us as a pack because everyone would just be in the same class and walk in this little pack to every class that we had, and that was so great to not walk in by yourself, bumbling and lost and whatever I would have done.

Focus Group F

Some students highlighted the importance of both living together and taking classes together. With the clustered classes and living on the same floor, one person described Flexus as a way to meet “automatic friends” because they were all going through the same experiences and difficulties. She added, “At the same time, it’s a large enough group that you can find the people you connect with the most.” (Focus Group C) Another woman went on to explain, “[They] only officially cluster you freshman year, or first semester. Afterwards, it was really easy for us to [do] it on our own.” (Focus Group C)

The connections and community that Flexus women developed through living with and taking clustered classes together seemed to help them overcome negative stereotypes regarding women in engineering. This conversation illustrates how Flexus helped these women view their fellow female engineers differently, proving negative stereotypes that they had internalized to be false.

Female 1: I think Flexus did a good job of showing a wide variety of female personalities that would be engineers. I thought it was going to be a bunch of nerdy people, too. When I went to open house, I realized that it wasn't. That's another thing Flexus does.

Female 2: Yeah, I think we all had the same exact outlook. We're like, is there any way we can live with somebody that we know? People met each other at orientation. It was like, "That girl is normal; I'm living with her." I know everyone did that...

Female 3: My sister's a senior, and so she has a friend who's coming here for engineering, and she's a girl. She messaged me and was like, "Your mom was telling my mom about this Flexus thing. Are the people really weird?" I was like, "First of all, I'm in this, so, insult, too." I was like, "No...for the most part, everybody is really, really normal and involved with other things on campus other than just engineering." I think that that really helped her, because she was like,

“I don’t want to do this. They’re gonna be so weird.” But I think hearing it, that people are normal, kind of makes it more inviting.

...

Female 4: I think being an engineer, in general [people] assume you’re going to be a big, huge weirdo that does whatever you do in engineering. [Laughter - group]

...

Female 6: I would definitely think so, but that stereotype’s totally shot within a week of being here. You all don’t look nerdy to me. [Laughter - group]

Focus Group F

Professional Development

A number of women indicated that they got a lot out of the various professional development activities and opportunities. Many described these as things they never would have done on their own, with one woman stating, “I can guarantee I would not have gone to the career fair as a freshman if I was not in Flexus.” (Focus Group F) Some women described how these kinds of activities challenged them to move “out of my comfort zone” and do things they would not have otherwise done. A number of students reiterated the fact that many of their peers, both in engineering and other majors, were not doing a lot of the professional development and preparation they were doing because no one was teaching them about it or informing them of the resources that exist on campus to help them, such as a resume clinic.

They were happy that they were made to do things they would not have done otherwise, and many students felt like they “got a head start” in terms of internship and other professional opportunities, over other engineers and non-engineers, as this woman explains:

[They] don't think about resumes or cover letters or going to job fairs or internships until now, which I interned last summer, so I feel like that's kind of directly related to having to do all those things beforehand.

Focus Group B

Some women explained how they did not enjoy certain activities and questioned why they were doing them, only to realize later that they were valuable experiences, as this student illustrates, “Flexus made us do a lot of things I absolutely hated freshman year...But later as a junior I appreciate almost every single thing that they made us do.” (Focus Group F) Other students talked about the job workshops as particularly useful and providing them with, as one woman put it, “things that I had never thought of.” (Focus Group C) For example, one group of women discussed the importance of learning about negotiating in the workplace.

