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2020 BEST ZONE III PAPER WINNER - Supplemental Instruction and Just-in-Time Tutoring: The Who, When, and Why Students Attend in a First-Year Engineering Course

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An Investigation on the Effects of Supplemental Instruction and Just-in-Time Tutoring Methods on Student Success and Retention in First Year Engineering Course

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Full Paper: An Investigation on the Effects of Supplemental Instruction and Just-in-Time Tutoring Methods on Student Success and Retention in First Year Engineering Course

Abstract

The University of Texas at Arlington (UTA) embarked on a study to identify where their engineering students were struggling over three years ago in an effort to address student success, persistence, and retention. In this study, the committee identified that students were ill-equipped in engineering problem solving methodology and basic engineering computer programming. To address these concerns, a new course named Engineering Problem Solving was created utilizing the Student Centered Active Learning Environment with Upside-down Pedagogies (SCALE-Up) method. This class has aided in improving student retention and persistence in engineering. However, to further enhance this effect, Supplemental Instruction (SI) was added to the existing just-in-time tutoring model already being utilized in the class. This addition was made in an attempt to increase student success within the course, especially addressing the mathematically underprepared and underrepresented minority groups within UTA's diverse engineering student body. SI provides a more structured studying environment in which students are led by a peer group mentor, known as an SI leader, in solving problems, receiving tips on good study habits, and other student success strategies. This is in contrast to the just-in-time tutoring sessions that are more "drop-in" in format, getting answers to specific questions the students have. This paper will assess the effects that these two different methods have on success rates in the course, defined as receiving an A, B, or C. Further, this paper will explore first semester engineering retention data in order to assess the effects that these learning resources listed above have made on the already effective engineering retention rates shown in the class as a whole. Finally, this paper will explore the effect these methods have on particular student groups shown to struggle more in the class than their counterparts, including underprepared students, and underrepresented minorities. This paper will show all students benefit from these resources as evidenced by increased first semester engineering retention and class success rates.

Introduction

In Fall 2015, the University of Texas at Arlington (UTA) created a new course designed to aid students in problem solving and the use of computer programming in a highly active and collaborative environment, calling it Engineering Problem Solving. 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, especially underprepared students and underrepresented minorities. This class includes peer leaders, called in-class assistants, which aid in mentoring and guiding the students in the problem-based activities in the class. To increase student success, just-in-time tutoring sessions, called Engineering Clinic, was included to allow students an opportunity to come with questions about their homework or the class. In Fall 2018, UTA added Supplemental Instruction (SI) to the class, giving the students more academic assistance outside the classroom.

Underprepared students and underrepresented minorities

The educational gap between the expectations placed on college students and the knowledge levels of underprepared students are not at all encouraging. These students are more likely to do more poorly in their courses and have lower graduation rates than other students. In looking for ways to meet the needs of these underprepared college students, one-to-one tutoring has become a service that is most often provided to them. Tutoring has sometimes been called the gold standard to supplement effective instruction [1]. Many universities have also adopted Supplemental Instruction programs to help students reach their academic goals. Supplemental Instruction works in conjunction with the tutoring program to provide multiple levels of academic aid. Some universities have First-Year engineering programs and Bridge programs that are designed to improve the preparation and ease the transition for students into college [2]. These programs are becoming more instrumental in the development of First-Year engineering students.

The achievement gaps between underrepresented minority students and their nonminority peers continue to hold strong. While these underrepresented groups have made some modest gains over the last several decades, their progress has been extremely slow [3]. It has been recommended that a one-size-fits-all approach should be avoided in aiding these student populations [4]. Therefore, identification of specific academic resources that offer more options to support the needs of these students remains a high priority.

Engineering Clinic and Supplemental Instruction

Academic support programs in higher education have evolved into several different models, including individualized tutoring, group tutoring, drop-in tutoring clinics, and Supplemental Instruction. These peer-led academic resources provide increased student success without significant financial demands. Providing opportunities for students to engage in discussion and problem solving outside of the class is helping to prepare these students for a future in engineering, where programs are increasingly asked to demonstrate competencies of working in groups and being able to engage in problem solving [5]. "Just-in-time" tutoring techniques, utilized by the Engineering Clinic, focus on addressing student questions as they arise, in a drop-in style group setting. Clinics using this technique require fewer financial resources; however, there are few studies relating to the assessment of the effectiveness of this model. One study found that first-year students who used a "just-in-time" model of academic support more than 10 times in a semester had higher rates of persistence [6]. Another study showed that students starting their academic career, particularly those identifying from underserved populations, are able to relate better to peers than to a professional tutor or faculty member [7].

