Understanding the Relationship between Living-Learning Communities and Self-Efficacy of Women in Engineering

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Abstract

Rutgers University's Douglass Residential College and School of Engineering developed a partnership to provide first-year women in engineering the opportunity to live together and study engineering through the Douglass Engineering Living-Learning Community (DELLC). This high-impact program, which provides first-year women enrolled in engineering a residential environment as well as intentional peer and faculty interaction to promote their success in the field of engineering, has exceeded expectations in retaining undergraduate women from the first to third year in engineering. Aspects of this community include students residing together on a floor of the co-educational hall dedicated to first-year students in engineering, access to a Douglass Peer Academic Leader (PAL) in-residence, support from a female engineering graduate student mentor, enrollment in the Douglass first-year course *Knowledge and Power: Issues in Women's Leadership*, and interaction with faculty from all engineering disciplines during their linked course *Introduction to Engineering* which is taught by a full-time faculty member.

Since the inception of the Douglass Engineering Living-Learning Community in 2012, 42 first-year women have participated and completed the program. Of those women, 38 have successfully stayed in an engineering curriculum (90% retention rate), and 29 have continued to live together in another residence hall. To assess the effectiveness of this program on the predictors of retention, all students participating were asked to complete the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) developed by The Pennsylvania State University and University of Missouri. This instrument measures several outcomes related to retention and is widely used to better understand students' feelings towards engineering. Focus groups were also used to generate feedback about specific elements of the LLC program. We have found that our first two cohorts of female engineering students, currently in their second and third years, express significantly higher levels of career expectations, self-efficacy, feelings of inclusion and coping towards engineering than when they first entered.

Introduction

Engineering remains an academic area where women obtain a small fraction of bachelor degrees, and this trend does not seem to be changing in the near future. A recent report by the National Student Clearinghouse found that although more students are pursuing S&E degrees, women's share of these majors has failed to increase over the last ten years.[1] Researchers' assumptions that as women claimed more of the undergraduate population their numbers would rise proportionately in S&E, proved to be false. Research that examines the low representation of women in STEM majors and careers is illuminating. No singular cause can be identified; rather it is the accumulation of negative experiences, self-perceptions, high demands, and cultural stereotypes that coalesce into this long-standing phenomenon. Studies that include large multi-year surveys point to a persistent undercurrent of bias and cultural stereotypes that negatively influence women's choice to pursue these majors. In order for the growing workforce to fill the need for engineers, sufficient institutional support for women to enroll and major in engineering is required.

Several reports have focused on the need to invest in the future U.S. engineering workforce. In their 2012 report, "Engage to Excel," the President's Council of Advisors on Science and Technology projected that in order to retain the nation's historical preeminence in science and technology the United States must supplement the science, technology, engineering, and mathematics (STEM) professional workforce by one million.[2] The report further suggested that in order to meet this goal, the United States must increase the number of students graduating with undergraduate STEM degrees by thirty four percent over current rates.[2] It also argues that the expansion of the nation's economy depends on a significant increase of this highly trained segment of the workforce.[2]

The lack of undergraduate women in many STEM fields essentially restricts the potential labor force of STEM workers. Women earn most of their bachelor's degrees in the humanities, education, and fine arts, and in the fields of psychology, social sciences, and biological sciences. By contrast, men earn most of their degrees in computer sciences; earth, atmospheric, and ocean sciences; mathematics and statistics; physical sciences; and engineering.[3] Increasing women's access to and retention in STEM fields is one important solution to the dwindling STEM labor force in the United States.

Living-Learning Programs for Women in STEM

Living-Learning Programs for STEM are considered a best practice by the AAC&U, the National Science Foundation, National Academies of Sciences, and the American Association for University Women. Early research has documented that participating in Living-Learning programs benefits undergraduates in both academic and social contexts including the transition to college, first-year retention, grade point average, civic engagement, critical thinking, and engaging in deep intellectual inquiry.[4-8] A number of organizations have endorsed this programmatic intervention because it is positively related to a variety of beneficial educational experiences and outcomes. Past research has found that participating in a learning community helps to facilitate the transition from high school to college.[5,9-11] Membership in a learning community has also been linked to a variety of positive educational outcomes, including grades in college, desired learning outcomes, and persistence and graduation.[7,8,10,12-21]

Until fairly recently, researchers struggled with assessing the direct educational outcomes of learning communities on student academic performance, such as GPA, progress toward degree, or other academic measures. However, the primary benefits of learning communities are due to the indirect impact of the increased educational engagement that learning communities provide. Participating in a learning community is significantly and positively related to all types of student engagement, and student engagement is in turn strongly related to educational gains.[4,7,17,19-21]

