Paper ID #35066

Evaluation of a Peer-Led Team Learning Course Designed to Increase Underprepared Students Success in Engineering

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Session XXXX

Evaluation of a Peer-Led Team Learning Course Designed to Increase Underprepared Students Success in Engineering

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Abstract

Several years ago, the University of Texas at Arlington (UTA), and specifically the College of Engineering, created a first-year engineering course in order to address student's deficiencies in solving engineering related problems. This class is called Engineering Problem Solving and teaches in-depth problem-solving methodology and programming in an active and collaborative environment, shown to benefit the most diverse preparedness levels of student groups. Since its inception, however, students placed into Pre-Calculus, instead of being Calculus ready, have suffered from higher failure rates than any other student grouping. While UTA has invested in many studies, programs and techniques that aid these underprepared students, a few strategies have emerged as being most effective. These strategies, shown in previous papers, were the implementation of Supplemental Instruction (SI), separate sections devoted specifically to Pre-Calculus co-enrolled students, peer-based instruction, and active learning activities as opposed to additional lectures. As a result of these findings, in the fall 2020 semester, UTA combined all these strategies into a learning course integrating these best practices into a required learning lab with problem-based activities and studying practices. The goal is to aid in increasing this group's success rate in this class, which has been shown to increase student retention in the College of Engineering. The students engage in effective "study habits" and problem-based learning practices with a Peer-Led Team Learning (PLTL) leader. What we have found is these practices, which will be shared in this paper, have taken the best parts of our previously effective strategies that have helped this particularly at-risk population. The students receive college credit hours, so they are able to spend the required amount of time studying the material and are guided by peers rather than their professors, encouraging more interactivity and engagement. This paper will show the effectiveness of this learning course by comparing success rates, defined as an A, B, or C in Engineering Problem Solving, of this student cohort for the fall 2020 semester versus the other singular implementations from previous fall semesters. This paper will show that this learning course is even more effective in its required implementation (lab learning) than the singular components for all students in the Pre-Calculus entry level.

Introduction and Background

To address retention issues with students in the College of Engineering at the University of Texas at Arlington (UTA), we created a new engineering skills course to equip students for the rest of their academic career[1,2,3,4]. As a result of this course having shown to increase retention for all engineering students[4], several works have been devoted to assessing techniques to improve the students' success in this class[5,6,7]with the theory that they will be more likely to be retained in engineering given the results from[4]. One of the challenging groups of students to support has consistently been those students who are co-enrolled in our Pre-Calculus course[4,5,6,7], our "at risk" population. In seeing the positive results from[5,7], we implemented a program based in Peer-Led Team Learning (PLTL) methodology in a required co-enrolled class that focuses on the material in the class as well as some cognitive activities found in a similar program[8,9].

This implementation is different from past studies[5,7] because it was required for all students in this group. These past studies all relied on voluntary participation. What was observed is while those studies showed that students responded well, the at-risk population were least likely to attend these voluntary programs. Therefore, we saw a need to make this mandatory for this at risk population not only to attend a program shown to benefit them but also to give college credit so they were more able to focus on their success in the problem solving course, which is correlated with greater retention and persistence[4,6]. In addition, the program was implemented this way to require mandatory sign up and thereby remove the possibility of the "self-selecting" aspect of the PLTL methodology to occur.

PLTL Programs and Methodology

In the 1990s, the Peer-Led Team Learning (PLTL) model appeared as a solution to assisting college students in science courses[11]. The PLTL model involves faculty, peer leaders, and students participating in the program. This model is a semester-long collaborative study group. The faculty for the course develops a packet of problems weekly that the PLTL leader delivers in a session to a small group of students ranging from 4-8 persons. The leader is a student who successfully passed the course leading 80-120 minute weekly collaborative group sessions[11]. In PLTL, peer leaders go through a careful selection process and are trained by faculty or learning specialists in "course content, group dynamics, the basics of learning theory, and diversity issues"[10].

