The Effects of Specialized Section Groupings on Success Rates in a Freshman Problem Solving Course

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ABSTRACT

The University of Texas at Arlington (UTA) created a first year engineering course using the Student Centered Active Learning Environment with Upside-down Pedagogies (SCALE-Up) method in order to reinforce the student's ability to solve engineering related problems. This class is called Engineering Problem Solving and teaches proper problem solving methodology and programming in an active and collaborative environment, shown to benefit the even the most diverse 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 strategies such as Supplemental Instruction (SI) have been shown to improve student performance in this group, other strategies have been implemented for Fall 2019. Specifically, UTA has attempted to separate the Pre-Calculus students into their own sections while allowing other sections to be for students who are Calculus ready. This separation allows UTA to customize the in class activities and messaging to more fully engage both of these student groups. This paper will assess the effectiveness of this experiment by comparing student success rates, defined as receiving an A, B, or C in the course. Further, this paper will compare student groups between Fall 2018 and Fall 2019, broken down by Calculus ready, Pre-Calculus students in non-specialized sections as a control group, and Pre-Calculus students in these specialized sections. This paper will show that this separation favorably affects the student success rates, for both the Pre-Calculus students as well as the Calculus I or above students.

INTRODUCTION

Over four years ago, the University of Texas at Arlington (UTA) created a new course that utilizes a highly active and collaborative environment, calling it Engineering Problem Solving (ENGR 1250). This course uses active learning methodologies while implementing peer instruction to enhance the student's ability to solve practically applied problems, while appealing to the largest base of students possible. Specifically, this course aims to enhance the student's ability to solve engineering problems and formulate practical engineering computer programs. The class allows students concurrently enrolled in Pre-Calculus and above to be enrolled. The influence this class has had on student success as well as retention has been explored in previous works [1-6], to great effect.

This course has included many resources to aid student success [1-6]. Some of these resources has been implemented into the classroom, such as the SCALE-Up pedagogical style, peer student teaching assistants, and problem-based activities within a team environment [1-4]. Many resources outside the classroom time have also been implemented with varying success [5,6]. However, it

has been evident that students who do not come in Calculus I ready have difficulties in this class, as well as other classes that they are concurrently enrolled [1-6].

Recently, much research has been conducted surrounding engineering students who are not deemed Calculus I ready [7-16]. One of the more difficult challenges for ENGR 1250 has been the disparity of mathematical backgrounds present in each section. In a single section of the class, an instructor may have to teach students ranging from being math complete to those concurrently enrolled in Pre-Calculus. This fact has presented a challenge to ensure that all students are appropriately engaged in the material. More recently, some research has focused on using cohorted strategies to be able to tailor activities to groups of students [12-16]. In Fall 2019, an effort was made to enhance student success in this class, not only for concurrently enrolled Pre-Calculus students, but for all students. Two sections of the class were created to particularly focus on Pre-Calculus students and their unique struggles with the class, while all others were designed to be taken by students who were already Calculus I ready. The differences between these two types of section will be described in the next section.

Methodology

The core concept of creating these two section types was to give special attention to the Pre-Calculus students and their unique struggles, while being able to challenge and engage those students who were Calculus I ready more effectively. The goal was to increase student success in both of these student populations. It should be noted that the overall evaluation process of the course did not change between these sections. In other words, students took the same exams, homework, projects, and other graded assignments. The difference between these sections are described below.

First, the Pre-Calculus focused ENGR 1250 sections were cohorted together with a university level student success course and within their Pre-Calculus sections. This strategy has been used in the past [12-16] and has shown to be effective in elevating student success. The true strength of this method is to provide a pathway to increase student study groups, camaraderie, and peer instruction. Students are more apt to form study groups with student they see in multiple classes. Calculus I ready students were cohorted as well, but not within ENGR 1250. Also, it should be noted that a control group of Pre-Calculus students were not cohorted into one of these specific ENGR 1250 sections in order to more fully evaluate the effectiveness of this method.