Research on single-sex learning communities for women in STEM is newly emerging. STEM settings with higher numbers of women have led to higher participation in STEM majors. Researchers have also observed a correlation with increased desire to obtain a leadership role in one's field compared to women at co-ed colleges.[22-25] Studies have also indicated that single gender environments within coeducational settings might hold important benefits for women, especially in some STEM fields, where women's historic under-representation continues to be alarming.[25] In addition, environments found in women-only LLCs, such as connections to an all-female peer group, learning in all-female environments, and course content that is more inclusive of women, have been regarded as enhancing experiences for women in STEM fields.[22,23,25] Kahveci examined a living-learning community for women in STEM as a component of a larger comprehensive program for women in STEM.[25] All of the program components in the LLC were found to benefit the women who participated, yet the experience of sharing a space in a residence hall was found to have contributed the most toward creating community among the women in the program.

Important research by the National Study of Living-Learning Programs (NSLLP) asks questions of particular relevance to the data presented in this paper. Women in women-only STEM LLCs were the most likely to express confidence in their math or engineering courses.[4] Meanwhile, behaviors of low self-confidence, such as dropping a class, doing less well in a particular class than expected, and feeling overwhelmed by homework, were most likely to be associated with women in STEM majors who did not participate in any form of LLC.[4,16,26] Inkelas further analyzed the NSLLP participants data and found women-only STEM LLC participants were 31% more likely to attend graduate school in a STEM field compared to women STEM majors in non-STEM LLCs (e.g., residential honors programs), and 29% more likely than women in STEM who did not participate in any type of LLC.[4,26] Most LLC participants lived in the LLC as freshmen, but the program continued to have an impact on the women into their senior years even accounting for the women's background characteristics and other college experiences. Somewhat conflicting data found that participation in an LLC (with a STEM focus or otherwise) had no direct relationship with STEM persistence for women.[16] However, women's likelihood of graduating from a STEM field was related to several facets of their college experiences that are generally assumed to be augmented through participation in LLCs; for example, conversations with peers about academic issues, faculty interaction and mentoring, and socially supportive residence hall climates. Thus, even though mere participation in an LLC may not necessarily facilitate STEM persistence for women, the types of activities undertaken in LLCs may be the conduits for STEM success for women. We take this to suggest that the "living" component alone of an LLC is not sufficient to encourage desired outcomes. Rather, the extent and nature of the related programming, both academic and community-focused, are also important.

Douglass Engineering Living Learning Community

The primary goal of the Douglass Engineering Living Learning Community (DELLC) was to build an engaging experience in the first year that would create a cohort effect to counter feelings of isolation as students progressed to graduation. The major components of the DELLC are (1) benefits of membership in an all female residential college, (2) shared living space, (3) a special section of the *Introduction to Engineering* course offered in the spring semester of their freshman year, (4) a community mentor who is a graduate student in engineering and (5) an engineering faculty advisor. We believed that building an engaging experience in the first year would create a cohort effect to counter feelings of isolation the students progressed to graduation. The program began recruiting students in the summer of 2012 as students applied and were admitted to the School of Engineering at Rutgers University. First-year women were notified of the program and encouraged to participate once they accepted admission to the School of Engineering. The students were able to choose the DELLC as a first-year campus housing option and were not required to submit any academic references or additional application materials.

Douglass Residential College is a program for women at Rutgers University. Founded as a historical college for women, Douglass is a leader in innovative educational experiences for women. As a co-curricular opportunity at Rutgers University, it prides itself on providing women at the university with unique opportunities for leadership and professional growth through a variety of programs, including a collection of living-learning communities and a first-year common course on women's leadership. Students in the Douglass Residential College are also provided a Peer Academic Leader (PAL) in their first year. A designated office at Douglass, The Douglass Project for Rutgers Women in Math, Science and Engineering, specializes in supporting women in every STEM field though advising, mentoring, programming, and undergraduate research opportunities.

In addition to these resources, the DELLC's graduate mentor provides invaluable support for the undergraduates participating in the program. She shares her experiences of being a woman in a male dominated field and acts as a resource during times of crisis and struggle. She coordinates programs and workshops for the students to create a shared sense of community. Informational sessions she provided in the 2013-2014 academic year included resume workshops, internships, and information about undergraduate research. She also relays important information to the community's leadership about how the students are acclimating to their first year at college, and co-facilitates the *Introduction to Engineering* course with the engineering faculty advisor.