PLTL Model

PLTL is traditionally self-selective, however for this particular context, all students were required to sign up as a class. PLTL comprises a series of weekly workshops offered to students in a historically difficult course who require more in-depth learning, development of problem-solving skills and support. A trained student leader who has previously taken the course, conducts a workshop study session of six to eight students who meet once per week throughout the semester[11]. Leaders are undergraduate students who have previously performed well in the course and possess "good communication and people skills" [11]. The PLTL workshop model is based on six critical components:

a) PLTL workshop must be coordinated with and integral to the course, b) close involvement from course faculty with the PLTL leaders and the workshop, c) PLTL leaders are students who have successfully completed the course being trained on teaching/learning strategies, and leadership skills for small groups, d) workshop content is challenging at appropriate levels, and integrated with the course to encourage active learning, e) organization of facilities, group size, noise level, and teaching resources promote learning, and f) logistical and financial support will be provided by the institution at the highest levels of administration and pedagogy to encourage innovative teaching [11].

A basic premise of PLTL is to change the experience of students with the course. Faculty ensure that workshop materials are closely aligned with course content. Faculty meet weekly with PLTL leaders to guide leaders through material for upcoming workshops and provide models for content and leadership[12.] There is evidence in the literature of success with PLTL and higher course grades for students participating in this model. Prince George's Community College (PGCC) in Maryland successfully implemented PLTL in Math, Chemistry, Biology, and Speech Communication courses [13]. In a comparison of two PLTL and two non-PLTL sections of college algebra, PGCC students in PLTL achieved at 62% rate of success with A's, B's and C's (abc) as the course grade compared to non-PLTL participants receiving a 54% abc rate[13]. In addition, the number of students failing was 31% for PLTL participants and 40% for non-participants[13].

PLTL has been a successful peer collaborative method implemented at four-year, public institutions as well[14]. Washington University, a four-year institution has utilized PLTL in their general chemistry courses since 2002 [14]. It was found that students participating in PLTL groups performed at one-third of a grade point higher than those who did not, successfully utilizing academic peer leaders to impact the success of other students. The success of the general chemistry PLTL led to the adoption of PLTL in General Physics, Calculus I and II, and Organic Chemistry[14].

At UTA, PLTL was piloted in Pre-Calculus and also the Engineering Problem Solving course for fall 2020. Engineering students who were enrolled for this course, were co-enrolled in a lab in which the PLTL method was employed. The embedding of PLTL in a lab meant it was required that all students in the lab sign up for PLTL which is a slight deviation from the model as students typically self-select to join PLTL. 206 students actively participated in PLTL for a 2-hour lab, once per week, for a total of 12-weeks working problem packets developed by the faculty coordinator and facilitated by a student who had earned an "A" in the Problem-Solving course.

Study Habits Activities

One of the more unique focuses of this program was to add in some metacognitive activities discussed in[8,9]. The goal for not only this learning co-curricular course but also for the problem solving course in general is to improve students' abilities to solve real-world problems, not simply pass a "math" class. Therefore, part of the activities that the PLTL leaders would engage in would be ideas of how to read and take notes from a book; how to study for an exam, much like what was explored in[8]; how to methodically break down a problem they have never seen before; and other such activities. The goal of these activities was to increase students' study skills to help them become more effective not only for this course but their subsequent courses. We were not able to individually assess the effectiveness of these activities versus the problem solving activities. The assessment plan to be able to delineate these activities is planned to be the focus of a future work.

Problem Solving Activities

The faculty for the course develops a weekly packet of problems that the PLTL leader facilitates in their sessions and guides the leaders through the material. The focus is on the process of solving the problem and the conceptual understanding acquired that can be applied to any real-world problem.

