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Work in Progress: Strategic, Translational Retention Initiatives to Promote Engineering Success

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Abstract

This **Work in Progress** will describe a pilot program designed to integrate and streamline existing coursework and resources at Clemson University to improve the engineering graduation rate and enhance the educational and social experiences of students who begin unprepared for Calculus I. Initial mathematics placement is a strong indicator of engineering matriculation beyond the first year. Students who begin at the Clemson University in Calculus I have a historic 68% six-year graduation rate within an engineering major. In contrast, students who begin in "Year-Long Calculus," an extended two-semester sequence for Calculus I, have a historic six-year graduation rate within an engineering major of 40%. First-year engineering students in Year-Long Calculus also fail the introductory engineering and chemistry courses at a higher rate than their Calculus I counterparts.

This paper will describe a pilot program designed to surround Year-Long Calculus students with intentional, targeted support within a community of learners. The program features co-enrollment in a two-credit course, developed by the engineering faculty and Academic Success Center (ASC) personnel. The overall course goal is to help students develop metacognitive awareness of their development in the domain of becoming successful STEM students. The program uses Entangled Learning as its pedagogical philosophy. Developed at Clemson University, Entangled Learning is a heuristic that empowers individuals to direct their own learning through intentional peer-to-peer collaborations and rigorous documentation, particularly in areas of narrating, self-regulating, critically reflecting, integrating, and collaborating.

Students are introduced to and encouraged to utilize existing support resources housed within the ASC, creating a single point of contact, eliminating the overload of choices for students, and maximizing collective impact. The ASC provides programs such as professional academic coaching, Peer-Assisted Learning, and content tutoring services, all of which are proven effective in enhancing retention, scholarship retention, and graduation rates.

The pilot program began in August 2017. Preliminary results during the fall semester are encouraging and suggest this may be an effective model for supporting first year, at-risk students in engineering. The paper will include a description of the new course and additional support efforts. Academic data for the Year-Long Calculus student group in comparison with the Calculus I student population are presented for historical data and for the pilot program. Preliminary qualitative data will be included to illustrate the experience of these students. Finally, we will suggest considerations for future implementations.

Introduction

This paper describes the program and initial results of the first semester of a new initiative to improve the academic success of students entering the General Engineering (GE) program at Clemson University (CU). The long-term goal of the program is to improve the engineering graduate rate and enhance the educational and social experiences of students who begin unprepared for Calculus I. Initial mathematics placement is a strong indicator of engineering matriculation beyond the first year. Students who begin Clemson in Calculus I have a historic 68% six-year graduation rate within an engineering major. In contrast, students who begin in "Year-Long Calculus," an extended two-semester sequence for Calculus I, have a historic six-year graduation rate within an engineering major of 40%. First-year engineering students in Year-Long (YL) Calculus also fail the introductory engineering and chemistry courses at a higher rate than their Calculus I counterparts.

Our program, called General Engineering Learning Community (GELC), combines social and academic environmental changes for students who are underprepared in calculus. Social changes include programming to establish and sustain development of community and collaboration. Academic changes include cohorting the underprepared students into their own sections of the Engineering I course, co-enrolling them in a study skills course, and requiring participation in a weekly peer collaboration session.

We present mixed methods analysis to assess program effectiveness and evaluate its success. Quantitative data includes individual course grades, GPR, and DFW rates. Qualitative data includes reflections, course work, and portfolio material from paired students in two categories who represent student characteristics of particular interest with low and high-predicted academic success. The results of the first semester of the program pointed to success for some categories of students, suggesting the overall concept is promising.

Background

All engineering students at Clemson begin their academic journey as a GE major and are required to complete a first-year curriculum sequence before declaring their intended engineering major, shown in Figure 1. To matriculate out of GE and into a degree-granting engineering major, students must pass the following classes with a C or better, and meet the grade point ratio (GPR) requirement for the desired engineering department: Chemistry, one semester; Calculus I and II; Physics, one semester; General Engineering, two semesters; and English Composition. Most departments require a 2.0 GPR; some have requirements that are more stringent. For example, Bioengineering has a requirement of a 3.0 to ensure