Supplemental Instruction was introduced in Fall 2018 in the class, as a structured attempt to increase student success in this first year engineering class and augment the "just-in-time" tutoring model. SI differs from the latter model by "drilling down" into the course material to enable students to gain a deeper conceptual understanding, as opposed to simply answering questions at a surface level. Deep level learning is particularly applicable to engineering so as to impart real-world situations into teaching and learning through a problem solving methodology [8].

The Supplemental Instruction (SI) program was first created by Dr. Deanna Martin at the University of Missouri-Kansas City (UMKC) in response to the high drop-out and failure rate in

historically difficult courses, particularly for underprepared and minority students [9]. The program is a non-remedial, institution-wide approach to retention, targeting traditionally difficult subjects and providing regularly scheduled, voluntary out-of-class, peer-facilitated sessions [9]. The SI sessions are facilitated by SI Leaders who are fellow students, who have successfully completed the respective course, received intensive training in the principles of facilitation of small group learning and equipped to lead the underprepared peers towards higher levels of understanding. The SI Leader is also required to attend the lectures to get re-acquainted with the material as well as build rapport with the instructor and students.

SI creates a non-threatening supportive learning environment due to the fact that it is peer-facilitated which has particular relevance for underprepared and minority students who are often reluctant to seek help [10-12]. Findings suggest that creating learning environments that offer students an atmosphere of care, respect and interaction can influence students' confidence in their learning and enhance their performance and retention within an engineering curriculum [10]. Further, the peer-to-peer aspect of SI provides the conducive forum to make personal connections and create a sense of community. A culture of belonging is an important factor in retention and increases learner satisfaction at the institution [11]. This peer aspect of SI is identified as a critical component for engineering students who appear to be consistently more comfortable going to a fellow student (or TA) for extra help over an instructor or other faculty member [12].

Methodology

Engineering Clinic is conducted by the teaching assistants that are embedded in the course during three afternoon sessions and four evening sessions a week. These hours followed a "drop in" policy. In this way, students could visit if they wished to get their questions answered about the homework or other class activities, then leave at any time they wished. The Engineering Clinic was specifically meant to be a personalized, unstructured way to provide assistance to students who knew the questions they wanted answered.

SI sessions, lasting for one hour a piece, were conducted by peer leaders who would fulfill the activities as described above. The SI leaders would also interact with the students outside the classroom by conducting sessions that were structured in nature, as opposed to the unstructured methodology of Engineering Clinic. These sessions provided students guided problem solving group sessions, studying and note taking tips within the class, and other important success strategies. The activities were pre-organized by the leaders rather than simply relying on answering student questions. In essence, the largest difference between the Engineering Clinic and SI sessions was the formalized learning structure that SI provided. To encourage attendance, bonus points were offered to those who attended SI sessions, while no bonus points were given for Engineering Clinic attendance.

Results and Discussion

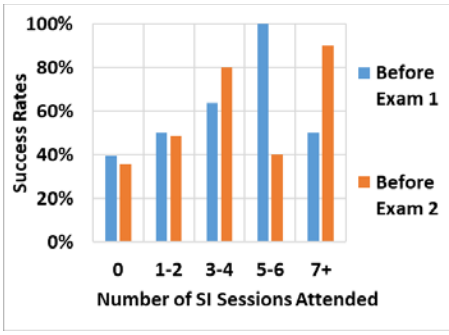


Figure 1. Effect of SI on success for students concurrently enrolled in Pre-Calculus

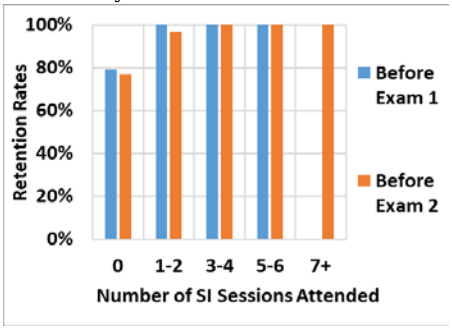


Figure 2. Effect of SI on first semester retention rates for concurrently enrolled Pre-Calculus

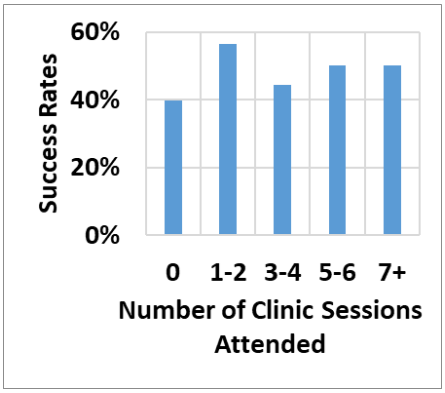


Figure 3. Effect of clinic on success rates for concurrently enrolled in Pre-Calculus

