Learning Communities: Impact on Retention of first-year students

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Three-Years of Quantitative and Qualitative Data Analysis on Engineering Learning Communities: Impact on Retention of First-Year Students

Abstract

In this evidence-based practice paper, we explore the first three years of an Engineering Learning Community (ELC). The research group at our University recognizes the need to increase retention rates at the Engineering College and has created the ELC to support increased retention. Three cohorts of ELC students have been observed to determine the potential success of this project. The results from this study indicate that participation in the ELC is beneficial for first-year college students in engineering. First year grade point average (GPA) is strongly related to first year retention in engineering at our University as shown through a binary logistic regression model. Despite a small sample size for the ELC group, results show that first year freshman students participating in the ELC have a higher average GPA at the end of their first year when compared to the rest of the students in the Engineering College. Our model indicates a higher probability of being retained beyond the first year as a result of having higher GPA, and when ELC participation is included, the model suggests a positive effect on retention as well. We also observe that the ELC students have higher retention rates for the three cohorts in this study, which supports the results from our regression model. Interviews with three students from the sample reveal various positive impacts of ELC participation including: improved social experiences, access to resources and mentoring, and valuable support for the transition from high school to college, all of which may have contributed to higher GPA for this group.

Introduction

This study examines the critical need for improving first-year student retention in Engineering and STEM majors, which disproportionately fail to retain students of underrepresented groups [1, 2, 5, 6, 8]. The ELC is a first foray into providing additional support and resources for these underrepresented students in this university setting. ELC students are matriculated into common first year Math and English courses as well as an Introductory Design course on fundamentals of engineering design. These attributes are thought to enhance the student's ability to overcome the hurdles of their first year and improve their interest in completing a four-year degree at the College of Engineering. This study provides additional information to support a common theory that cohort-model learning in higher education significantly improves student outcomes via improved social and academic integration [3, 4, 5, 8, 9].

To provide evidence for an affiliation between the ELC and first year retention at the College, quantitative and qualitative data was collected on students attending the College for the three years corresponding to the first three cohorts of the ELC. The goal is to compare students that participated in the ELC to their counterparts within the college who did not self-select into the Learning Community and identify, from ELC students, the impact the ELC has had on their academic careers.

Over the course of the three years, a total of 62 ELC participants fall into the category of first year freshman, while any other participants that transferred into the college or were not freshmen are not considered here. The data obtained is restricted to first year freshman students so that we

may consider the effects that the ELC has on first year retention. Furthermore, first year retention is affirmed when a student completes their entire first year and registers for courses in engineering in their second year.

Quantitative Methods

This mixed-methods sequential study design first investigated the quantitative retention and GPA data for the ELC participant sample [10]. Tables 1 and 2 show the sample sizes and retention rates between two groups, the ELC participant group (treatment group) and the general population of the College of Engineering first year students (control group). Retention rates and GPA between the two groups were compared to determine if a difference exists between the ELC and non-ELC groups.

Table 1. Count of ELC participants vs. Non-ELC First Year Engineering Students

Cohort	ELC	Non ELC
2016	14	122
2017	29	115
2018	19	168
Total	62	405

Table 2. Retention Rates in Engineering for ELC and Non-ELC Students After One Year

Cohort	ELC	Non ELC
2016	71.4%	55.7%
2017	62.1%	56.5%
2018	57.9%	54.8%
Average	63.8%	55.7%

Qualitative Methods

Three convenience sampled students from the ELC were interviewed to expand upon quantitative data analysis. The purpose of these interviews is 'contextualization:' to add richness and detail to individual student experiences, present themes of ELC success, and provide additional themes for improvement as the ELC program moves forward [11].

One of the known challenges of a sequential mixed-methods study design is the sampling of students in the cohort for follow-up interviews [10]. In this case, students were convenience sampled. Students were first contacted either by a familiar professor or student mentor via email. All efforts were made to contact the entire population of ELC participants (N=62), including those who did not retain in the College or in the university at large. Participants were contacted regardless of demographic information, high school GPA or college GPA. Because the qualitative perspective of this study is specifically focused on the ELC and the experiences of students therein, only ELC students were contacted for interviews.

Qualitative research methodologists have long debated the ideal number of interviews needed in order to reach "knowledge saturation," which is defined as the point at which an additional

interview will not yield additional themes of information around the research topic [12]. The point of saturation is largely dictated by the homogeneity of the sample and the specificity of the interview protocol [13]. The more homogenous the sample and specific the interview protocol, the fewer interviews are needed in order to reach saturation [13]. For this study, the participant sample is relatively homogenous, for example all ELC participants were college freshmen. The interview script and research question are both specific (Appendix A). This leads to the conclusion that three interviews are enough to reach saturation for the purposes of this study. The participants' identities were kept confidential from all faculty members through a 2-step de-identification schema that is kept on a password-protected server, per IRB approval #1807353208. All interviews were recorded using a personal device and immediately deleted upon transcription. Transcripts have been de-identified as described above and stored on a password protected document drive with restricted access. Member checks of transcribed interviews were sent to interviewees and approved for accuracy.