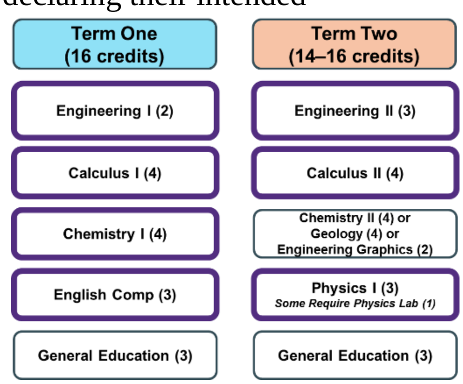

Figure 1. GE curriculum listed in 2017-2018 Undergraduate Announcements.

students who enter this major can successfully matriculate to graduate school, as most graduates in this field continue to pursue an advanced degree. GPR restrictions ensure student success both in the major and upon graduation.

In the first term, students who do not have Advanced Placement (AP), International Baccalaureate (IB), Dual Enrollment (DE) or transfer credit for Calculus I are placed into a math course based on their Clemson Math Placement Test (CMPT) score, shown in Figure 2. Prior to 2013, CU administered a placement exam developed at Clemson; since 2013, Clemson has used the Assessment and LEarning in Knowledge Spaces exam (ALEKS [1]) to assess students for math placement. Students who score lower than 80 place into one of two tracks. The first track enters students in PreCalculus in the first term, and then students advance into Calculus I, then Calculus II. The second track enters students into "Year-Long (YL) Calculus". YL Calculus is a two-semester sequence course. The first semester is four-hours, pass/fail and devotes one-third of the semester reviewing pre-calculus material, followed by Calculus I material. The second semester is a four hour graded course. Students passing both semesters of YL Calculus earn credit for Calculus I. In this sequence, students spend almost twice as much time on each topic than in regular Calculus I [2]. Students then advance into Calculus II. The Clemson Mathematical Sciences department has used YL Calculus since 2009.

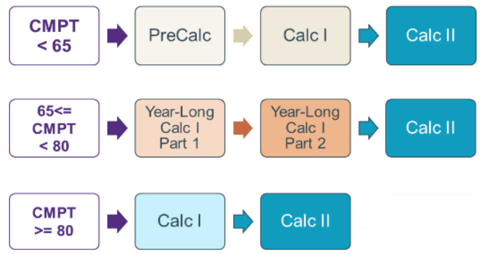

Figure 2. CMPT score impact on math placement and length of stay in GE.

In both tracks, students require an extra term to complete the coursework necessary to declare an engineering major. Since 2013, approximately 13.5% of incoming new undergraduates in GE have placed into PreCalculus or YL Calculus, representing 128 students per year on average, shown in Figure 3. Students who place into PreCalculus are not eligible to enroll in Chemistry I or Engineering I and are not considered in this analysis.

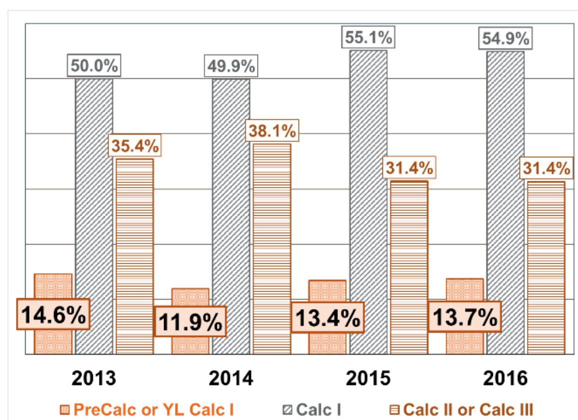

Figure 3. GE enrollment based on math placement, 2013 – 2016 for new undergraduate students.

Initial math course placement carries with it significant implications for graduation. A study of six-year engineering graduation rates based upon entering math course at Clemson, shown in Table 1 below, indicates that students who place into Calculus I or higher as their initial math course have a six-year graduation rate in an Engineering major of 65.4% or higher. In contrast, students who place into YL Calculus have a 40.4% six-year graduation rate in an Engineering

Table 1. Six-Year Engineering Graduation Rates based on initial math placement, 2006 – 2010 cohorts [2]

Starting MATH Course	6-year Graduation Rate in Engineering Major
PreCalculus	19.1
Year-Long Calculus	40.4
Calculus I	65.4
Calculus II	68.5
Calculus III	78.5

major; those placed into PreCalculus are at 19.1%. The data spans the entering cohorts in 2006 – 2010 of first-time enrolled undergraduates admitted as GE majors (n values: PreCalculus=173; YL Calculus=695; Calculus I=1772; Calculus II=619; Calculus III-637) [2].