Students described how participation in the various professional development activities in Flexus increased their confidence. In some cases the activities helped them overcome their fears and resulted in students feeling more confident talking with others and giving presentations, building faculty relationships (which resulted in recommendations for some of them), knowing where resources were, and feeling more prepared overall. For example, students described how one mandatory activity involved working with advisors at events which improved the students’

confidence in engineering and made them feel more comfortable going to talk to professors. This student shares why the Flexus professional development activities were important to her:

[P]ersonally, I think the biggest thing for me was the professional development that we got from Flexus, in terms of some of our assignments, [including] you had to write a resume, or you had to go to the career fair and get five business cards. Or we had someone come in and tell us what to wear for an interview, or we had someone lead [an] etiquette dinner. Those are things that you kind of learn by experience, unless you have something like Flexus that taught you exactly how to do them. Because my first semester, freshman year, I had a resume written that I could bring to a career fair, and I knew how to talk to an employer, and I knew people up to junior year that were still afraid to do that, because they never were told how. I think that was definitely one of the biggest things for me.

Focus Group F

Students also described being more involved in the engineering school and organizations on campus as a result of Flexus. Some students talked about continuing on as RAs, mentors for younger students, and/or participating in recruitment efforts. One woman asserted:

I think that Flexus made us all...much stronger girls in engineering. I think that because I was so confident in where I started, I've become so involved in every part of the engineering school...[W]hen I look at all the girls who are [leaders] in different organizations, most of the time they're Flexus girls...I think that it definitely [strengthened] that foundation, that [helped] me just grow so much more.

Focus Group F

A couple of students described wanting to do something that involves supporting women studying engineering once they graduate, such as running a program like Flexus, or working in industry but giving back to Flexus and supporting female students as a professional engineer.

Female 1: I'm going to go get a job doing something...like Flexus, getting younger people involved in school. I could easily see myself doing something like that, once I—

Female 2: I [see] myself being very willing to give back to what this program's given me, so I know that once I get a job I want to be able to talk to freshman at these networking receptions that Flexus does...I know that I want to be accessible to that...I think that as the individuals [we've] become through Flexus, it's so important that we come back and be a part of those things and help the freshmen [grow].

Focus Group F

Persistence in Engineering

Multiple students described thinking about leaving engineering and gave multiple reasons for why they stayed, including it being too far to turn back now, liking the challenge, not wanting to

feel like a failure, and the support their peers gave them. A number of students described how Flexus peers and staff helped them decide to stick things out and stay in engineering when they were struggling. These students describe how helpful it was to be surrounded by other women engineering students who were in similar situations:

Female 1: I probably would have been out of engineering [if I was not in Program]. You need people to do homework with, and what if I'd gotten on a floor with all sociology majors who are taking that math class where you just make graphs the whole time? That would not have helped me at all. But because we were all doing [WebAssign] at the same time, and I would get so frustrated and hate it, I would go out in the hall and be like, "Who's doing this?" Four other girls are down the hall, they're already on that problem, working on it together. I think that it just builds that foundation that makes you stronger as a person.

Female 2: I know when I wanted to quit, I had people telling me, "Why? Why do you want to quit?" [Besides] I hate it, I didn't have a valid reason. [Laughter - group] I hated it at the moment. I probably had three tests that week and I was really overwhelmed, so I had people there who were in my situation...who could help me [and] talk through it. That is what made me eventually lead to staying.

Focus Group F

Not only was it helpful to be around others who could understand the struggles they were facing, but the moral support and reassurance that Flexus women receive from one another could play a critical role in helping students decide to persist in engineering, as these women explain:

Female 1: Yeah, I think I would've dropped engineering, if I wasn't in Flexus. Just, it gave me support, a lot of times, when I did bad on a test, or like questioning if I wanted to stay in engineering. Just seeing other girls go through the same thing just kinda reassured me.

...

Female 2: I had a really tough sophomore year...Flexus and AOE, together, they're probably the reason why I stayed in engineering...I would talk to my close friends about how I didn't really want to do this anymore, and they were just like, "No, what are you talking about? You're just upset because you did bad on a test." I think, at one point, I actually was on the architecture website, and they just took my laptop, [laughter - female] and they were like, "You need to calm down for a few hours and come back to this tomorrow," or something like that. I don't know. They just knew I was upset, because I did bad on a test, and [I] guess, they thought that I could do it, and so—I don't know.