An exemplar interview conducted with a research team member was code-calibrated by the research assistant and a faculty member to generate and define *a priori* codes for the three target interviews. Codes were iteratively re-defined and refined throughout the coding process through on-going conversations with the research team through constant comparison analysis [14]. For example, the statement "it's great to sit down with somebody that's further along in college, that's been through it" was coded *Mentoring* due to the direct reference to an older student sitting down and communicating with the interviewee. Codes were then collapsed into themes in order to reduce the data down to overall patterns of response [14]. After coding for themes, classical content analysis was used to determine the frequency of each theme and highlight the importance of the themes based upon their overall frequency across all interviews [15]. Final codes, definitions, and examples are listed in Appendix B.

Results

Binary Logistic Regression Model

In general, students who perform well academically have a strong chance at being retained in engineering. Moreover, we want to prove that being in the Engineering Learning Community has a positive effect as well. To quantify these relationships, we use binary logistic regression models to indicate if having a strong GPA at the end of the first year has a positive or negative effect on being retained after that year, and if ELC plays a role as well. The following results provide evidence for the idea that good grades are associated with being retained. These models include data collected for the entire three-year range described above, and can be defined by the commonly known log of odds formula:

$$ln\,(\pi) = \beta_1 + \beta_2 x + \beta_3 x \qquad (1)$$

Where:
$\pi = Odds\ of\ Retention$
$x = 1^{st}\ Year\ GPA$
$\beta_i = Coefficients\ to\ be\ determined$

The results from these regression models indicate that first year GPA is strongly related to first year retention rates in the engineering at our University. The estimates for the coefficients can be seen for both cases in Tables 3 and 4. Furthermore, the second model indicates that participation in the ELC also has a positive effect, however we believe that due to small sample sizes, the p-value is 0.269. In other words, there is a 26.9 percent chance that the observations are random. Given the nature of this study and the relatively small sample sizes for ELC cohorts, we have accepted the results from the model.

Table 3. Results from Binary Logistic Regression Model performed in R

Coefficients	Estimated Std.	Error	Z value	Pr(>|z|)
$\beta_1 = Intercept$	-2.3189	0.3377	-6.867	6.57e-12
$\beta_2 = 1st\ Year\ GPA$	1.0088	0.1240	8.138	4.03e-16

Table 4. Results from Binary Logistic Regression Model that Include ELC Participation

Coefficients	Estimated Std.	Error	Z value	Pr(>|z|)
$\beta_1 = Intercept$	-2.3654	0.3411	-6.935	4.08e-12
$\beta_2 = 1st\ Year\ GPA$	1.0091	0.1240	8.138	4.03e-16
$\beta_3 = ELC\ Participation$	0.3448	0.3122	1.105	0.269

To take a step further, these results are used to analyze the probability of being retained after accounting for first year GPA and again for the model including ELC participation. This probability is calculated using the corresponding formula:

$$Probability\ of\ Retention = \frac{e^{\pi}}{1+e^{\pi}} \quad (2)$$

This formula is then used to calculate the probability of retention and used to make inferences about students in engineering at out University across the entire range of possibilities. The probability relationship generated by these models reflects the idea that having a higher GPA at the end of the first year is associated with having a higher probability of being retained. It represents the affiliation between retention and GPA and is not a direct correlation. The results also reveal that this relationship is enhanced for students who participate in the ELC. The first observation of this plot is that the overall probability of being retained is higher for ELC students. The second observation is that in the range of GPA's from 1.0 to 3.0, ELC students have a larger increase in probability of being retained for an increase in GPA of any amount. That is to say that the slope of the curve is steeper in this range. The second observation directly shows that average and below average students benefit the most from being ELC members. In that range, an increase in 0.1 GPA has an increase of 2.9% probability for ELC students and an increase of 2.3% probability for Non-ELC students. These results are shown in Figure 1.