The initiative of interest in this current study is not the first attempt to address student success for underprepared calculus students. In fall 2015, an initiative was undertaken to improve the engineering course content and delivery. This change is called PREPARE, and is outlined in the literature [3]. While the YL Calculus cohort had seen marginal improvement in pass rates, they continued to be at least 20% behind students who begin in Calculus I. The pass rates for the Engineering I course based on math placement. In addition to having a lower pass rate in Engineering I, students who begin in the YL Calculus I have lower passing rates in math and chemistry courses when compared to students who began in Calculus I as shown in Figure 4a and 4b.

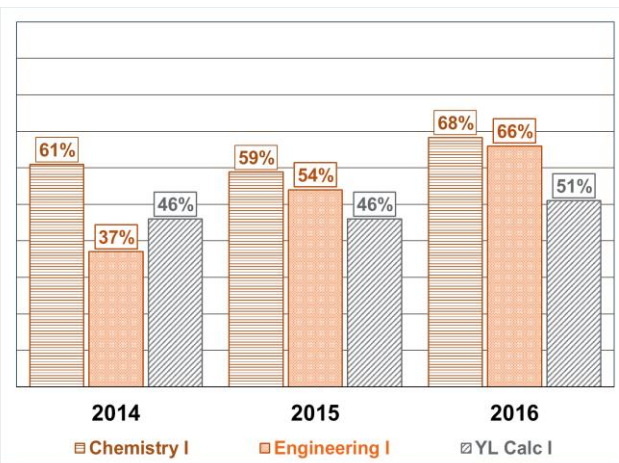

Figure 4a. Pass rates in Chemistry I, Engineering I and Year-Long (YL) Calculus I in GE 2014 - 2016

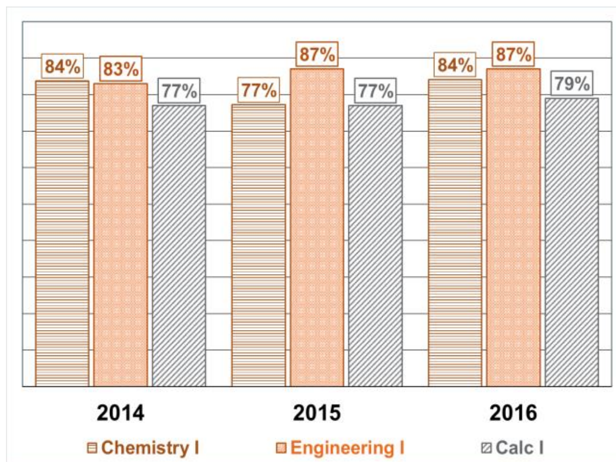

Figure 4b. Pass rates in Chemistry I, Engineering I and Calculus I in GE 2014 - 2016

To increase the overall graduation rate with engineering, we piloted a program in fall 2017 with the goal of increasing the academic success of students who begin the engineering sequence in YL Calculus.

Our Solution

To address the problem of lower academic success, we created the General Engineering Learning Community (GELC). Students were invited to opt in if their score on the CMPT placed them into YL Calculus. These students were cohorted into three sections of Engineering

I and co-enrolled into the same sections of a study skills course. The same instructors taught the Engineering I course and the study skills course sections. An assistant director of the ASC participated in the design and delivery of the study skills course.

The foundation for programming and academics that characterizes the GELC is based on a specific approach that emphasizes collaboration, reflective practice, and well-documented skill development. Figure 5 illustrates this approach, called Entangled Learning (EL) [4]. This approach models a process for deeper learning piloted for the past three years at Clemson in a training course for peer educators [5, 6]. Four interconnected areas constitute the model.