All women in the DELLC are required to take *Introduction to Engineering* in their first year. This 3-credit course is designed to meet the needs and challenges of the DELLC, replacing the traditional 1-credit seminar lecture course taken by other engineering students with hands-on design projects completed in small teams. This format provides opportunities to work more closely with their faculty advisor, Dr. Helen Buettner and the course's co-facilitator. Additional time for group discussion and communication with the community's faculty advisor allows students the time to go more in depth on an area of engineering that interests them in a low stakes environment. The format of the course consists of several interdisciplinary design projects spanning the Rutgers University School of Engineering's available majors: bioenvironmental, biomedical, chemical, civil, electrical, industrial, materials, and mechanical. The students also receive in-depth tours of engineering laboratories including built-in discussion time with faculty and graduate students who work in the labs. During team projects the students are provided with a brief description of the goals, key concepts, and some basic background material and encouraged to use all available resources, including internet information or other faculty members. Projects typically span several class periods. A variety of methods are assigned for reporting results, including group, individual, written, oral, and poster presentations to introduce students to the different modes of technical communication. Interspersed among the project work are short (20-30 minute) presentations by primarily women faculty from different engineering departments as well as women trained as engineers who work in the private and public sector. The presenters are asked only to share a bit about themselves and their experiences with engineering, and to entertain questions from the students. Student interest and engagement with these presentations has been so overwhelming that the syllabus has been fine-tuned to increase the number of these presentations in successive years.

Second Year Leadership and Mentoring Program

After the DELLC's inaugural year, women from the first DELLC cohort wanted to live together during their sophomore year. The program coordinators adapted several programs in development at Douglass Residential College to meet the needs of sophomore women in engineering. Because research had shown that as women in engineering move into their sophomore year, and into coursework that becomes more specialized to their engineering major, their feelings of isolation can increase, organizers introduced a peer mentoring, career and industry networking, and a service-learning project that would keep students engaged. The Engineering Leadership Program objectives were to:

- Provide monthly exposure to successful women in engineering, including practicing engineers, engineering alumni, and engineering faculty members whose presentations featured their latest research, experiences, and personal journeys with students
- Utilize an individual and group-mentoring model designed to match sophomore-engineering majors with junior and senior engineering majors to specifically target feelings of isolation in engineering. This adapted a mentoring program for all STEM students at Douglass that was already being planned for the 2013-2014 year to target engineering students.
- Provide opportunities for engineering students to develop leadership skills through a service-learning program, later named the LIFE! Workshop. This workshop, coordinated by the second-year engineering students, allowed them to utilize the engineering concepts they had learned so far in their curriculum to inspire middle school girls to explore engineering as a possible career.

From the very beginning of the program, the combination of peer mentoring and industry talks became the most popular program for sophomore students. However, the staff faced several obstacles at the beginning of the program. With little existing research on industry mentoring programs for women in STEM, and industry collaborations for women in engineering particularly, staff did not know what problems to anticipate. Students in engineering often report spending more time in class and studying outside of class than any other undergraduate group.[32] Therefore, finding time for students to participate in programs and workshops, like industry site visits, required significant effort. Inevitably some course trips were compromised in favor of on-campus industry networking events, as students were able to come to the event after their classes had ended and industry professionals were able to attend the event after work on a weekday.

The DELLC cohort from 2012 responded with tremendous enthusiasm to mentoring engineers in the 2013 cohort. The mentoring program also had the added benefit of creating community between the students and helping to promote additional beneficial activities to the mentors and the mentees. Advertising relevant workshops or industry visits became easier because student mentor/mentee relationships could be leveraged to advertise the events throughout student networks. Mentors applied to the yearlong program and were selected based on their commitment to participating, their leadership roles to date, and their shared interests with mentees. Throughout the 2013-2014 academic year, mentors attended four trainings and met with their mentee in person a minimum of three times per semester. After two of the trainings, the mentees joined the mentors to informally get to know them better, which allowed mentees to meet other pairs in the program. In-person meetings ranged from mentors showing mentees around campus, to discussing possible courses, having lunch together, attending lectures, networking events, volunteering, and attending club meetings. Each in-person meeting required a report on the activity from the mentor outlining the activity, any mentoring skills that were used or learned, and any challenges that arose during the meeting. Mentors and mentees also communicated via email, text and phone calls to catch up, share advice and information on available resources or sometimes just to send an encouraging word.

The major service-learning component of the program consisted of the development and delivery of a full day workshop for 7th and 8th grade girls with interests in engineering-related fields, using workshops and other activities focused on engineering, and showcasing inspirational undergraduate role models. The 2012 DELLC worked together to prepare the workshops and target students at over 50 middle schools in New Jersey. Students divided up a list of engineering subdisciplines to research and test activities that would be relevant for the program. In addition to the hands-on projects the DELLC women gave short workshops on public speaking and presentation skills, including tips on overcoming public speaking anxiety. The middle school girls were given additional time to prepare poster presentations for each of their projects, which they practiced and presented shortly afterward. Certificates of participation were awarded to the middle school students by their group facilitators, and the program concluded.