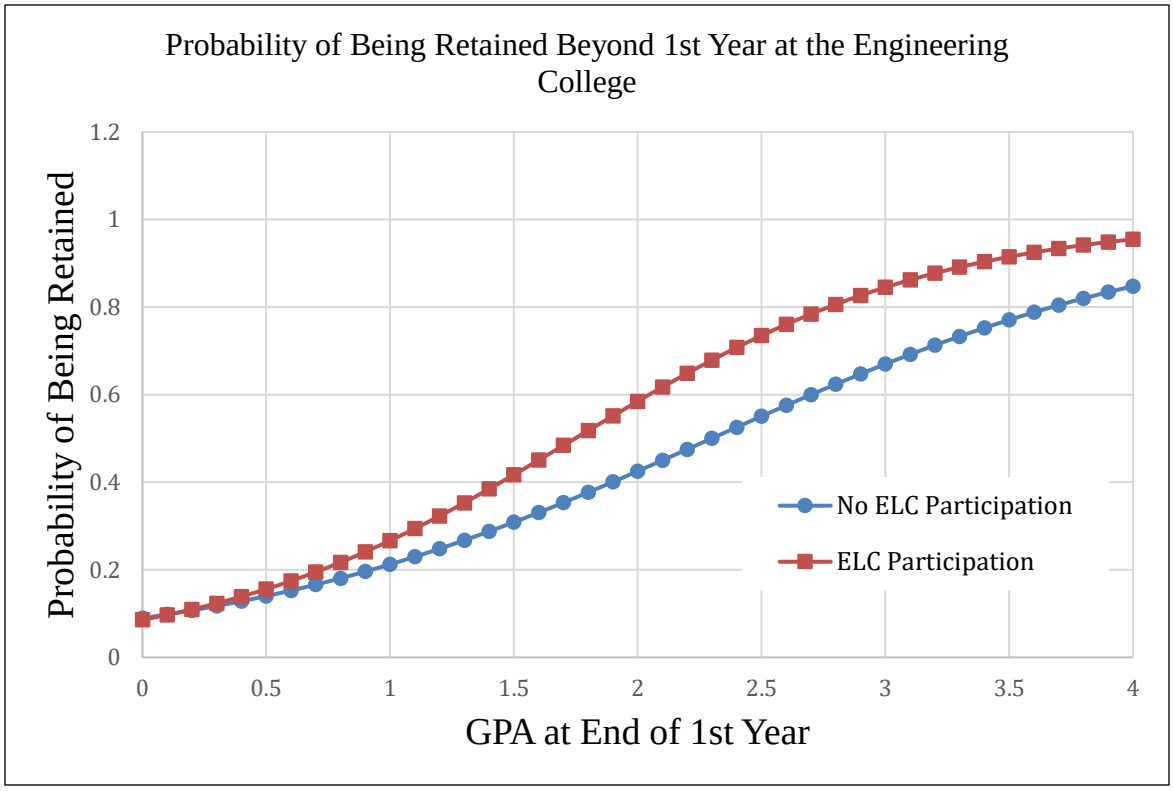

Figure 1. Probability of First Year Retention based on both binary regression models

ELC Impact on Retention of Average Students

After observing the first three cohorts of the Engineering Learning Community, the data indicates that ELC participants have larger retention rates when compared to the control group. Furthermore, if these retained students are split into three sub-categories regarding their High School GPA: Low, Medium, and High, it is more common that students with low High School GPA have higher retention rates when they participate in the ELC. This observation indicates that the average or below average high school student benefits the most from being in the learning community during their first year as engineering students. Tables 5, 6, and7 show these retention rates as percentages of their respective category. When added up, they amount to the total retention rate for each category for that year.

Tables 5. First Year Retention & High School GPA from Cohort of 2016

GPA Level	H.S. GPA	Non-ELC	ELC
Low	(0.0 , 3.0]	13.00%	14.30%
Medium	(3.0 , 3.5]	15.70%	35.70%
High	(3.5 , 4.0]	25.00%	21.40%

Table 6. First Year Retention & High School GPA from Cohort of 2017

GPA Level	H.S. GPA	Non-ELC	ELC
Low	(0.0 , 3.0]	8.60%	10.30%
Medium	(3.0 , 3.5]	18.10%	20.70%
High	(3.5 , 4.0]	29.30%	31.00%

Table 7. First Year Retention & High School GPA from Cohort of 2018

GPA Level	H.S. GPA	Non-ELC	ELC
Low	(0.0 , 3.0]	3.70%	10.50%
Medium	(3.0 , 3.5]	18.30%	15.60%
High	(3.5 , 4.0]	33.50%	31.60%

To investigate the effects that the ELC has on these students further, we consider their College GPA at the end of their first year and observe if the ELC helps them become better students. It is believed that this Learning Community specifically encourages engineering students to create a STEM identity and subsequently piques their interest in excelling academically in their Engineering program.

ELC Participant Distributions

In order to prove that students who self-select into the Engineering Learning Community are not inherently better students than those who do not participate, we compare the relative density distributions for ACT/SAT scores as well as high school GPA. Figure 2 shows these distributions side by side for a visual comparison which show similar distributions for both groups. This indicates that before these students arrive at the Engineering College, both groups have students with similar ranges of academic achievement. These distributions also lay the foundations for observing differences in the same students after their first year of College. Since they are similar before they arrive, any observed differences after their first year will be affiliated with being an ELC participant or not.