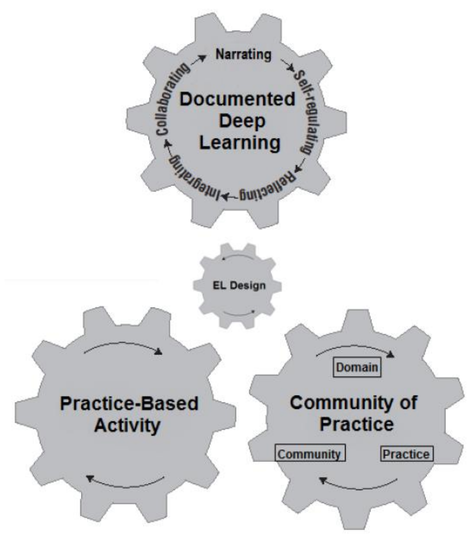

Figure 5. Entangled Learning Design
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The first is articulating an individual's sense of purpose and motivation, expressed as their learning design. Second is support and participation in a community of practice (CoP) [7, 8] whose domain is becoming a skillful STEM student. Third is engagement in practice-based activities (such as doing homework, participating in academic support programs, engaging in effective learning strategies, etc.). Finally, documenting deep learning includes skill development by documenting self-regulating behaviors, critical reflection, integrating knowledge, collaborating, and synthesizing learning into one's own narrative as a portfolio [9].

EL principles guided program design decisions, such as planning for initial community-development and workshop programming during an initial Early Fall Move-In period, as well as the structure and assignments of the study skills course.

Our analysis involved a mixed methods approach to understanding students' success. We used quantitative data to evaluate utilization of services to support academic success and academic success. Qualitative data provides insights into factors that may have contributed to success.

Timeline of placement and cohort formation

At summer orientation, students with CMPT scores between 65 and 80 attended a separate registration advising session to explain the GELC program. Students who opted into the program registered for YL Calculus I and corresponding Engineering I and study skills courses. Each math section was comprised of 15 GE students out of the 45 total students in each section. Other majors who take the YL Calculus sequence are also in STEM fields such as Architecture, Computer Science, Biochemistry, Biological Sciences, Chemistry, Microbiology, and Physics.

Cohort demographics
In fall 2017, 142 GE students enrolled in YL Calculus. The entire new undergraduate enrollment in GE in fall 2017 was 1063, making the enrollment in YL calculus 13.3% of the new undergraduates.

During summer orientation, 110 students opted into the GELC program, 91% of those offered the program. Eleven of the students turned down the program at orientation. The remaining 21 students in YL Calculus but not part of the GELC are part of two cohorts. The first group indicated at orientation they had prior AP calculus experience, and were going to attempt to retake the CMPT to gain access to Calculus I but ultimately did not raise their score. There were 13 students in this group. The second group attended the final orientation session in August or moved into YL Calculus after classes began, with their late enrollment in the course making them ineligible for the GELC. There were eight students in this group.

In the overall GE new undergraduates in fall 2017, 28.5% were female; 13.4% were first generation; 36.4% were from out of state; and of those from South Carolina, 14.9% were from the “Promise Zone.” The “Promise Zone” is a group of 20 high-poverty communities named by the Obama Administration in 2013 in an effort to raise awareness of the need for economic development in these areas. The breakdown of the incoming students by race is as follows: 83.4% Caucasian, 5.5% African American, and 11.1% other non-white races.

The makeup of the GELC community for fall 2017 was as follows: 28.2% were female; 23.6% were first generation; 27.3% were from out of state; and of those from South Carolina, 25% were from the “Promise Zone.” The breakdown of the GELC students by race: 77.3% were Caucasian, 11.8% African American, and 10.9% other non-white races.

Program Components
Early move-in: Programming included the encouragement for students to move in three days prior to the "regular" freshman arrival during August. During this extra time, students attended a series of workshop-style presentations geared toward preparing them to make the most of the fall semester. Events included presentations on effective study strategies, communities of practice, and EL as the philosophical foundation of the program. Time was also devoted to teambuilding activities and informal activities with faculty and staff.

One of the primary goals of the early move-in was to make students comfortable in the ASC facility so they would utilize tutoring and Peer-Assisted Learning (PAL) services. The hope was that the students would form a point-of-attachment with the ASC. Studies conducted by the ASC demonstrate the success in first- to second-year retention rate, scholarship retention, and six-year graduation rate of students who utilize the available services [10].