A unique feature for this program is that no answer sheets are provided by the Engineering faculty for the problem sets. This encourages the leaders to work through the problems themselves and with each other thus practicing the problem-solving strategies and process skills that they will model for their PLTL groups. The emphasis is on the process and steps involved to be able to approach any problem with confidence and conceptual understanding, as opposed to simply acquiring the solutions. Students in turn apply critical thinking skills to the problem-solving methods they adopt and provide feedback on input from other group members. As a result, PLTL students develop process skills that can improve their performance in the course as well as be transferred to their other courses. In PLTL, "the emphasis is on learning to find, evaluate, and build confidence in answers… in a supportive environment" [15]

Results and Discussion

Overall Pre-Calculus Performance

To assess the effect of this program, we will compare results from previous works[1,2,3,4,5,6,7] and the results from this past semester (Fall 2020). Before we get into specifics, we must define a few terms for clarity. First, "success" in this course means that the student received an A, B, or C in the course. Further, to show the specific effects of the PLTL methodology versus simply separating students into a different section as published in[7], the Fall 2019 cohort will be focused only on the Pre-Calculus co-enrolled students that were in the separate Pre-Calculus focused sections of ENGR 1250. For more information, please refer back to[7].

Table 1. Class sizes for each fall cohort

Fall Cohort	Number of students
2017	178
2018	208
2019	147
2020	195

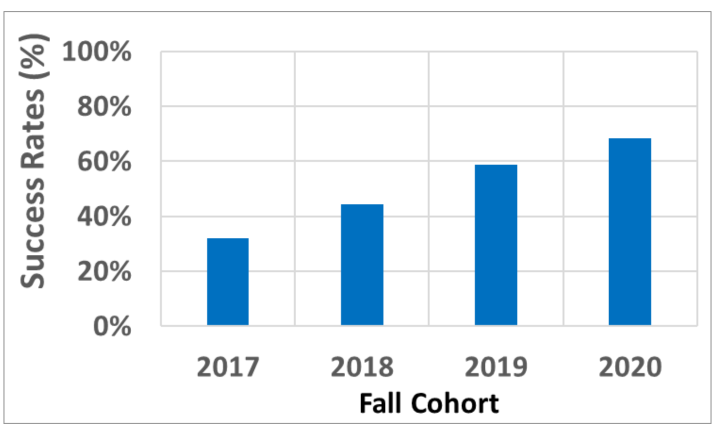

Figure 1. Success rates for each cohort for Pre-Calculus co-enrolled students

For Figure 1, it should be noted that Fall 2017 was the last semester that the problem solving course was taught without any specific treatment for the Pre-Calculus co-enrolled students. Fall 2018 included implementing supplemental instruction (SI), which was an opt-in program[5,6]. Fall 2019, as discussed above, was when we separated some Pre-Calculus co-enrolled into focused sections[7]. For the previous cohorts, we noticed that these treatments were effective for people who would opt-in. We also observed that the populations that needed these treatments the most, were the least likely to attend. Those specific populations included many of our underrepresented minority populations.

For the rest of the results and discussion section, we will only compare this fall cohort to the fall cohort from last year that were already separated into a separate course. We are doing this to specifically focus entirely on the added affects of this methodology and implementation.

Gender Effects

Table 2. Sample sizes for the male population

Fall Cohort	Number of students
2019	115
2020	153

First, we did notice that males were much less likely to attend SI and other voluntary programs. In making this PLTL pilot model mandatory by co-enrolling students in a lab in which the PLTL method was employed, we saw a significant increase in the success rate in our male population, as seen in Figure 2. Not only do we notice that the success rates dramatically increase, we also see that overall letter performance in the class also increased. We even saw a decrease in withdrawals as well. With the foci of the PLTL methodology and the studying activities, our male population have been positively influenced.