Second, several in-class activities were developed to aid these special cohorts. In-class activities are problem-based, active learning-focused, student-centered, and cast in a team work environment [1-6]. One of the past difficulties with ENGR 1250 was trying to balance the difficulty of the problems done in class. The issue would be the activities were too easy for Calculus I ready students, effectively disengaging these students. But, they were also too hard for Pre-Calculus students to understand when paired with students of a higher math placement. Therefore, with this new cohorted section, the professors were able to focus on activities that would allow for the Pre-Calculus students to experience more of a “ramp up”. Alternatively, the professors were also able to start with more difficult examples in the other Calculus I ready sections, keeping them engaged.

In combination with this strategy, differing homework schedules were developed for these two section types. In the Pre-Calculus focused sections, the homework was more spread throughout the week. The students in these sections did not do any more or less amount of homework than the Calculus I ready sections, just more due dates. This means that, though the homework problems were the exact same ones, the Pre-Calculus sections would be forced to engage more often with the material, aiding in retention of what they were learning.

Finally, messaging of student resources was focused even more heavily in Pre-Calculus sections than the others. Particularly, the results of previous studies [5,6] were shared with the Pre-Calculus sections to encourage them to take advantage of Supplemental Instruction (SI), Engineering Clinic, office hours with their professors, and the extra problems given to study. This messaging was done to encourage Pre-Calculus to attend statistically proven interventions that would aid their success, especially SI [5,6].

Results and Discussion

For discussion purposes in this section, we will define success in the class as students having achieved a record of A, B, or C in the class. Further, when reporting the success rates or the letter grade distribution, the information presented is a normalized rate for each student group represented in that graph.

Overall Effect on Class

Table 1. Number of students per cohort separated by math level

Fall Cohort	2016	2017	2018	2019
Pre-Calculus	224	178	208	246
Calculus I or above	481	578	596	674
No Co-requisite	296	254	222	279
Total	1001	1012	1026	1199

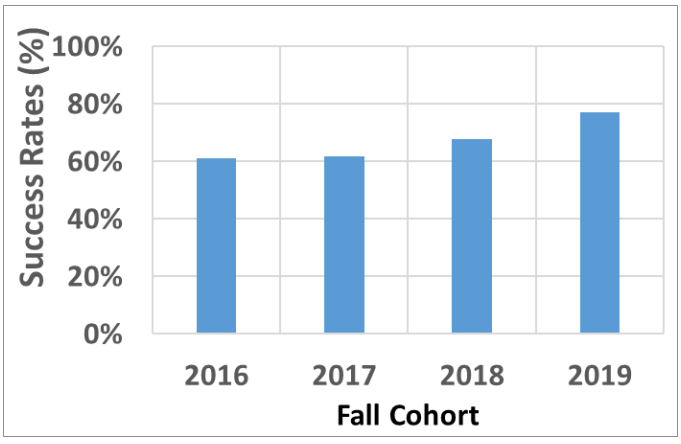

Figure 1. Overall success rates in ENGR 1250 Fall cohorts only

Figure 1 shows a historical comparison of the success rates for the Fall cohorts from 2016-2019. For ease of comparison, Table 1 shows the number of students for each category. ENGR 1250 is designed to be the first engineering class a student takes at UTA and, therefore, only the Fall cohorts will be discussed. In Fall 2018, SI was first implemented in ENGR 1250, showing the increase in success rate for that cohort.

However, as can be seen in Figure 1, the cohort success rate increased by 10% points (67% to 77%). This can be contributed to several factors that include continuous improvement in the class, and the university's strategy of overall cohorting all new

students. However, we can also attribute this increase to the activities and strategies in ENGR 1250.

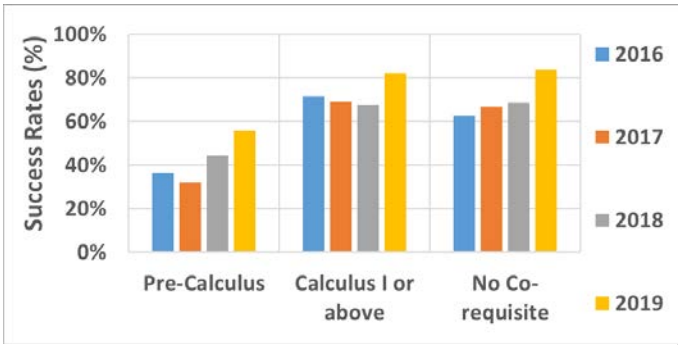

Figure 2. Historical success rates in ENGR 1250, separated by math placement.