Focus Group C

In addition to peer support, some students described the tutoring provided by Flexus as pivotal to getting them through some of their more difficult classes. Also, students from multiple focus groups described the strong support they received from program staff, particularly the Director of the Women in Engineering Program. Many students described her as a key source of support,

who often goes above and beyond to ensure that they have what they need. They also talked about the importance of feeling like “someone cares” about them.

Not only did Flexus students describe how participating in the program helped them persist through their engineering programs, but many also expressed clear goals to pursue careers in engineering post-graduation, at least to start. Most talked about either finding or already having jobs lined up in the engineering industry, while a couple students mentioned that they wanted to continue their engineering studies in graduate school.

Discussion

Students in Maryland’s Flexus program described a number of benefits they gained from participating in the program, all of which highlight some best practices for building an inclusive environment that works to support and retain women pursuing engineering majors. Many of these benefits stemmed in great part from two specific aspects of the program: the sense of community fostered among participants, and the professional development workshops and activities in which the women participated. These two aspects of the program seem to connect very closely with Tinto’s model of attrition which focuses on academic and social integration as key aspects that help students stay in college.⁶

Social Integration and Sense of Community

Based on both the quantitative questionnaire data as well as the qualitative focus group data, a sense of community is a clear outcome of Flexus LLC participation. Questionnaire data indicated that Flexus students met other engineers because of their participation in Flexus and they felt more connected to other students. The focus group data described in more detail why students felt more connected. The strong sense of community can be attributed to various program components. Students indicated that having the opportunity to come to campus before the rest of the students, meet one another, and get oriented helped them start to establish bonds with each other. They described what could be viewed as somewhat of a *built-in community*, where they came in as part of a group, as opposed to coming in alone and having to form their social and support networks *from scratch*. Student persistence often hinges on students finding compatible student groups on campus.¹³ Flexus helps make that process easier for students by creating the opportunity for engineering women to connect with others like them right from the start. Living together with other Flexus students, taking clustered classes together, and participating in Flexus courses with one another all worked to solidify these bonds. Tinto found that membership in at least one supportive community, such as that found among Flexus participants, can be sufficient to ensure continued persistence.¹³

Academic Integration and Professional Development

The impact of LLC activities on students’ professional development was seen mostly through the focus group results, although questionnaire results hint at this as well. Students described gaining a variety of benefits from the different professional development activities they participated in through Flexus. By being required to take various steps to prepare themselves professionally, such as working on resumes, participating in career fairs, and giving presentations, the women felt they had a leg up in terms of preparing themselves for internships and other professional opportunities. These kinds of exercises, which were described by a number of students as things

they would never have done on their own or if they had not been in Flexus, also helped many of them overcome fears and boost their confidence.

Interactions with faculty, staff and peers in various contexts allows students to engage in *anticipatory professional behavior*, as they start to master technical knowledge and practical competencies, which helps them learn to project a confident and capable image to others.²⁸ In fact, at least one student noted the number of women she sees in leadership roles around the college. Activities requiring students to interact regularly with faculty and staff can work to stave off incongruence and help students feel more academically integrated.¹³ In contrast, the absence of such interactions can function as a predictor of individual departure from institutions.¹³ Additionally, the women described learning a great deal about the engineering workplace from job workshops, particularly during the first year of the program. Many students expressed that they valued this information and probably would not have had access to it if not for Flexus. Knowledge and understanding of the engineering profession and workplace can contribute to students' confidence in their ability to successfully perform the professional role of an engineer and find fulfillment in that role.²⁸ This *professional role confidence* can predict students' behavioral and intentional persistence in engineering.²⁸

Persistence and Retention

The institutional quantitative data showed the impact of participation in the Flexus LLC in terms of improved retention rates for Flexus participants. In fact, the impact of Flexus participation seems to grow over time, keeping Flexus participants in engineering, while non-participants are more likely to leave engineering in years 2 and 3. This further reiterates the importance of female-only LLC's in retaining women in engineering. Students in the focus groups echoed the quantitative data when they described how the Flexus community helped them stay in engineering.