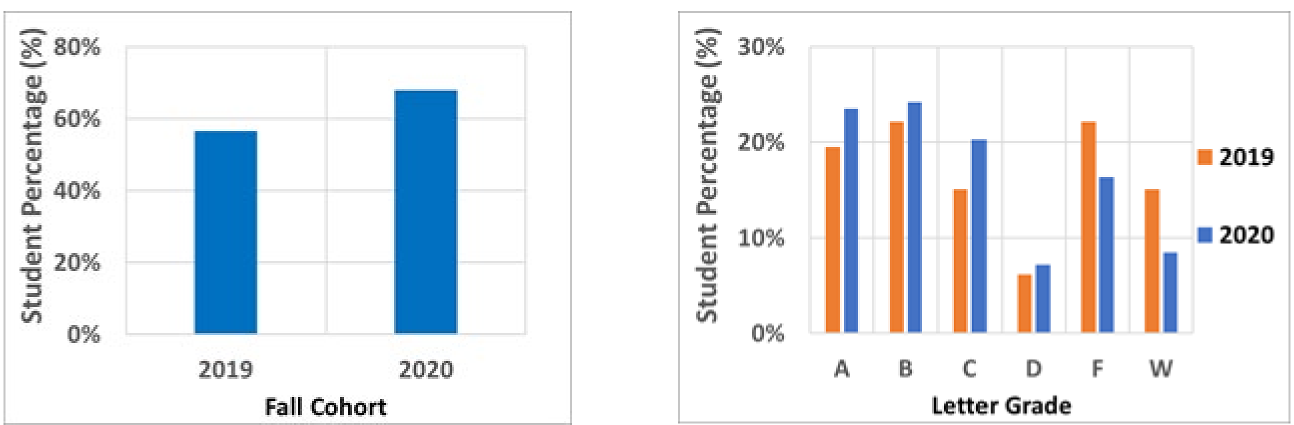

Figure 2. Success rates for our male population (left panel) and the corresponding letter grade distribution (right panel)

Table 3 and Figure 3 show the effects on our female population. As can be seen, the effect is much less pronounced for our female population. This may be caused by a couple of different considerations. First, in our prior studies, our female population were much more likely to attend the voluntary programs previously. Second, we do note that the sample size, though not small, is much smaller than the male population. Finally, due to the need for fast implementation, we were not able to pay closer attention to gender populations not only in the "small group" choices but also the PLTL leader choices. These all may explain the little to no statistical improvement for our female population.

Table 3. Sample sizes for our female population

Fall Cohort	Number of students
2019	32
2020	42

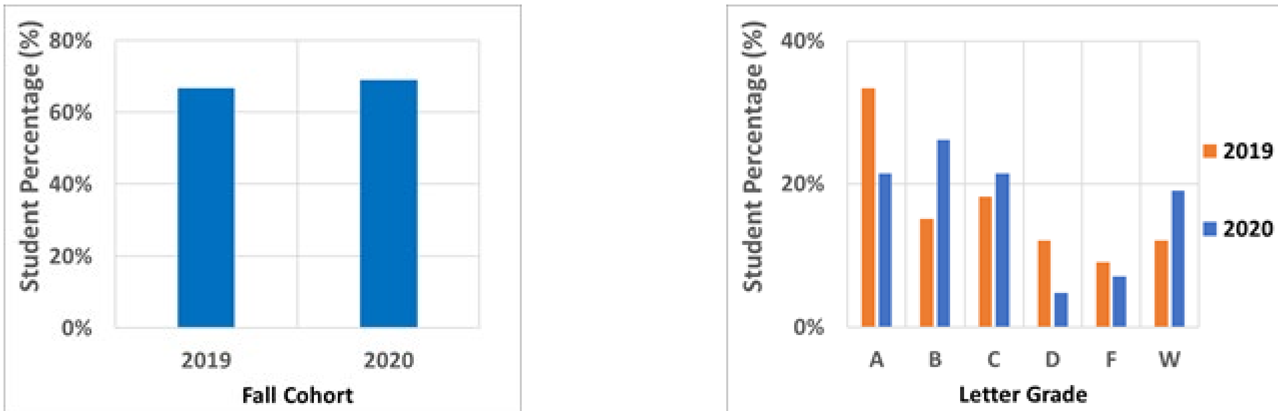

Figure 3. Success rates for our female population (left panel) and the corresponding letter grade distribution (right panel)

Ethnicity Effects

Since UTA is not only an Hispanic Serving Institution (HSI) but also services a largely diverse student population, especially underrepresented minorities, it is important to assess the effectiveness of any implementation for all our populations. Specifically, we will focus on our traditionally most populated ethnic groups, which are Asian, African American, Hispanic, and Caucasian.