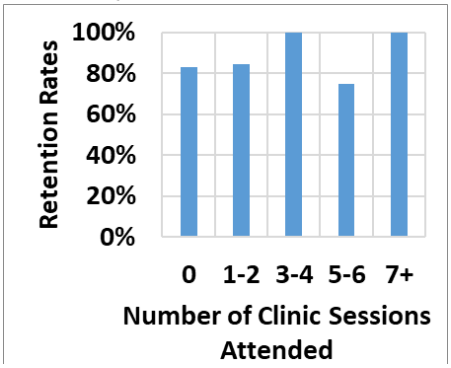


Figure 4. Effect of clinic on first semester retention for concurrently enrolled in Pre-Calculus

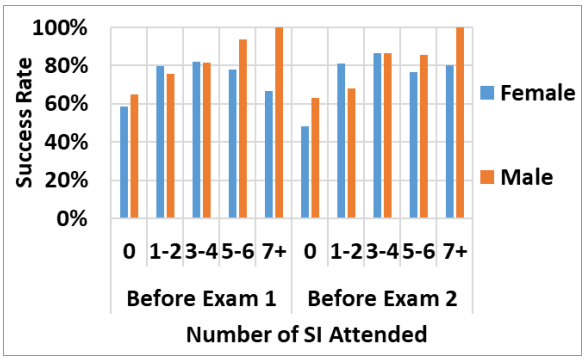
For overall trends and total session attendance, see [13]. For discussion purposes in this section, we will have to define a few terms. First, when reporting success rates and retention rates, the information presented is a normalized rate for each student group represented in that graph. Next, success in the class is defined as a student earning an A, B, or C in the class. Further, the retention rates mentioned in the following graphs refers to students remaining as engineering students at the end of their first semester. Finally, it should be noted that the class mentioned in this work gives three exams, including the cumulative final exam. Therefore, where noted, attendance has been tracked by how many sessions students attended "Before Exam 1" and "Before Exam 2".

Figure 1 shows that SI attendance greatly enhances the Pre-Calculus students' success in the class, even though this population is generally considered to be underprepared for engineering. In each instance, the more sessions students attend, even at low attendance numbers, the better their success rates are. There is some variability in the data at higher number of sessions attended due to the low sample sizes that those categories contain, such as seen in the 5+ categories.

In Figure 2, the first semester engineering retention rates are explored. It should be noted that 100% of students who attended SI before the first exam were retained. Even though this may be due to the "self-selective" nature of these students, it is encouraging that even if they wait until after the first exam to attend, they still can be successful and be retained in the class, as shown in Figures 1 and 2.

In Figures 3 and 4, the effect of Engineering Clinic on retention rates is shown. We do not separate these effects by exam times because the number of students attending Clinic is much lower, as also reported in [13]. Further, both figures show no discernable effect. We feel that this may be due to the fact that Clinic requires students to know what questions to ask, rather than SI helping students develop these particular skills. Overall, for underprepared students, we find that SI has a greater effect on success and retention, possibly due to the structured learning nature of SI.

The effects of SI on our female population, when compared to our male population, are shown in both panels of Figure



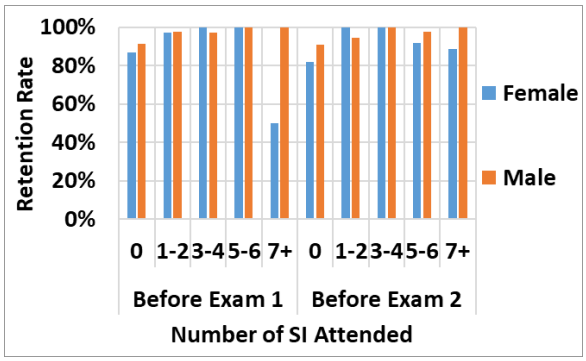


Figure 5. Effect of SI attendance on success rates (left panel) and first semester retention rate (right panel) by gender