Throughout the program students had an opportunity to meet and network with women from a variety of engineering fields and industry sites. Students toured a major technology company and a large nuclear facility. They received a demonstration from an industry representative about LinkedIn and had a question and answer session with a panel of engineers from an energy company. Students met with an aerodynamics engineer from NASA Langley and had breakfast with a faculty member from the Industrial and Systems Engineering department at the University. The culminating event was a group trip to an art/science exhibit in New York City.

Procedure

This paper combines data from different sources in order to understand the different program components that have impacted the 2012 and 2013 cohorts. Internal program evaluations from the office reflect student feedback about the effectiveness of the peer and industry-mentoring program. Data presented in this paper utilizing the AWE LAESE survey were part of a grant provided by the Engineering Information Foundation to implement and evaluate the impact of a second-year program for undergraduate women in engineering. Additionally, as part of a large scale survey to evaluate the first-year experience at Douglass, focus group data on the 2013 DELLC cohort are also presented to better understand their perception of the DELLC program. This work was funded by a generous grant from the New Jersey Health Foundation and done in collaboration with the Center for Women and Work at Rutgers University. The Colgate Palmolive Corporation provided additional funding for the evaluation and implementation of the mentoring component of this program.

Quantitative Methods

Since the success of this program is determined by many different factors, we used several different measures in order to assess its effectiveness in supporting women in engineering, including engineering self-efficacy, average GPA, retention rates, and major selection of our student participants. All of the data, with the exception of engineering self-efficacy, was gathered through questionnaires and verified using official university data. In order to determine the engineering self-efficacy of our students, we administered the Longitudinal Assessment of Engineering Self-Efficacy (LAESE v 3.1) survey developed by The Pennsylvania State University and University of Missouri Assessing Women and Men in Engineering Project (NSF grant #0120642).[27-30] This tool, designed to identify longitudinal changes in the self-efficacy of undergraduate students studying engineering, measures several outcomes related to retention and is widely used to better understand students' feelings towards engineering.[27-30]

The LAESE survey uses a 7-point Likert scale (0-6) to address issues related to self-efficacy including student efficacy in "barrier" situations, outcomes expected from studying engineering, student expectations about work load, student process of choosing a major, student coping strategies in difficult situations, influence of role models on study and career decisions, and career exploration.[30] The survey groups items into six subscales which are designed to measure specific factors of self-efficacy because using multiple questions to measure these concepts has been found to yield better results. These subscales are grouped as engineering career success expectations, engineering self-efficacy I, engineering self-efficacy II, feelings of inclusion, coping self-efficacy, and math outcome expectations. AWE has determined that the Cronbach's alpha, an indication of the reliability that is most commonly used when multiple Likert questions

Table 1

Cronbach's Alpha for LAESE Subscales

	Number of Items	Cronbach's Alpha
Engineering career success expectations	7	0.84
Engineering self-efficacy I	5	0.82
Engineering self-efficacy II	6	0.82
Feelings of Inclusion	4	0.73
Coping self-efficacy	6	0.78
Math outcome expectations	3	0.84

in a survey/questionnaire form a scale, for the subscales are .84, .82, .82, .73, .78, and .84 respectively (Table 1).[27-30] An alpha score of between 0.7 and 0.9 is generally considered good for low-stakes testing.[31]

The engineering career success expectations subscale measures students attitudes towards their future career in engineering by asking students to rate their agreement to items such as "Someone like me can succeed in an engineering career" and "I expect to feel 'part of the group' on my job if I enter engineering." The engineering self-efficacy I and II subscales measures the students perception of their ability to achieve academic milestones in both the engineering curriculum and major. Sample items for these subscales include "I can succeed in an engineering curriculum while not having to give up participation in my outside interests (e.g. extra curricular activities, family, sports)" and "I can complete any engineering degree at this institution." To measure feelings of inclusion, the survey asks how much students "can relate to the people around [them] in class" and whether or not they "have a lot in common with the other students in [their] classes." For coping self-efficacy, the measure of how well students believe they can cope with their choice of major, the survey asks students to rate their agreement to items such as "I can cope with not doing well on a test" and "I can approach a faculty or staff member to get assistance." Finally, the survey asks students if they think "Doing well at math will increase my sense of self-worth" and "Taking math courses will help me to keep my career options open" to assess math outcome expectations.[27-30] Students respond to these items using a 7-point Likert scale with "0" representing "strongly disagree" and "6" representing "strongly agree."[27-30] There is also an option available when students are unsure how to answer.[27-30]All students participating in DELLC are given a paper version of the LAESE survey as their "pre-test" during their first official community meeting during the Fall Orientation and Move-in Weekend in September of their first year. This meeting takes place the day they move to campus and a few days before the start of the fall semester courses, so we are able to capture their perceptions before actually starting any classes at the university. We also asses their perceptions in April, towards the end of the academic school year, by asking all students continuing in engineering to complete the