In Figure 2, to further see the effect that the strategies explained in the methodology section, we will explore success rates as separated by the student's math placement. For clarification, the "No Co-requisite" category is defined as students who did not take a concurrent math class at UTA. As seen, Pre-Calculus concurrently enrolled students have suffered a much lower success rate than other students, even though the class does not teach anything above the College Algebra level. In Fall 2018, SI was implemented and was shown to more highly affect the success rate of Pre-Calculus students over all other student groups [5,6]. However, their relative success rate rose even higher in Fall 2019 due to the methods mentioned in the previous section. Even more interesting is the ultimate rise in success rates for all math placement in Fall 2019. This success is shown to be as much as a 15% point increase (i.e. from 67% to 82% for Calculus I ready students). The separation of student populations has allowed the instructors to not only challenge the Calculus I ready students but also to provide a "ramp" for Pre-Calculus students. Overall, the methods practiced has helped us to improve success rates in all students, not just our "at risk" population.

Cohort Effect on Pre-Calculus Students

Table 2. Sample sizes for Pre-Calculus students by ENGR 1250 section type

Pre-Calculus Section	Regular Section
147	100

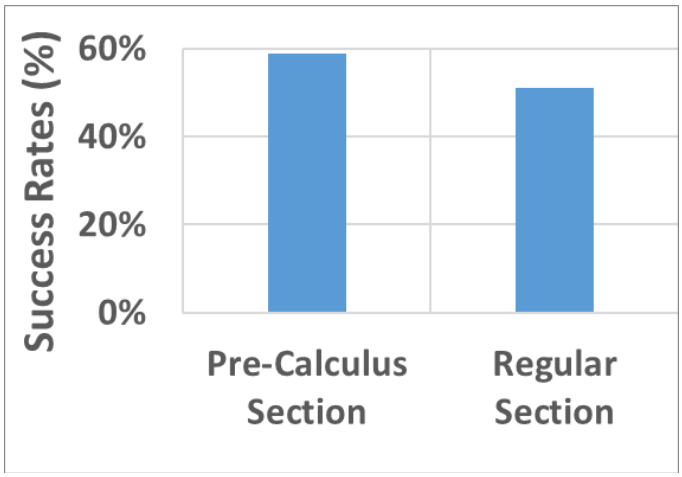

Figure 3. Success rates for Pre-Calculus students, separated by section type.

Figure 3 shows Pre-Calculus students who were cohorted in one of the two Pre-Calculus focused sections of ENGR 1250 and Pre-Calculus students who were in one of the other 11 sections of ENGR 1250. For ease of assessment, Table 2 contains the sample sizes for each of both of these section types. The success rate for the special sections of ENGR 1250 was 7% points higher than the one in the other sections. It should be noted that SI was equally available across all sections. Also, it should be noted that the success rates were higher in general for Pre-Calculus student even in the non-specialized sections of ENGR 1250 when compared to

previous semesters, which can be contributed to normal continuous improvement processes within the class and with the extra learning resources as well. However, there is a clear net positive effect that the specialized sections had on the Pre-Calculus students.

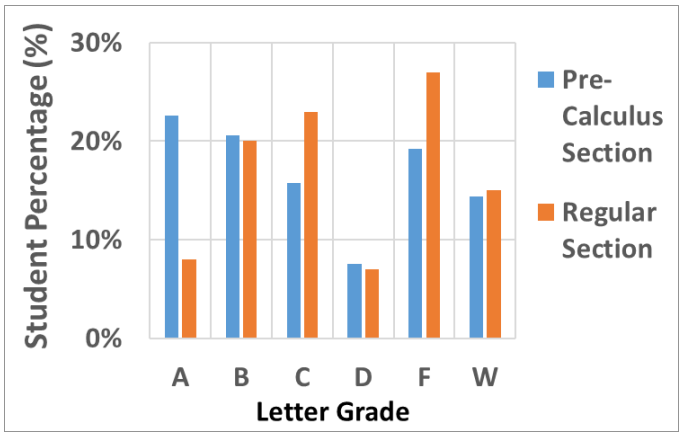

Figure 4. Letter grade distribution for Pre-Calculus students, separated by section type.