First, as seen in Table 4 and Figure 4, our Asian population appears to be positively affected by the PLTL implementation. Not only was the passing rate much better but also the letter grade distribution improved, although the overall trend did not seem to change. Therefore, we were able to support this cohort by improving their overall grades and lowering their attrition rates.

Table 4. Sample sizes for our Asian population

Fall Cohort	Number of students
2019	31
2020	27

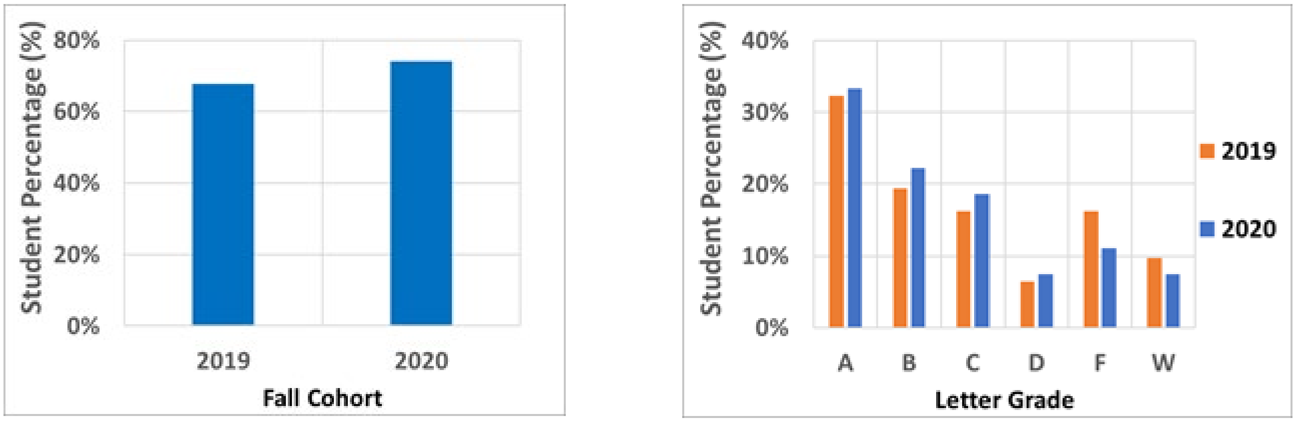

Figure 4. Success rates for our Asian population (left panel) and the corresponding letter grade distribution (right panel)

Table 5. Sample sizes of our African American population

Fall Cohort	Number of students
2019	14
2020	18

In engineering at UTA, as can be seen in Table 5, our African American population does not account for much of our population, seen by the fact that 18 students identified as African American within 195 this fall. However, in reviewing Figure 5, we can clearly see there is no discernable effect from the PLTL implementation. In fact, the right panel of Figure 5 suggest that there is even a negative effect with PLTL. A deeper dive into the data is required to fully ascertain why this may be. However, it should also be noted that since the sample size is relatively small in comparison to other student populations, which may be throwing off our observations.