Table 2

Difference in 2012 Cohort LAESE Subscales from 2012 to 2014

	Mean Fall 2012 (n=18)	Mean Spring 2013 (n=18)	Mean Spring 2014 (n=17)	Difference (13 - 12)	Difference (14 - 12)	Difference (14 - 13)
Career Expectations	4.841	4.992	5.217	0.151	0.376*	0.225
Engineering Self-Efficacy I	4.489	4.256	4.982	-0.233	0.493*	0.726**
Engineering Self-Efficacy II	4.880	4.981	5.424	0.101	0.544**	0.443**
Feelings of Inclusion	3.917	4.472	4.975	0.555*	1.058**	0.503**
Coping Self-Efficacy	4.806	5.111	5.235	0.305	0.429	0.124
Math Expectations	5.167	4.907	4.961	-0.26	-0.206	0.054

Note. *p < .05, **p < .01

survey again. First-year students retake a paper version of the survey in their final *Introduction to Engineering* class; upper-year students are asked to complete the survey online using SurveyMonkey. The 2012 cohort has been measured longitudinally twice: once at the end of their first year (spring 2013) and again at the end of their second year (spring 2014). The 2013 cohort has only been measured once at the end of their first year (spring 2014).

Quantitative Results

The first DELLC cohort started in the fall of 2012 (designated as "2012 cohort") with 20 students enrolled in the School of Engineering. The Rutgers School of Engineering requires all students to declare a major in April of their first year, so of these 20 students, we consider 18 of them who declared an engineering major at Rutgers as persisting to their second year (90% retention). We were able to assess all 18 of these women at the end of their first year (April 2013), excluding the two students that did not persist, so the self-efficacy scores only include those students who persisted. Although all 18 students continued to pursue engineering degrees through their second year and into their third year, only 17 successfully completed the LAESE survey online in April of 2014.

We had similar results for the second DELLC cohort who entered the University in the fall of 2013 (designated as "2013 Cohort"). There were 22 students who started in this cohort and all but one declared an engineering major at the end of their first year (95% retention rate). Unfortunately, two of these continuing students did not successfully complete the survey in April of 2014, so only 19 students were assessed on their self-efficacy longitudinally from this cohort.

Table 3

Difference in 2013 Cohort LAESE Subscales from 2013 to 2014

	Mean Score Fall 2013 (n=19)	Mean Score Spring 2014 (n=19)	Difference (2014 - 2013)
Career Expectations	4.929	4.869	-0.060
Engineering Self-Efficacy I	4.747	4.569	-0.178
Engineering Self-Efficacy II	4.984	5.092	0.108
Feelings of Inclusion	4.167	4.397	0.230
Coping Self-Efficacy	4.865	5.091	0.226
Math Expectations	5.263	5.053	-0.210

In order to determine the longitudinal changes in engineering self-efficacy for the women participating in DELLC, we computed the mean score of the items for each subscale, which in turn, gives us only one score per subscale per student to compare for each iteration of the survey. Thus each mean score is between 0 and 6, with values between 4 and 6 suggesting that a student has higher engineering self-efficacy related to that subscale.[27-30] Using the paired samples *t*-tests for the six subscales we determined if there were significant differences in their scores from the initial survey taken at the beginning of their first-year on campus to each of the subsequent surveys at the end of each year.

As shown in Table 2, there were significant increases in the students' mean scores for feelings of inclusion ($p < 0.05$) for the 2012 cohort from September 2012 (pre-survey) to April 2013 (end of their first year), as well as for career expectations ($p < 0.05$) and engineering self-efficacy I and II ($p < 0.01$) from September 2012 to April 2014 (end of their second year). These results indicate that DELLC participants had increased feelings of self-efficacy in these areas from when they first entered college to the end of their second year, with the most significant change happening over the course of the second year.

For the 2013 cohort, no significant changes were observed from September 2013 (pre-survey) to April 2014 (end of their first year), which means their feelings of self-efficacy did not change over the course of the first year on campus (Table 3).