ELC Participant, Average GPA, and Retention

Participation in the Engineering Learning Community is thought to increase student collaboration from an early stage in the first semester in hopes that students will begin forming study groups and good study habits together that will continue through their entire four-year journey. Furthermore, the Special Topics course is thought to enhance the student interest in Engineering through hands-on design projects. The data collected for this study tends to indicate that participation in the ELC is associated with having higher average GPAs at the end of the first year at the College.

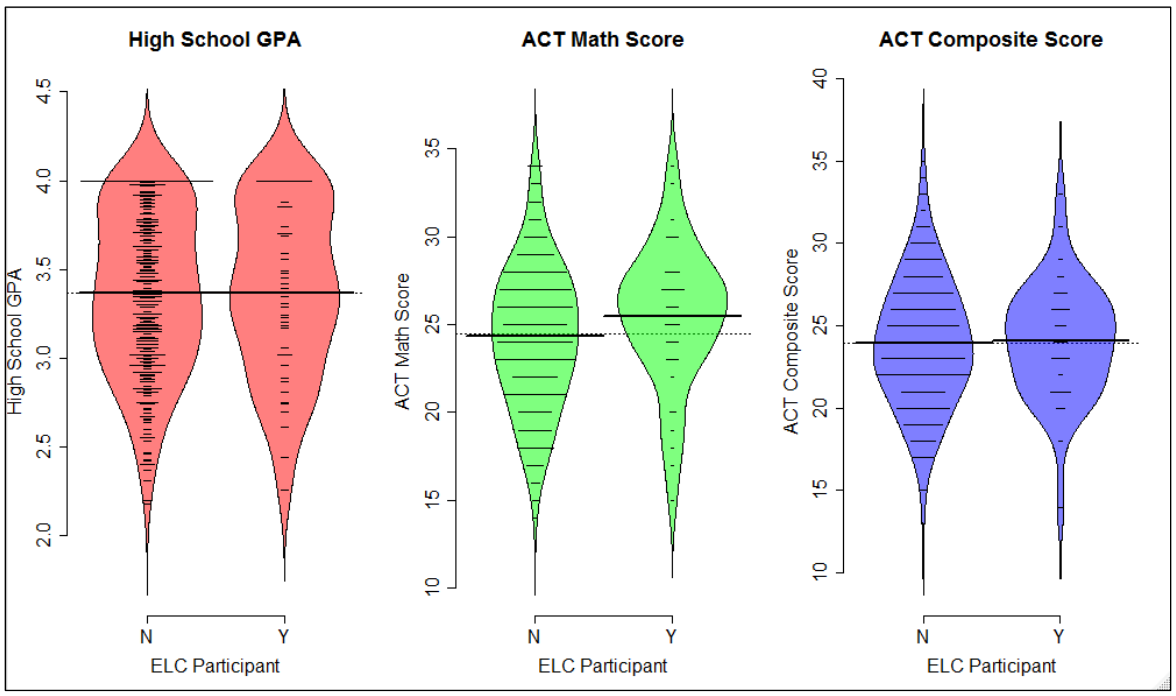

Figure 2. Density Distributions of ACT Math, ACT Comp, and High School GPA for Students at the Engineering College: The visual comparison between ELC Participants and Non-Participants shows both groups have similar academic scores before they begin their first year at the Engineering College

The box plot of Figure 3 visually indicates this affiliation marginalized across the entire three-year range. They reveal that, on average, for both retained and not retained students who participate in the ELC, have higher GPAs than non-participants. The plot on the left is provided to show again that students who self-select into the ELC are not inherently better students than non-participants before they arrive at the college.

ELC Participation, Average GPA, and Cohort Term

The box plot of Figure 4 show First Year GPA against ELC participation for the three years of observations. They indicate that each year the students who self-select into the ELC end up with higher average GPAs at the end of their first year at the college. Again, the plot on the left shows the same thing for High School GPA and indicates that ELC students do not have higher average GPAs at the High School level before they arrive at the Engineering College.