Study skills course: In addition to the standard curriculum for first-year GE students, GELC students enrolled in a study skills course. The intention of this addition course was to facilitate integration of effective learning practices into students' work across the STEM courses they were taking. In this course, students articulated the meaning and purpose for their matriculation, set goals that corresponded to different areas of wellness, explored learning skills that successful students employ, and identified their "nemesis" challenges for learning. They submitted a portfolio illustrating their focused learning practices at the end of the semester in their most challenging course as well as a reflection on their semester goals and any transformation in meaning and purpose. A feature of the course was required attendance in a weekly peer collaboration session. Trained peer coaches were present to assist the students with organizing their self-directed learning and to consult on course content.

Utilization of services, particularly in the ASC

Increasing the utilization of academic support resources was one goal of the GELC. Over 82% of the student in the GELC used at least one academic support resource during the fall 2017 semester. By comparison, 75% of the other students enrolled in Engineering I used at least one resource. Figure 6 shows a breakdown of usage by type of service.

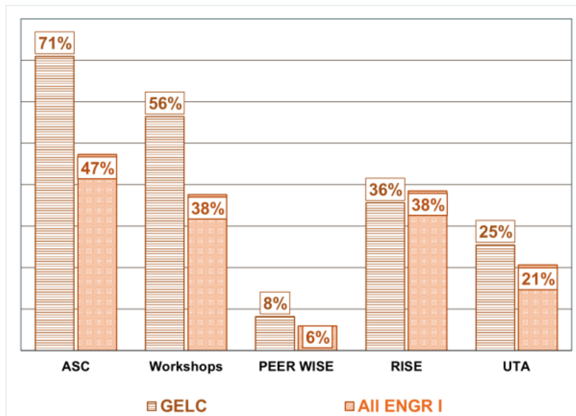

Figure 6. Support service utilization by GELC students compared to all Engineering I students in Fall 2017.

ASC resources include PAL sessions for math and chemistry, tutoring, academic coaching, and learning strategy consulting. The workshops offered by the ASC can be used for extra-credit points in Engineering I. RiSE offers evening tutoring in math, chemistry, and engineering, and it is available to students living in the Residents in Science and Engineering (RiSE) Living-Learning Community. The percentage of students who live in RiSE who used this service can be seen above in Figure 6. UTA refers to the undergraduate teaching assistants (UTAs) who function as tutors provided by GE for the Engineering I course only.

As a way of encouraging all engineering students to learn about and utilize the services of the ASC, a "pro-active" bonus structure has been in place in the Engineering I course since 2009 [11]. If the participation, shown on the resource graph as "Workshops" is not included in the services, 80% of the GELC students used at least one resource compared to 66% of the other Engineering I students. This demonstrates the GELC students used the ASC services for more than just attaining bonus point in class.

Course success rates

Multiple comparison points are possible for course and overall grade data. Figure 7 shows some initial results. Here, we have chosen to compare the GELC student performance with that of the overall performance of first-year GE students who placed into YL Calculus in 2014 – 2016, and to other first-year GE students who placed into YL Calculus but opted not to enroll in the GELC in 2017.

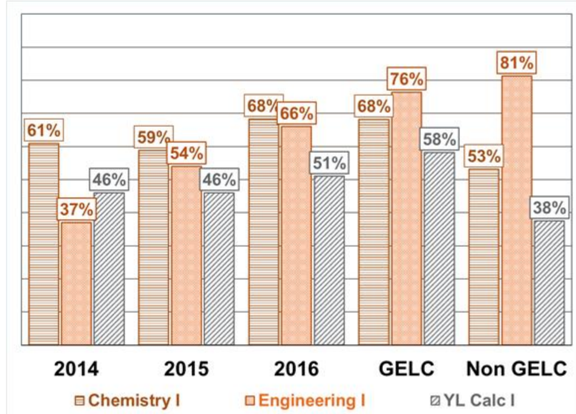

Figure 7. Pass rates in Chemistry I, Engineering I and Year-Long Calculus I in GE 2014 – 2016, GELC in 2017, and Non-GELC in 2017.

Year-Long Calculus: Since 2014, the average pass rate in the fall semester for YL Calculus has been 47.9%. This year, the GELC students had a pass rate of 58.2%, a four-year high, while the non-GELC students had a pass rate of 37.5%, a four-year low.