It is difficult to compare the small DELLC cohort to the overall population of students and women at the School of Engineering. The retention rates of our students compared to those of their peers in the School of Engineering indicate that DELLC students are retained at higher rates than all men and women in their engineering class (Tables 4 and 5). Our women are also

Table 4

Comparison of Retention for 2012 Cohort to School of Engineering Peers

	DELLC	All SOE	SOE Women
Enrollment in Fall 2012	20	770	161
Enrollment in Fall 2013	18	679	151
Enrollment in Fall 2014	18	581	135
Retention Rate From Year 1 to Year 2	90%	88.1%	93.8%
Retention Rate From Year 2 to Year 3	100%	85.6%	89.4%

Table 5

Comparison of Retention for 2013 Cohort to School of Engineering Peers

	DELLC	All SOE	SOE Women
Enrollment in Fall 2013	22	713	150
Enrollment in Fall 2014	21	639	136
Retention Rate	95%	89.6%	90.6%

retained at a higher rate than the other women in the class from the second to the third year for the 2012 cohort and the first to the second year for the 2013 cohort.

We also noticed that the women in DELLC had mean GPAs above a 3.0 in addition to their higher retention rates, although we did not select students for the program based on their high school academic record. As GPA is considered a factor in determining self-efficacy, we wanted to see if DELLC GPAs were related to DELLC students' self-efficacy.[36] In addition to analyzing the difference between self-efficacy scores longitudinally, we decided to also use regression analysis to determine if there was a correlation between cumulative GPA and the self-efficacy scores from LAESE. Using both Spearman's Rho and Pearson's Correlation Coefficients, we compared the 2012 cohort's cumulative GPA at the end of the Spring 2013 semester to their self-efficacy scores from April 2013, as well as both cohorts' cumulative GPAs at the end of the Spring 2014 semester to their self-efficacy scores from April 2014. Correlation coefficients are measures of how items are related to one another. A correlation coefficient close to 1 or -1 indicates that there is a strong relationship between the items. If the correlation coefficient is positive, it indicates that as one variable increases, so does the other. A negative correlation coefficient indicates that as one variable increases, the other variable decreases. Both Spearman's Rho and Pearson's correlations were calculated to have a better idea of the correlation.

Table 6

Correlations Between 2012 Cohort Cumulative GPA and LAESE Subscales

	Spring 2013		Spring 2014	
	Spearman's Rho Correlation	Pearson's Correlation	Spearman's Rho Correlation	Pearson's Correlation
Career Expectations	-0.07	0.11	-0.05	0.12
Engineering Self-Efficacy I	0.7**	0.79**	0.7**	0.69**
Engineering Self-Efficacy II	0.73**	0.76**	0.83**	0.74**
Feelings of Inclusion	-0.18	-0.09	0.03	0.20
Coping Self-Efficacy	0.05	-0.02	-0.12	-0.28
Math Expectations	-0.14	0.04	0.17	0.18

Note. **p < .01

Table 7

Correlations Between 2013 Cohort Cumulative GPA and LAESE Subscales

	Spring 2014	
	Spearman's Rho Correlation	Pearson's Correlation
Career Expectations	-0.058	0.145
Engineering Self-Efficacy I	0.329	0.407
Engineering Self-Efficacy II	0.085	0.086
Feelings of Inclusion	-0.20	-0.085
Coping Self-Efficacy	-0.002	0.173
Math Expectations	-0.162	-0.316

As Table 6 demonstrates, the only significant correlation occurred for the 2012 cohort when cumulative GPA was compared to Engineering Self-Efficacy I and Engineering Self-Efficacy II for both the end of the first year and the end of the second year. For the 2013 cohort, however, cumulative GPA is not significantly correlated with any of the self-efficacy subscales (Table 7).

Qualitative Methods and Results

In the 2013-2014 academic year, the Center for Women and Work (CWW) administered a survey for first-year students at Douglass Residential College to study their first-year experiences generally. In spring 2014, the STEM office followed up the survey with focus groups in order to understand student attitudes and feelings about the office and provide insights into the first-year experience. A special focus group was conducted with first-year engineering students in the DELLC program. Utilizing a semi-structured approach, interactions among participants were encouraged to explore their feelings about the DELLC and the first-year experience overall. The quality of responses was extremely rich due to participants' ability to build on the responses of other participants in the group.

A total of 9 engineering students participated in this focus group, which was conducted and audio-recorded at the Rutgers by Dr. Danielle Lindemann from the Center for Women and Work. Recordings were transcribed for analysis and responses were hand-coded for emerging themes. The focus group results describe student perspectives on the impacts of the program, especially around a shared sense of community, opportunities for professional development, and attitudes about persisting in their engineering major.

The strongest theme to emerge in this focus group was about fitting into engineering and a general sense of belonging that they attribute to their activities as part of the DELLC.

Our group [for women in engineering] has completely altered my view of a woman engineer, making me see that, okay, I can probably do this…All engineers I had ever met were men. I could picture myself as a scientist, but I couldn't picture myself in a group of engineers until I saw [the group], basically."