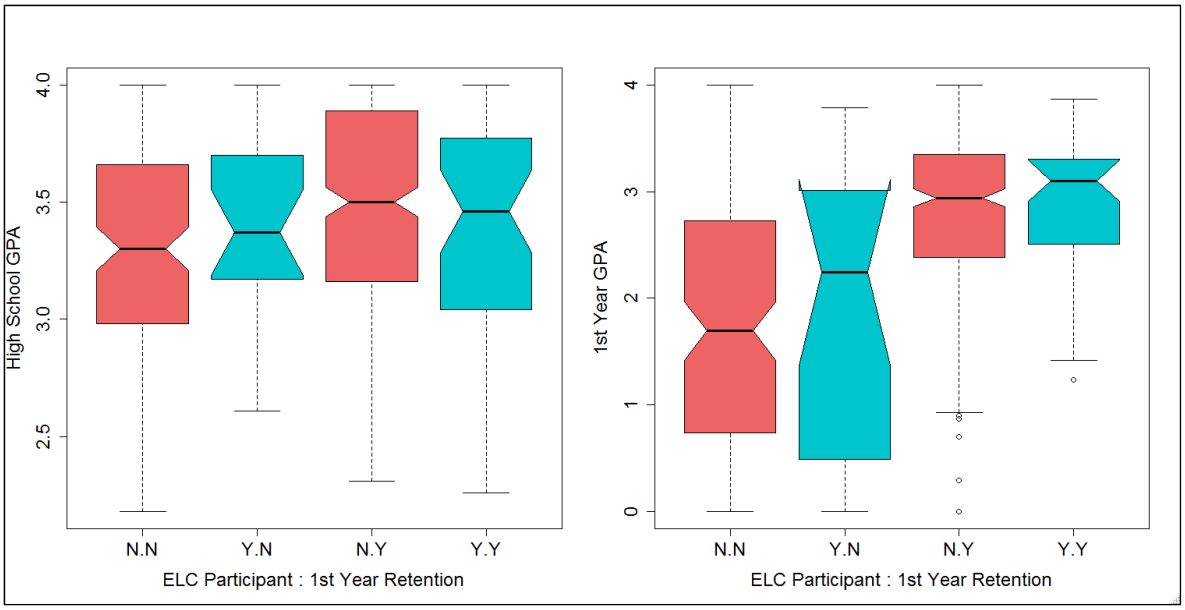

Figure 3. Box plots for High School and First Year College GPA weighed against ELC Participation and First Year Retention. The lower axis subsets the variables ELC Participation: 1st Year Retention where Y.Y means yes for both

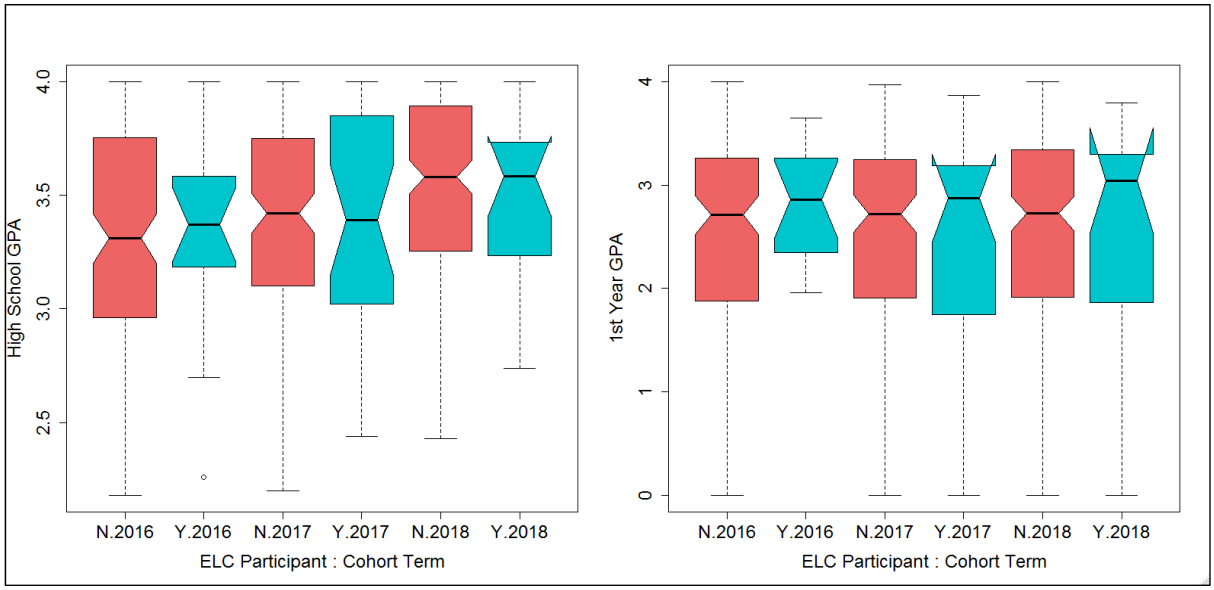

Figure 4. High School and First Year College GPA for ELC participants and non-participants for each cohort term. The lower axis subsets ELC Participant: Cohort Term where Y.2016 confirms ELC Participation in 2016

Interview Results

Through the process of coding in the interviews, themes emerged in alignment with the final codes by frequency of code occurrence and balance of occurrence across all three interviews [15]. For example, Social codes emerged consistently in all three interviews, indicating that social opportunities are a core benefit of ELC participation. This finding supports previous research on the benefits of cohort learning experiences [5, 7]. Disconfirming examples were discovered and explored for Social, Introductory Design (subcode of Feedback), and Resources. These disconfirming examples serve to highlight students' unique experiences and needs based upon their individual perspectives and backgrounds.