Engineering I: Prior to the introduction of PREPARE to the Engineering I course, the average pass rate in the fall semester was 43.5% for students in YL Calculus. Since PREPARE was introduced, the pass rate has increased each year, with a pass rate in 2016 of 65.9%. This year the GELC students had a pass rate of 76.4%, while non-GELC students had a pass rate of 81.3%. The difference between the pass rate of the non-GELC students and the GELC students was a single student in the non-GELC, due to the low number of students in the non-GELC cohort (21).

Chemistry I: Since 2014, the average pass rate in the fall semester for YL Calculus students has been 64.2%. This year, the GELC students had a pass rate of 68.2%, while the non-GELC student had a pass rate of 53.1%.

End of Fall GPR: Prior to Fall 2017, 36% of YL Calculus students on average overall ended with a GPR of 3.0 or higher. For the GELC students, 42.7% ended with 3.0 or higher. For non-GELC students, only 31.3% had a 3.0 or higher.

End of Fall Probation: Prior to Fall 2017, 17.4% of YL Calculus students on average overall are placed on academic probation (GPR below 2.0), ranging from 11.6% in 2013 to 21.7% in 2014. The probation rate for GELC students was 20%, while the probation rate for non-GELC students was 25%.

Factors that may have contributed to success

In keeping with our research questions, we decided to use a case study method [12] to learn what experiences contributed to student success. Representative students were selected on demographic characteristics and success in fall 2017 courses. GELC students were assigned to categories based first on their initial mathematics placement score, then subdivided according to whether they had taken calculus in high school and/or a technical or science AP/IB course, SAT scores, and predicted GPR. For the analysis described in this current study, one pair of students selected represents the lowest range and one pair represents the highest range of predicted success. Students in both pairs initially placed into YL Calculus. Each pair includes one student who was academically successful and one who was not. The qualitative analysis data originated as reflections, final portfolio material, or other assignments for the study skills course.

The first pair of students entered the program with low predicted success ratings. Their SAT scores were below 1200 (1030 and 1180 respectively), and neither had taken AP/IB STEM courses in high school. The two students selected for the current study from this group, LaTonia and Janelle, are both African American females. Their predicted GPRs were between 2.9 and 3.2. LaTonia withdrew from or failed all her STEM courses, while Janelle earned an A or "pass" in the same courses.

LaTonia*:* As demonstrated throughout the semester in her reflections and other written work, LaTonia struggled to take ownership of her learning. In the middle of the semester, she stated that she tried to learn from her mistakes by analyzing what she did that could have contributed to the failure. At the end of the semester, although she reiterated that she learned from her mistakes, LaTonia blamed external factors. For example, her reason for not understanding Chemistry course content was a professor who presented unclear information. She wrote, "*I am definitely not comfortable with the teaching styles of this professor. I am not used to professors using chalkboards. His notes are unclear to me and I think if he would [use] PowerPoint I would follow better.*"

LaTonia valued traditional instruction from a teacher or tutor over learning from peers, beyond asking questions. "*I study the best in multiple small intense sessions. When I study with the study group twice a week, I have a couple of days to figure things out on my own and then I have the one day a week I meet with my tutor.*" At the end of the semester LaTonia mentioned her realization that, "*The more you review the topics, the more the[y] stick. I also learned that you should never leave a class confused and come back to the next lecture and still be confused on that topic. If I am having trouble with a specific topic I should get it under control before it gets out of hand.*" LaTonia expressed this same realization at midterm, so it is unclear whether this is a recurring challenge for her, or if this was one of only a few realizations about her learning, she gained during the semester. She recognized additional resources available to her, including professor office hours, tutors and mentors related to programs that support students of color, private tutoring, and structured study time with peers, but she did not engage significantly with ASC support resources as she only attended one academic coaching appointment and one workshop.

LaTonia mentioned challenges with managing her time well, either by focusing on one course to the detriment of others or by procrastinating. To combat this, she discussed daily self-regulatory behaviors, such as developing time management skills and utilizing a weekly planner. For example, "*I sometimes put classes over other classes. I tend to distract myself with the work of one class and neglect another class. I should not completely neglect one class over another. If I put the same amount of energy into every class that I take I should be successful. One way to combat this from happening is addressing what needs to be done in each class every day. So, on my white board I write down everything that needs to be done for the next couple of weeks*." Despite saying the right things about learning from her mistakes, utilizing resources, staying on top of her classes, and making sure she continually understands the material, LaTonia withdrew from or failed all of the STEM courses in her first semester.