Lessons Learned

Many lessons have been learned since Flexus began in fall 2007 with 18 students and only 50% continuing into the second year of the program. These lessons have been applied and as a result, Flexus has grown into a first year cohort of 50-62 students, 82% of whom continue into the second year.

One of the most important lessons has been with respect to academic integration. The first year of the program, the emphasis was on community building, mentoring, and role modeling experiences and a smooth transition into Maryland. Many students left Flexus after one or two semesters because they did not see a strong connection to engineering and the coursework they were taking. In the second year of the program, the first semester seminar was expanded to include supplemental instruction in the first engineering course (Introduction to Engineering Design). This change continues today and has been augmented to also include supplemental instruction in Mechanics I, which is another first year engineering course. In the third year of the program, tutoring within the community space was added. This has facilitated group studying within the residence hall.

As Flexus continues to grow, the staff and students are becoming more concerned with the development of community among the participants. After 62 students enrolled in Flexus for fall

2012, a change was made requiring students to live within the LLC unless they were living in another living and learning community. Exceptions are made for those students who chose to commute to campus. This new policy might be one explanation for why the number of first year participants decreased to 50 for fall 2013.

Because of the growing size of Flexus, the staff has been challenged by the management of the seminar which has an important role in developing the sense of community among the participants. With the large number of first year students in fall 2012, the staff split the cohort between two seminar times. An instructor was hired to lead one of the sections and the Women in Engineering director led the second section. This had unexpected detrimental consequences. Flexus students developed strong ties to the students within their seminar sections but did not develop strong ties outside of the sections. As a result, in fall 2013, all 50 first year students were placed into a single seminar section. The instructor intentionally focused four sessions on community building to ensure the students had the opportunity to get to know all members of the community. Furthermore, students were given credit within the seminar for participating in a variety of community social and academic events (e.g., attending the mid-semester study break or tailgate, or attending a review session for chemistry). Extra points were given for events when a first and second year student attended the event together. Simultaneous to the changes in the seminar, the student executive board developed a Flexus Friends program that matched first year students with second year students. While the data are still being analyzed, preliminary results indicate that students feel better connected to each other, and more importantly, there are stronger ties between the first and second year students.

Conclusion

The Flexus living and learning community serves as a model for other women-only engineering LLCs. Extant research highlights the importance of social and academic integration for retention in college.¹¹ In engineering, social integration can be especially difficult for women, who represent approximately 18% of engineering undergraduates nationwide. Academic integration is likely difficult for all engineering students, given the heavy workload and fast pace of engineering study. This makes it very important to ensure that women in engineering find strong networks that they can access to help them be successful in engineering. This study emphasizes the important role of living learning communities in general, but specifically the role of the University of Maryland Flexus LLC in creating a strong sense of community, providing confidence-boosting professional development, and ultimately helping students stay in engineering.

Women-only engineering LLCs provide opportunities for participants to socially integrate into a large campus, develop academic skills and knowledge to improve their professional role confidence, and create new communities of social and academic support that can help retain women in engineering majors. Participants in Flexus have higher retention in engineering than their peers, and this retention is especially clear after a few years of participation.

The use of both quantitative and qualitative analysis in this study helps unpack the particulars of what contributes to the program's effectiveness. Mixed methods research can result in especially rich understandings of the impact of programs. In this case, the quantitative methods provided

empirical data to show that retention of women in engineering is improved through participation in the Flexus LLC, and that the LLC also has a strong cumulative impact on student perspectives on engineering. The qualitative methods provided the deep description of mechanisms through which student retention, confidence building, and professional development is achieved. The use of Tinto's attrition model provides a framework for understanding how these program characteristics relate to student persistence.

Based on this research, successful engineering LLCs for women should focus on developing the following program characteristics: a) orientations for first year students that get them on campus early, b) residential programs that place students on the same floors of a dormitory, c) student-led social activities, d) grouping of students into some of the same courses, and e) additional professional development opportunities through a required seminar or one credit course.

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