Four key themes emerged from iteratively coding the interview transcripts: Relationships, Resources for Transition, Mental Health, and Feedback. Each of the themes played an integral role in students' experiences of the ELC, both in positive and negative ways. The themes were developed through logical interpretation of related ideas and code co-occurrence. Overall, Resources co-occurred with other codes the most, 18 times, and Professor Connections co-occurred the least, 3 times. Because Resources co-occurred across many contexts, it features in multiple themes. Feedback co-occurred 6 times, with the Social, Resources and Attitude / Mindset / Emotion codes, predominantly around the need for more mental health support for new college students. Specific development for each theme is discussed below. See Figure 5 for an overall picture of code dispersion.

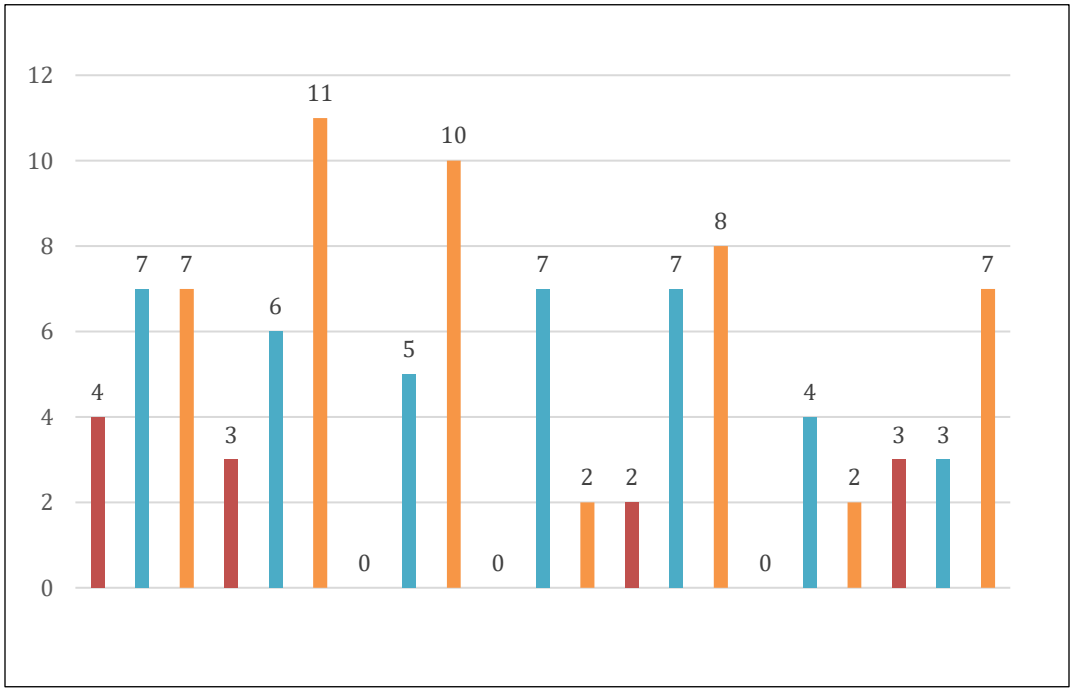

Figure 5. Code Frequency by Interview (A, B, C) and Code

Development of Four Key Themes from Interviews

Theme I: Relationships

The codes for Social and Professor Connections make up this theme. Each of these codes relates to the idea of spending intentional time connecting with others, whether peers, mentors or professors. This theme represents almost a quarter of positive impact of the ELC mentioned by interviewees (24/98 total codes: 24%). This theme was also the most dispersed across all three interviews; 33% of the codes in interview A, 28% of B, and 19% of C. Interview A summarized the positive impact of relationships this way:
"I recognize a lot of people and we'll collaborate and meet at the library to work on stuff. So, it's been a good way for us to keep in contact through these classes and *we've all been together from the beginning."*
Interview B summarized professor connections as a positive way of getting access to a job and being a successful engineering student when stating:
"my professor has been a huge supporter in trying to get me on the right track, making sure I'm doing what I'm supposed to, preparing myself for the future as an engineer."
Two disconfirming examples of the positive impact of socialization for ELC students occurred in Interview C. Both described how socializing can be tiring and straining for busy students, especially those who identify as introverts and need time to recover from extensive interaction with others. This instance co-occurred with Feedback, as the student suggested having purposeful social time planned, such as study groups, in lieu of social time for the sake of socializing, such as going to a theme park. These disconfirming examples show that relationships are still a chief positive impact of the ELC, when tailored to the unique needs and personalities of engineering students [8].