Janelle*:* In contrast, Janelle held herself accountable for her learning and utilized available resources frequently, including professor office hours, PAL sessions, and tutoring. Throughout her reflections, she articulated a variety of actionable learning strategies, such as trusting her confidence as a way of overcoming test anxiety, putting in significant time outside of class for practice, creating concept maps or note sheets, participating in tutoring sessions for students of color, and filling in the gaps between the lecture and the PowerPoint slides. Janelle formed and collaborated within a peer study group. She set obtainable goals and followed through with them or made necessary adjustments.

Janelle also demonstrated through critical reflection a growth mindset and the grit to persevere through academic challenges. Janelle wrote at the end of the semester, "*Learning is equivalent to adaptability. The ability to alter my perspective and my approach to a topic for a certain course. (sic.) My first semester of college has taught me that learning is not done in its full potential in a classroom environment. Even though the introductory and foundational blocks are being laid in class, the learning component is done in several ways outside of class. Clemson has shown me that I am accountable for my learning experience and that it is up to me how successful I want to be but it will require a tremendous amount of effort. I am now responsible for the depth at which I comprehend topics that will appear on an exam because every exam is based on application rather than memorization. I believe that I have grown to be [a] dynamic learner through my wiliness and commitment to adjusting [to] any space when it comes to my education. As an adult I am in control of my future and being a dynamic learner gives me the opportunity to maximize resources that offer me a greater chance of achieving my goals*." In addition, she connected her work as an undergraduate STEM student to her future career as an engineer. Janelle not only passed all of her courses, but also earned straight As.

The second pair of students entered the GELC program with high-predicted success. Students in this group had taken calculus in high school through AP/IB or dual enrollment at a community college and may have had other AP/IB STEM courses. Both students had an SAT score of 1260, with predicted GPR values between 3.2 and 3.4. The two students selected from this group are Mary (African American female) and Geoffrey (Caucasian male). Mary earned D or "no pass" in her STEM courses, while Geoffrey passed or earned an A or B in the same courses.

Mary: In her written assignments in the study skills course, Mary expressed an internal locus of control for her learning, yet she did not exercise self-regulation. Thus, though she did not always follow through with her goals, she was aware that any shortcomings were her own doing. For example, Mary made lists of the coursework and did projects on the importance of motivation and time management but struggled with following through. Lack of motivation, distractions, and ineffective prioritization of her responsibilities were recurring challenges she mentioned throughout the semester. These challenges led to cycles of procrastination and stress that meant she did not have enough time to address her studies effectively. She stated, "*My top academic distraction would be spending more time on the less important assignments than I should. Sometimes, I misconstrue what needs my attention the most, and waste so much time working toward a deadline, that I do not finish other, more weighted assignments. I could make much more progress in my work by prioritizing work better*."

Mary expressed that she understood how she learned best and attempted to create around her an environment conducive for her learning. For example, she benefited from seeing visual representations of the course material to make sense of concepts, so she had a whiteboard in her room to jot down notes and create diagrams. She realized she was susceptible to distractions: "*I am easily distracted from my goals by immediately gratifying things such as taking a nap over doing work, because it is more appealing in the moment. My phone usually distracts me from being efficient pretty often as well, so turning it off would help me focus, too. I could combat this distraction by turning my phone off while working, and staying in a public place where napping or distractions are minimal*." Because of distractions, Mary preferred to study alone.

Although she claims to know how she studies best, she did not realize she was not employing effective learning strategies nor did she realize what she misunderstood. For example, when asked to identify one specific resource or learning activity she would employ, Mary listed three in one instance, and in two others listed "*extra practice*." Although exposed to a variety of learning strategies, Mary said she predominantly relied on professor office hours and individual repetition. Her aversion to working with others was borne out by a portfolio rubric ranking that indicated she did not demonstrate effective collaboration. She wrote, "*I am a student with strengths in [STEM], but an issue with devoting enough of my time to understanding new concepts. I can think critically pretty well, but my mind moves at a slow pace sometimes. This* *semester, I should have spent more time working alone, because I work best when I know what I need to be doing, my mind is settled, and I am not distracted*." Although Mary intended to solve her distraction problem by studying alone, cutting herself off from others, working ineffectively with others, or not attempting her homework alone first, these strategies may have prevented her from learning from others what she did not realize she did not know. Mary is able to connect her work as a student broadly to her future career as an engineer when prompted and expresses a desire to use her Industrial Engineering degree to do good in the world. Mary received Bs in non-STEM courses, Ds in engineering and chemistry, and a failing grade in math.