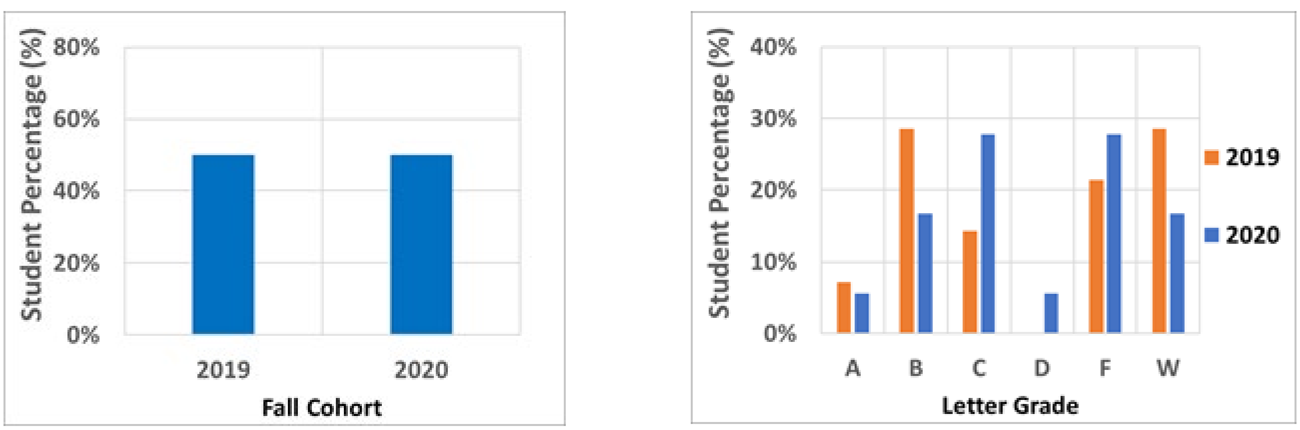

Figure 5. Success rates for our African American population (left panel) and the corresponding letter grade distribution (right panel)

Next, since UTA is an HSI institution, our Hispanic population is extremely important to study. As can be seen in Figure 6, we made the largest strides in increasing student success. The increase was over 20 percentage points, while also affecting over double the number of students from the previous semester. The right panel of Figure 6 further illustrates the true nature of what happened, in shifting the failing grades into the normally distributed A-C range. Our strides in the Hispanic population certainly demonstrates that these techniques, while beneficial for all students, are very effective for underrepresented and underprepared students in their success in the problem solving class.

Table 6. Sample size for our Hispanic population

Fall Cohort	Number of students
2019	35
2020	74

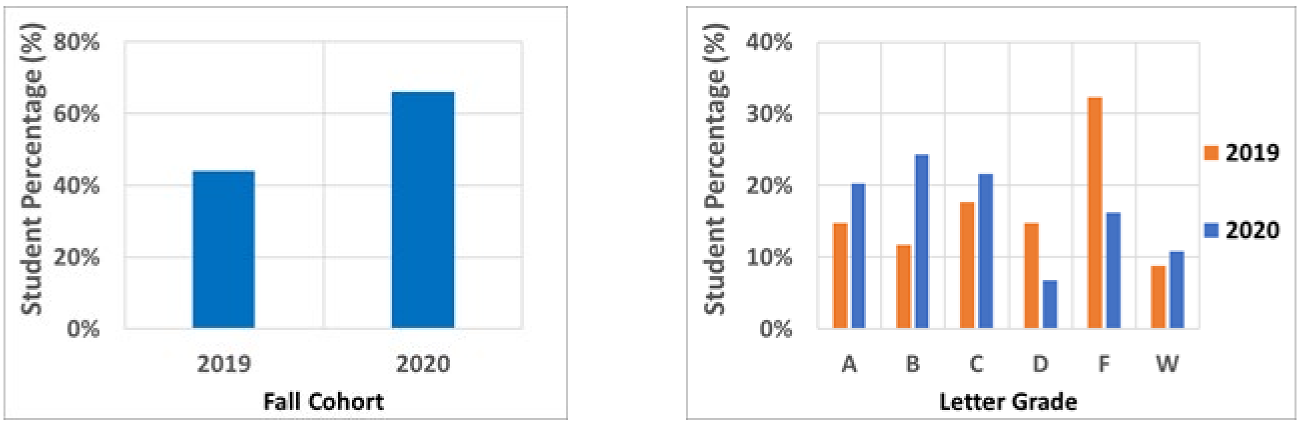

Figure 6. Success rates for our Hispanic population (left panel) and the corresponding letter grade distribution (right panel)