Theme II: Resources for Transition

This theme is made up of Resources, Mentoring, and Transition to Adulthood, which cumulatively co-occurred 11 times in the data. This theme is the most prevalent theme in the data; almost half of the comments made by the interviewees related to the importance of accessing school resources including mentoring to support their transition from high school to college life (41/98 total codes; 42%). Interestingly, Interview A did not mention anything related to either college resources or mentoring, and only mentioned the transition to college twice. Interviews B and C heavily discussed the importance of this theme, stating the positive aspects already inherent in the ELC. Interview B stated:
"[in high school] you had five minutes between classes, now you have two hours between classes. [Mentees ask me] What do I do with myself? Well, you can go to the writing center, or find tutors, or take a nap."
Interview C highlighted the importance of having specialized resources like study labs for ELC participants:
"I found out they had a math lab and I definitely went there every single week. I was using it to its full extent whenever I was struggling with certain problems or content."
Two disconfirming examples of the positive impact of resources for students occurred in Interview C. These co-occurred with the Feedback code, as the interviewee described how

current campus resources are not reserved for ELC students and can be underused or misused as a result:
“I know they do have study labs, but usually they’re fairly limited and have people from all over trying to get in [...] It can get really busy and as a new student, if I come in and see there’s a line of 12 students before me, I’ll just go and try to figure it out on my own.”

Theme III: Mental Health

This theme is made up of the Mental Health code, which has three subcodes: Attitude, Mindset, and Emotions. Resources co-occurred often with these subcodes, primarily because of Interview C’s commentary on the importance of improving mental health resources for ELC participants. This will be explored further in a section dedicated to the Feedback code. Attitude, Mindset and Emotions represented 20% of the total codes in the interviews. It was well represented across all three interviews: 25% of the codes in interview A, 15% of B, and 23% of C. As a subcode, Attitude reflected multiple interviewees’ comments that much of student success is dependent on the individual students’ willingness to put in the required effort for success in engineering:
“If you walk in expecting that this will be a fun easy major and then get hit with the (academic) brick wall, it’s a lot harder than if you’re expecting it (to be hard);”
“I definitely have a general strategy of what I want to do here; I’ve been focused on what I need to do.”
Mindset reflected multiple interviewees’ view of themselves as engineering enduring since before coming to college:
“I’ve always been an engineer at heart”
“When I was little, I wanted to design airplanes”
“I’m a huge gearhead. I love building motors, cars, anything with wheels.”
“I’ve known it since I was young. I’ve always wanted to be an aerospace engineer.”
“I’ve always wanted to work at Lockheed Martin. They hire a lot of mechanical engineers, so I picked that.”
Finally, Emotions reflected the emotional toil that studying engineering can take. Interview B noted: “A lot of my mentors are confused and don’t quite know what’s expected of them.” Interview C stated:
“when kids fail for the first time, they get really discouraged and lost;”
“it’s like a big tower of work and anxiety that hits you immediately;”
“the job market is competitive, which causes anxiety and worry, and you’re saying to yourself ‘there’s no way I can succeed, there’s no way I can do as well as this guy.’”
Overall, the Mental Health code co-occurred often across many other codes and represents a significant response theme for the interviewees. Resources including mentoring relationships, professor relationships, study labs and social relationships all support student mental health, but more can be done, as we will see in the Feedback theme [9].

Theme IV: Feedback

This final theme had four subcodes, as key ideas for ways to improve the ELC occurred multiple times. See Table 8 for a comprehensive list and counts of subcode occurrences.

Table 8. Feedback Sub-Codes Frequency and Examples

Subcode	Count / Percentage	Example
Special Topics	3 / 23%	"The first class, Special Topics, I wish that was organized a little better."
ELC-Specific Academic Supports	3 / 23%	"I think the best thing the ELC can do is incorporate set weekly study groups or open labs that are specific to ELC students or younger college students."
Individualized Experiences	3/ 23%	"18 credits per semester isn't really reasonable for most students." "Some students should get a job on campus because everything you need for the week is right here." "It would be great if there was somewhere to share these thoughts, get some closure or something."
Extend ELC to Sophomore Year	4 / 31%	"Continue having these ELC classes further into the degree." "The focus should be freshman year, but it shouldn't cut off entirely after that; it should trickle off toward the end of sophomore year."

It is important to note that these interviewees participated in the first three years of the ELC and many changes have been made that reflect responsiveness to student concerns. For example, the Special Topics class has become more focused and streamlined to reflect the important process of design that accompanies engineering for a specific user audience and marketability. The ratio of mentors to mentees has been improved to provide more personalized support to students that can be individualized and responsive; in addition the mentors are all previous members of the ELC, so they have a strong context for the needs of incoming ELC students.