To further illustrate the success of this cohorting, Figure 4 shows the letter grade distribution between these two section types for Pre-Calculus concurrently enrolled students. What is important to note about this graph is the fact that, though the success rates in Figure 3 show a smaller effect on overall success rate, Figure 4 shows that the students in the specialized sections of ENGR 1250 are more likely to pass with a higher grade. Of course, Figure 4 shows a much higher F rate in the regular sections of ENGR 1250, owing to the overall higher non-success rate. However, Pre-Calculus students in the specialized sections are nearly three times more likely to get an A in the class, while students in the non-specialized sections are more likely to get a C in the class as their passing grade. Overall, students not only pass at a higher rate in these specialized classes but also pass at a higher grade than others.

Pre-Calculus Gender Effect

Table 3. Sample sizes for Pre-Calculus students by gender and ENGR 1250 section type

	Male	**Female**
Pre-Calculus Section	115	32
Regular Section	78	22

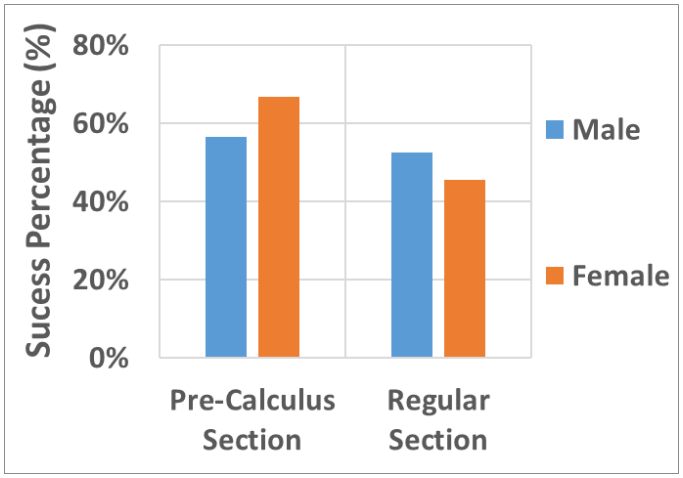

Figure 5. Success rates for Pre-Calculus students, separated by section type and gender.

The effect that these specialized sections of ENGR 1250 student for our female population is of special note. Figure 5 and Figure 6 repeats the analysis shown in Figure 3 and Figure 4 but is also separated by gender. For ease of assessment, Table 3 contains the sample sizes for each of both of these section types. What is most important to note in Figure 5 is that this specialized section experiment seems to have a profound effect on our female population at UTA. Further, in Figure 6, female students are more likely to earn a much higher grade than their non-specialized cohort. It appears that female

students thrive better in this environment of cohorting where they are supported by their peers, but