Just being in the same classes with people and struggling through—I think that makes a really strong bond. I think I pep-talk my best friends and they pep-talk me every day. Or we've cried together. That's happened so many times.

However, while there was a good deal of discussion about how students in the group struggled to succeed in their engineering courses, students did not explicitly connect their involvement with the DELLC to academic success. Students' desires to be part of a community and accompanying feelings of belonging have emerged in other research on the persistence of women in STEM fields. While the intention of living-learning communities has largely been to promote academic success, it is possible that the DELLC's program impact lies with increasing the likelihood that women will identify with an engineering identity.[32,33]

Mentoring Program Results

The responses in the final evaluation questionnaire for the peer and industry networking program were also indicative of this desire for community. Because students in other STEM majors were also invited to participate in the mentoring program, program evaluations were not targeted specifically to engineering students. However, engineering students mentor/mentee pairs represented 31 of the total 66 pairs.

An end of year survey was also sent to mentors and mentees alike. Mentees continued to report the positive trends that were echoed at mid-year. Of the 42 mentees who responded, over 60% found the Mentoring Program "effective" or "very effective," and over 70% felt strongly that it should be continued. Almost 90% of respondents reported that they were "very likely" or "likely" to graduate with a STEM major and consider a career in a STEM industry. Almost 75% of respondents said that they learned more about careers in STEM due to the mentoring program, while about 70% felt the programs helped them make friends at the University and gave them greater confidence to succeed in a STEM field. Students reported the program to be most useful at the beginning of the year during their initial transition to the University, despite the required mentor-mentee meetings all year long. The vast majority of students (90%) met with their mentors four times one-on-one throughout the year as indicated through post-meeting reports. When mentees reflected on their year in the program many of them mentioned the first month of school as a difficult time of transition. They commented that their mentor's positivity, friendship, support, advice and resources were extremely valuable. Students said:

> *The mentoring program has personally enhanced my first year experience tremendously, especially at the beginning of the year when I didn't know anyone. Whenever I ran into financial, academic and/or personal issues, I knew who to reach out to. My mentor was always there for me and we mutually helped each other share resources etc.*
>
> *I got to have lunch with my mentor, and participate in activities with her. She taught me about different clubs, and how to get classes I wanted. She made the transition MUCH easier.*
>
> *I learned about so many opportunities I have available that I didn't know about before and I think overall it made my transition easier, just knowing that there was someone to help me if I needed help.*
>
> *I felt more confident that I had another person to support me and help me through adjusting to college and a tough [STEM] major.*
>
> *I was insecure in the beginning because I had to start making new friends but my mentor became my friend and she has been an important part of allowing me to enjoy my first year in college. She gives me advice about what classes are good, which professors people love and she's just so amazing and supportive.*
>
> *[My mentor] really was a student resource who was honest about the pros and cons about becoming an engineer. I love the idea of someone to look up to who ends up being an important resource for networking in the present and the future! She encouraged me to stay in STEM fields and really built a strong foundation for me to graduate with and excel.*

Mentors felt similarly about the mentoring program. Of the 23 mentors who responded, over 90% agreed the program should be continued, with over 80% finding the program "effective" or "very effective." One hundred percent of mentor respondents' felt that it was "likely" or "very likely" that they would graduate in their major and consider a career in industry. Mentors also reported gaining valuable skills from serving as an experienced and trusted adviser. Mentors stated learning more about the University, gaining confidence, and improving their leadership development and networking through the program.

> *The mentoring program gave me an amazing opportunity to branch out and get to know more women in the field. It was a great feeling being able to guide a fellow student through an experience that I was once went through. It really opened my eyes to all that [the University] has to offer!*
>
> *I've been able to be more structured when it comes to the way I give people advice. Through this program I was able to not only help my mentee with networking, but I took advantage of the many networking opportunities.*
>
> *The mentoring program was beneficial and a two-way street that I was able to not only help my mentee, but she was also an inspiration and a great support for me as a mentor. It allowed me to become more involved and give back to [the Residential College] and gain a new friend.*
>
> *The mentoring program has allowed me to have the experience of being a peer mentor. I enjoyed being able to help my mentee throughout her freshman year. This program has inspired and encouraged me to apply for other peer leadership programs such as the STEM Ambassador program and the [University's] Research Center's Peer Instructor position.*
>
> *It taught me how to relay useful information to my mentee and improve my own leadership and communication skills. I found it to be a very rewarding experience.*

These comments suggest that both mentees and mentors found value in the opportunity to engage with each other and the likelihood that this program created a great deal of engagement between the 2012 & 2013 engineering cohorts. The program evaluation responses of mentors, however, seem to indicate a greater positive impact on self-confidence and leadership development that were target goals of the second year DELLC program.