A recommended next step for the ELC would be to consider strategies for extending the supports offered by the ELC into sophomore year, as that was the most common feedback provided by interviewees. One interviewee mentioned that, academically, sophomore is more demanding and intensive academically than freshman year, and the additional support would be especially salient in helping students establish strong relationships and good study habits during that time [4].

Conclusion

These sequential mixed methods study first explored the GPA and retention data of three cohorts of freshmen in the Engineering Learning Community program. The ELC provides a wide variety of supports, from mentoring to socializing to specialized classes. Analysis of boxplots, comparing ELC participants and Non-participants indicates that being a member of the ELC helps students to become more interested in engineering overall and provides a platform for student collaboration that ultimately shows through in final grades. In turn this increased GPA is highly associated with an increase in the probability of being retained beyond the first year at the Engineering College. The fact that retention rates for the three cohorts observed are higher than those of their Non-ELC counterparts is evidence that our statistical models have merit. In time when the overall sample size becomes larger, we hope to show more statistical significance through smaller p-values.

In order to determine which of the ELC supports have been the most impactful on student retention and to gather feedback about continuous improvement, interviews were conducted with three cohort members. These interviews revealed the key impact of social-emotional experiences in college, the challenge of transitioning to a more independent life in college, and the value of accessing resources such as tutoring, mentors and professors. Key areas of feedback include refining ELC classes, increasing academic and mental health supports, addressing unique student needs, and extending the ELC program to sophomore year. This feedback shows the desire for *more* of the ELC in the engineering degree program, not less, which indicates that, overall, students recognize and value the benefits of being in the ELC program.

A convenience sample of three interviewees represents a key limitation to this research. More interviews across diverse demographic groups would enhance the richness of the ELC story. The ELC is in a continuous state of improvement, with changes and enhancements offered each year. The fourth cohort, for example, has been given scholarship funds and online networking opportunities with engineering students across the United States. Mentor to mentee ratios continue to shrink, and the ELC support staff (research assistants, teaching assistants, etc.) continues to grow. Additional research on the impact of these changes upon retention, GPA and unique student experiences is warranted to evaluate the impact of these changes.

Acknowledgment

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Appendix A: Interview Questions

Research Question:

What are ELC students' perspectives on the benefits and drawbacks of the ELC?

1. Tell me a little bit about yourself.
2. How did you hear about the ELC?
3. What did you think of your experience as an ELC student?
4. What was the best part of the ELC?
    a. Follow-up: Tell me more about that.
5. Is there anything that the ELC did not provide that you expected?
    a. (If no) Why do you think some students struggle despite the support/resources provided by the ELC? Is there more we could do to help them?
    b. (If yes) Tell me more about that. Did that impact your decision to continue in Engineering?
6. If you could change anything, what would you change in order to improve the ELC?
    a. (If nothing) Why do you think some students struggle despite the support/resources provided by the ELC? Is there more we could do to help them?
    b. (If something) Tell me more about that. How would that impact the ELC experience for students?
7. Do you know anyone who chose to leave Engineering? Tell me about that.

Appendix B: *A Priori* Interview Codes

Code	Definition	Example
Social	Friendship development, collaboration on class projects, intentional coordination of activities based on a desire for interaction with peers	"The ELC was a great experience to push us together so that I don't see random kids every class and don't know who to talk to."
Mental Health	Reflections on internal mental and emotional processes, needs, or reactions, and the influence of those processes on academic performance. Subcodes: 1. Attitude 2. Mindset 3. Emotions	"It's not just that you have this large pile of work, it's that you feel 'I can't do this pile of work, I'm not good enough to do this, I'm gonna get stuck'."
Mentoring	Activities related to being mentored and/or mentoring others in a peer-to-peer interaction and impact of said activities	"It's great to sit down with somebody that's further along in college, that's been through it."
Resources	Recommendations and use of college resources including, but not limited to campus tutoring labs, transportation, student services, and more.	"I've recommended the physics tutoring center, the writing center and the math center, those are the ones I end up pushing people to the most."
Transition to Adulthood	Impacts of changes in expectations, workload, freedom and independence from high school to college upon decision-making around academics, time-management, employment decisions, and related behaviors.	"There's a lot of changes between high school and here; in high school you showed up at 8am and got out at 3pm and you have five minutes between classes. Now I have two hours between classes, what do I do with myself?"
Professor Connections	Impact of relationships and connections with professors involved in the ELC upon student academics and participation	"She's a great professor. I still try to get advising appointments with her."
Feedback	Mentions of ways to improve the ELC experience for future cohorts. Subcodes: 1. Special Topics 2. Extension to Sophomore Year 3. Additional Resources 4. Miscellaneous	"Maybe continue having those ELC classes further into the degree. Because I feel like after freshman year, we really didn't have anything."