***Geoffrey**:* Geoffrey initially had difficulty adjusting to the pace of the courses in college but was able to catch up by setting goals and using the resources available to him, especially PAL sessions. Although he did not document his self-regulation in accomplishing the goals, he stated that making the goals gave him focus. "*Before, college was very overwhelming and moving away from my parents did not help that feeling. However, after creating these goals I started to get into the swing of things and my studies and responsibilities became easier to handle*."

Geoffrey also expressed challenges with procrastination and distractions, but he took steps to minimize those challenges. He wrote, "*Going to the gym [h]as allowed me to get into shape and when I am in shape my body feels great. When my body feel great so does my mind and I am able to study and process information better…By going to the library, I am able to escape the distractions that are in my room. Also, I feel more motivated to do work in the library*." Geoffrey collaborated effectively with his peers by bringing questions to CoP meetings and learning from others in his section. He was able to participate effectively in collaborative learning by being aware that he could learn from others. He wrote, "*The COP was a great resource because it allowed me to review class materials with my peers. Not only was I receiving help from other students so that I may learn the content I was also teaching the content with [sic.] helped me learn a[nd.] process the information better*."

Geoffrey took a leadership role several times throughout the semester, including helping his group creating a sheet of important facts across STEM classes. Geoffrey demonstrated an ability to see the "big picture" and seamlessly connected his current work as a student to his future career plans as an electrical engineer. Geoffrey passed all of his courses with As and Bs.

Discussion

Cohorting the students, from the instructors' perspective, seems to be a beneficial practice. In previous years, GELC-eligible students would be distributed across sections of Engineering I where they disappeared into the background of the course. When divided into teams, the GELC-eligible students may not have spoken up about their questions and may have been carried on the coattails of the stronger students.

Concentrating intentional effort during Early Move-In on developing community among the students seems to have paid off in creating and encouraging a culture of collaboration and mutual support. While not all of the students bought in to this culture, instructors were able to share observations most weeks of GELC students sharing their knowledge and support with others. These at-risk students were no longer isolated; they recognized their own challenges in the experiences of their classmates and drew upon their own successes to help others.

The case studies reported in this paper revealed factors that contributed to success outcomes. Students who were successful demonstrated characteristics EL emphasizes in its process model. Unsuccessful students were able to identify factors that impeded their success. Successful students added to this recognition the self-regulation skills necessary to overcome the obstacles and the critical reflection necessary to recognize what had been helpful so they could replicate that behavior. Successful students utilized and contributed to their CoP so that they and their community members benefitted. Unsuccessful students used their CoP time poorly rather than using the CoP as a supplement to their individual learning. Unsuccessful students placed the blame for their poor success on external factors and remained stuck in unproductive cycles of thought or action. Successful students realized that their approach to learning contributed significantly to their ability to succeed. They also took action that promoted their success.

Conclusions and future research

The GELC students arrived with characteristics that appear to be deficits when viewed from the perspective of a typical instruction paradigm, which views student success as the ability to learn from an instruction-oriented and input-focused presentation of material [13]. Some students were in the program because they appeared not to put enough effort into reviewing for and retaking the CMPT in order to improve their score and place into Calculus I. Some did not have the requisite background for calculus. Others focused more on the social aspects of college life than putting in sufficient time to study, which could be a habit developed in high school. Some faced challenges created by their attitudes towards the academic work or by fixed instead of growth mindsets.

Our goals for the second year include delving into the literature more deeply to understand challenges faced by at-risk students so that we can further shape the learning environment to remove barriers and to increase their motivation and intrinsic engagement. We want to align more with the learning paradigm [13], which includes reshaping the learning environment to what works for the students. Discussing program goals and coordinating pedagogical approaches will be a next step so that each section of the STEM courses for the GELC cohort will have a similar approach to promoting development of learning capacity. The study skills course will continue to have a holistic approach, but reshaped to have a more explicit connection to the STEM courses and a deeper developmental approach to learning, mastering, and utilizing specific learning strategies.

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