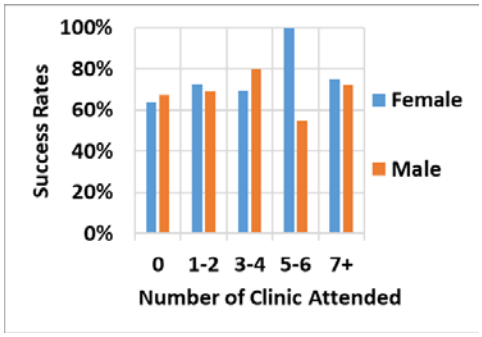


Figure 6. Effect of Clinic attendance on success rates by gender

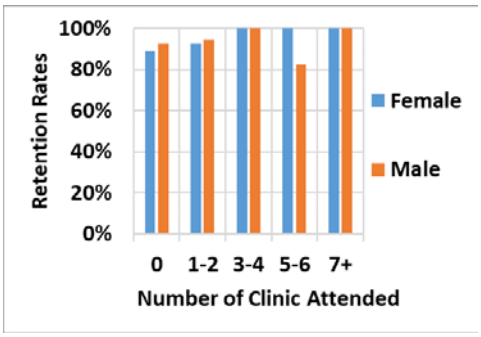
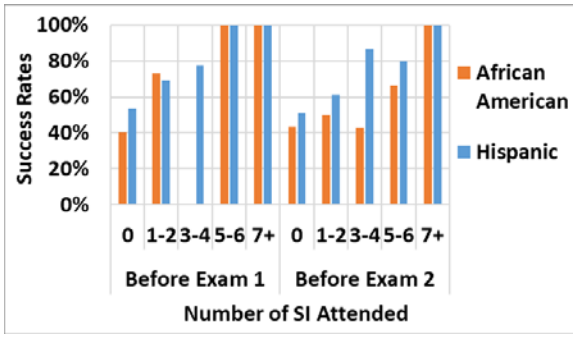


Figure 7. Effect of Clinic attendance on first semester retention rates by gender

5. As can be seen, SI attendance for both genders is critical to increased success and retention rates. Of particular interest is the fact that there is a greater increase for our female population than our male population for most attendance categories, except the 7+ category due to low sample size. Even of larger interest is the effects of attendance before Exam 2. There is a much larger difference between those who still have not attended before Exam 2, especially within the female population.

Figures 6 and 7 show the effect Clinic had on these rates. There is still much variability due to low attendance in Clinic. Therefore, we do not feel that this data is revealing any discernable trends. More can be known by further incentivizing Clinic attendance. Until sample sizes are increased, these numbers are not statistically significant.

Finally, Figure 8 shows the effects of SI attendance on UTA's two largest underrepresented ethnic minority groups. Of particular interest in the left panel of Figure 8 is the significantly large difference that SI attendance has on success rates for both groups, especially before Exam 1. However, it is also noted that the effect for African Americans before Exam 2 is not clear until much higher number of sessions attended. In the right panel of Figure 8, for the most part,



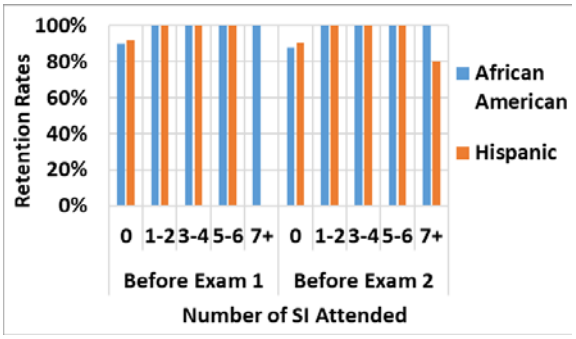


Figure 8. Effect of SI attendance on success rates (left panel) and first semester retention rate (right panel) by ethnicity

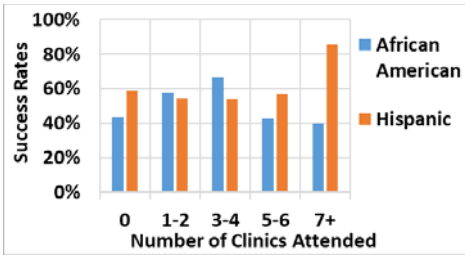


Figure 9. Effect of Clinic attendance on success rates by ethnicity

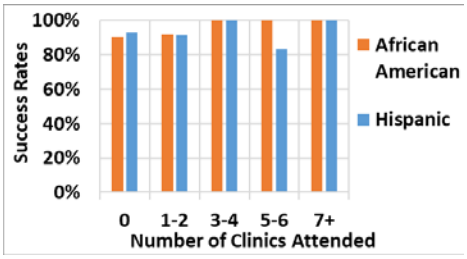


Figure 10. Effect of Clinic attendance on first semester retention rates by ethnicity

SI attendance shows high first semester retention, possibly due again to group-based academic support structures.

Shown in Figures 9 and 10, Clinic appears to increase student success for African American students at low attendance numbers. However, it seems that Clinic may have minimal effect on first semester engineering retention, but this may be due again to low sample sizes.

Conclusions

In conclusion, this paper has shown that SI enhances student success and first semester retention for underprepared students and underrepresented minority populations at UTA. Further, Clinic appears to aid student success with certain underrepresented minority populations as well, but larger sample sizes are needed. The structured and active learning atmospheres that both of these resources offer provide students the academic support structure that are critically needed in their first year. Finally, underlying all data is the importance of offering widely varying support services and inter-departmental collaboration to combine the strengths of all parties involved.

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