Discussion

GPA and Self-efficacy

When we ran the regression analysis on the GPAs and their self-efficacy scores from the LAESE survey, we discovered that only the engineering self-efficacy I and II subscales were significantly correlated with GPA. This would seem to indicate that although our students do well in their classes overall, their self-efficacy scores, and ultimately their retention, are not correlated with their grades. Although more analysis is needed, there is some evidence to suggest that factors outside of the classroom influence the self-efficacy of our students.

Differences Between Cohorts

Although we used the feedback given by the students in the first year of this program to improve aspects of the second year, the structure of the Douglass Engineering Living-Learning Community did not change much from year 1 to year 2. The biggest difference between the two years was that women in the 2012 cohort served as peer mentors for the 2013 cohort in both a one-on-one setting as well as in the *Introduction to Engineering* course. Because there were not any major programmatic changes for the 2013 cohort, we are not sure why a strong correlation exists between GPA and engineering self-efficacy for the 2012 cohort but not the 2013 cohort. Results from focus groups and mentor evaluations suggest that the 2013 cohort perceived their first year at the University to be fairly daunting. Neither faculty nor staff have noted any major changes in either the first-year curriculum or in the demographic of the 2013 cohort that could account for this disparity. One possible explanation would be the integration of peer mentors into the program. Although the data shows these peer mentors have demonstrated a high correlation between engineering self-efficacy and GPA, they may have communicated to their mentees that GPA is not the most important aspect of their engineering education, leading to the weaker correlation. DELLC organizers intend to follow the 2013 cohort during their sophomore to investigate any other significant disparities.

Importance of the Second-Year

The most significant changes in both self-efficacy and retention occurred for our students over the course of year 2. Mean scores for four out of the six subscales increased significantly from the beginning of year 1 to the end of year 2, with most of the change happening from the end of year 1 to the end of year 2. We also observed a 100% retention rate for our group from year 2 to year 3. We hypothesize that two major factors contribute to these results. The first factor relates the building of a community in the first year to increased peer support as they start to enroll in their engineering-specific courses. Through their participation in DELLC as first-year students, the women had a full year to bond and create a strong support network of other women. We have found that almost all of them continued to live together as second-year students, which meant their network was intact as they began year 2 in the engineering curriculum. In fact, their sense of community is so strong that they continue to perceive themselves as members of DELLC even after they moved out of the residence hall and are technically no longer members of the official program (the official program is the first-year residential experience). Since social persuasion has been shown to be an important factor in self-efficacy, having access to a group of female peers in engineering who know each other very well and who encourage each other to persist in engineering has probably strongly influenced their self-efficacy and decisions to persist in the field.[27,29,34]

Another factor that may have contributed to the increase in self-efficacy and retention for the 2012 cohort from year 2 to year 3 is the implementation of a second year leadership and mentoring program, including the addition of a second graduate mentor to foster community and coordinate workshops for the second-year engineering students. Over the course of their second year, in addition to continuing to live together, the 2012 cohort developed the LIFE! Workshop, mentored first-year students, and attended events with successful women in engineering. Mastery experiences and vicarious experiences both highly influence self-efficacy, and providing our students with the opportunity to not only teach future engineers the engineering concepts they have learned, but also hear from current engineering professionals who have been very successful, may have contributed to the increase in their self-efficacy scores.[27,29,34]

Implications and Future Directions

Since self-efficacy is important to determining women's success and persistence in engineering, we have found that using a two-year model that incorporates aspects focused on social persuasion, mastery experiences, and vicarious experiences is most beneficial.[27,29,34] Providing our students with a space to form a strong community, while also exploring their engineering options, has shown to be the best foundation for them to persist into their third year. By adding opportunities for them to meet with successful and established women engineering professionals as well conduct outreach in engineering during the second-year, we have found all of our students persist from the second to the third year.

Although we have found that this two-year model works very well for retention of undergraduate women in engineering, we understand that more research should be done with this program and its outcomes. We intend to evaluate the scores from this year's assessment to see if the trend continues for the 2013 cohort. We hope to utilize qualitative methodology such as focus groups and interviews to better understand why the scores are much higher for second-year students. Additionally, we hope to explore further the ways in which the DELLC program has impacted the development of an engineering identity or an increased sense of belonging in an engineering cohort.

Conclusion

While the Douglass Engineering Living-Learning Community has been an effective way to retain and support undergraduate women in engineering at a large, public research university, more research needs to be done to determine the significance of other contributing factors. The combination of a first-year living-learning experience supplemented with a peer mentoring program and access to female faculty and professionals in engineering has so far been shown to improve student self-efficacy, which in turn increases persistence.

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