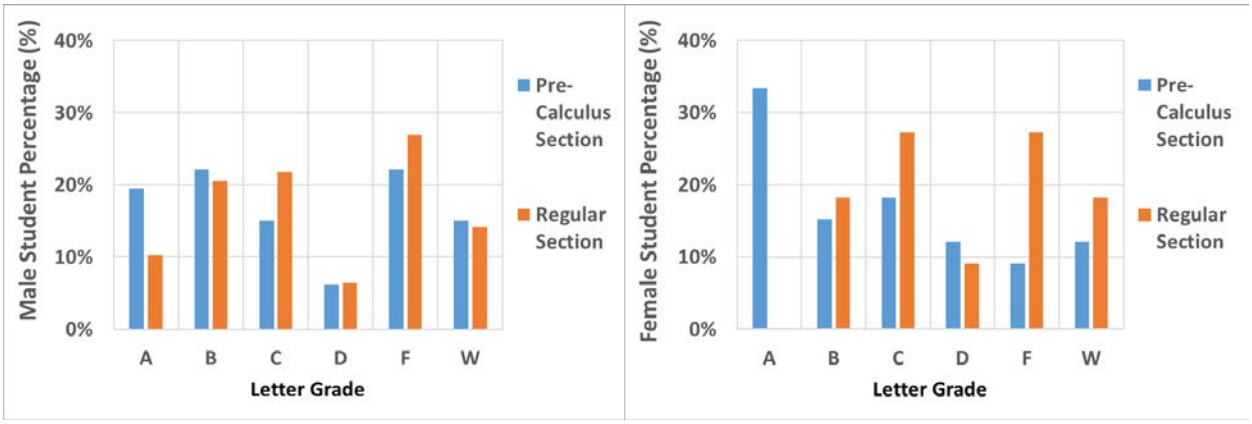

Figure 6. Letter grade distribution for Pre-Calculus students, separated by section type and gender. The left panel is for the male population and the right panel is for the female population.

more research is needed to explore the exact reasons for this observation.

By contrast, the male population shows only small increases in success rate overall, as seen in Figure 5. However, their most important gains are also seen in Figure 6. They are also more likely to earn a much higher passing grade than in the non-specialized sections. While both gender groups have shown to be favorably affected by this specialization, female students appear to thrive in this environment more than their male counterparts. More information and research is needed to fully understand this distinction.

Pre-Calculus Ethnicity Effect

Table 4. Sample sizes for Pre-Calculus students by ethnicity and ENGR 1250 section type

	Asian	African American	Hispanic	Caucasian
Pre-Calculus Section	31	14	35	42
Regular Section	18	13	24	29

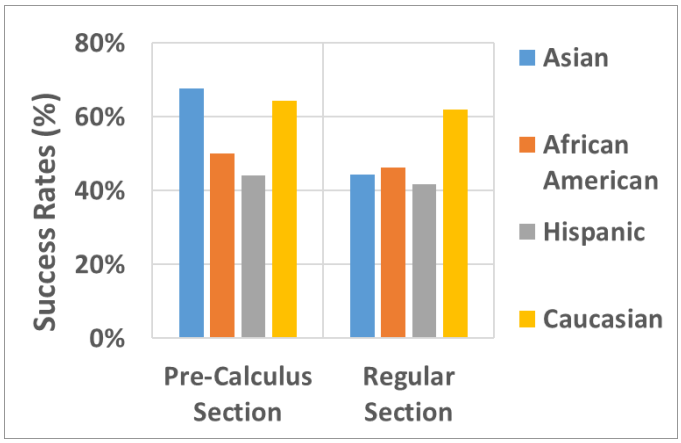

Figure 7. Success rates for Pre-Calculus students, separated by section type and ethnicity.

Finally, Figure 7 and Figure 8 show the same analysis as above, but separated by major ethnicity represented at UTA. For ease of assessment, Table 4 contains the sample sizes for all groups for each of these section types. UTA enjoys a highly diverse student body, including it being classified as a HSI university. It is, therefore, important to consider the effect any intervention has on underrepresented minorities. As shown in Figure 7, success rates for all ethnicities studied made some improvement within the specialized sections over the non-specialized sections.

Of more interest is the great effect it had on our Asian population, which necessitates further study.

Figure 8 better shows the overall effect that this specialization has on our diverse population. For all student groups, the specialized sections aid students in achieving higher grades, not simply passing. The groups where this is most evident is in our Asian and African American populations. It is interesting to note that though there is a net positive effect, our Hispanic population appears to be the least affected by this specialization. The reasons for this fact are not immediately evident and need future research considerations.