Finally, in Table 7 and Figure 7, we will explore our Caucasian population for comparison. First, we should note that, as seen in Table 7, that Caucasians were not the largest population in the Pre-Calculus co-enrolled population, giving some insight into where our underprepared population is concentrated. Next, as seen in Figure 7, we had another significant increase in overall success rates as well as a marked effect on the letter grade distribution and persistence in the class. Therefore, we see that, except for the low sample sized female and African American populations, the PLTL implementation was extremely effective for our underprepared population of Pre-Calculus co-enrolled students.

Table 7. Sample sizes for our Caucasian population

Fall Cohort	Number of students
2019	42
2020	62

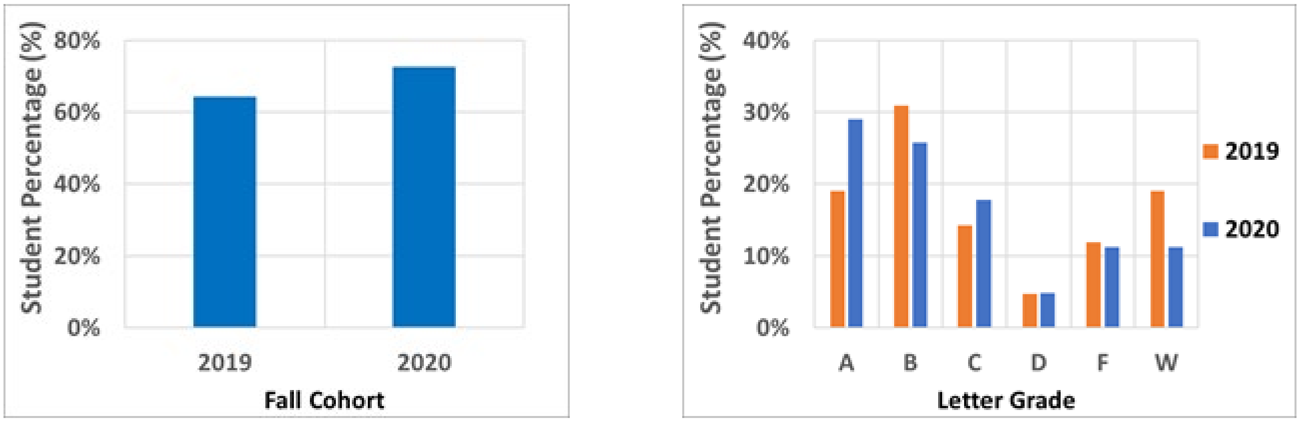

Figure 7. Success rates for our Caucasian population (left panel) and the corresponding letter grade distribution (right panel)

Anecdotal observations from faculty and PLTL leaders

While we did not quantify our anecdotal observations, we would like to note that the professors, all who have worked with this particular grouping of students for the last few years, noticed a marked improvement in the student's work in class and on exams. Particularly, the professors noticed the student's abilities in math and ability to methodically solve even the most difficult problems through analysis and abstraction were markedly improved more than any other semester. Additionally, many of the PLTL leaders also noticed a large growth in not only the students but also in themselves as facilitators and students. We feel that these observations, though currently not able to be numerically studied, represents the largest and most rewarding outcomes of this study.

Summary and Conclusions

To summarize, in implementing a mandatory learning strategies course using the PLTL methodology for academically at-risk students, we have seen tremendous influence over the success of these students. Most notably, our underrepresented minorities, except for African American students, seem to benefit greatly from this treatment as well as our male population. To fully explore the differences, a much deeper background analysis will need to be studied to determine why exactly this implementation has proven so effective. However, within our population, we believe that, considering past studies[5,6], not only does the PLTL implementation work well for the populations, but also the required nature of this particular implementation seems to greatly benefit students in their overall success.

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