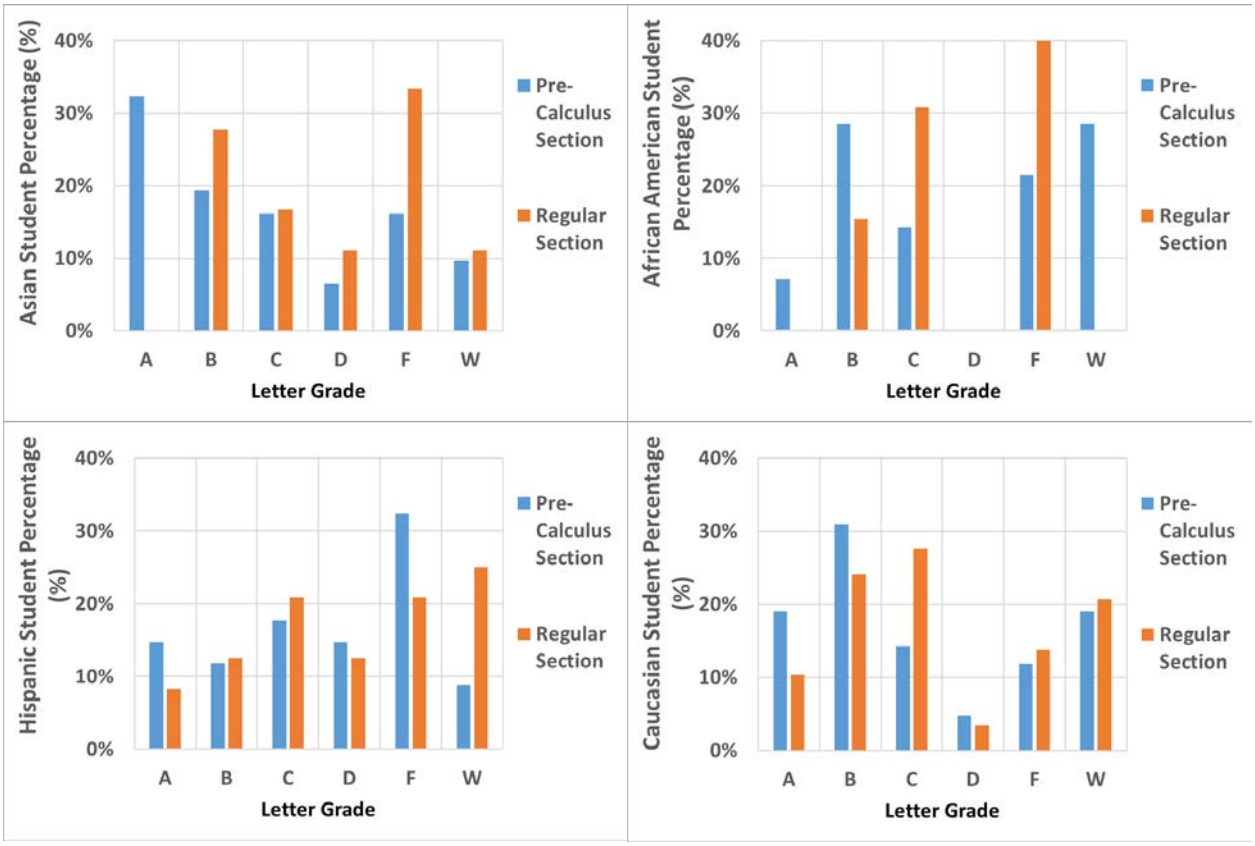

Figure 8. Letter grade distribution for Pre-Calculus students, separated by section type and ethnicity. The top left panel is the Asian population, the top right is the African American population, the bottom left is the Hispanic population, and the bottom right is the Caucasian population.

Conclusion

In conclusion, this paper has shown that cohorting Pre-Calculus students into specialized sections of ENGR 1250 to be effective for all students groups at UTA. This cohorting has allowed us to more effectively engage our Calculus I ready students as well as our Pre-Calculus students. Further, Pre-Calculus students have been shown to more successful and achieve higher grades than their non-cohorted counterparts. Finally, the enhancement in success is most seen in our female, Asian, and African American populations, furthering our goals to be more inclusive and diverse

in our educational efforts. Further research is needed to more effectively implement enhancements, not only within the classroom but outside the classroom as well.

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