The Unsubstantiated Cutoff: Deeper Analysis of Supplemental Instruction Sessions on Engineering Courses

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Abstract

Active learning sessions such as those in the Supplemental Instruction model are often reported as successful when incorporated into high DFW (Drop, Fail, Withdraw), high enrollment courses [1]. Research conducted by The U.S. Department of Education, Redish, Longfellow, and many others have reported significant benefits to students enrolled in courses that incorporate active learning strategies [1, 2, 3]. The initial analysis of the impact of Supplemental Instruction on students in the College of Engineering at Louisiana State University (LSU) was consistent with these previous findings [4]. However, researchers like Dawson and McCarthy recognized some sobering truths–many analyses regarding Supplemental Instruction were incomplete and made weak conclusions [5, 6]. The research presented herein investigated two different modes of analysis to better determine the effectiveness of Supplemental Instruction (or similar models), taking advantage of the large dataset at LSU and attempting to remove the possibility of student self-selection bias.

The first analysis was conducted in attempt to directly answer Dawson's comment that SI success often was proven after choosing unsubstantiated cutoffs to define regular attendance; the number of SI sessions a student needs to attend in order to be considered a "regular attendee" varies greatly in the literature and can be defined to meet a researcher's preconceived notions of success [5]. It was found that the trend appears linear–students continually improve their passing rates and course GPA's as SI session attendance increases. Therefore, any choice of an attendance cutoff supports previous conclusions of increased course performance and passing rates.

The second mode of analysis used standardized test scores to create a model to predict student success in certain courses and then determine if SI attendance affected the modeled prediction expanding on what has been done in previous literature [7]. When examining these variables independently, students who regularly attend SI sessions as well as students with higher Math ACT scores are more likely to pass a given course. However, it was found that Math ACT and SI session attendance were inversely correlated with each other, thus dispelling the misconception that only "good students" go to SI sessions. Similarly, when looking at both variables simultaneously, data indicates that SI may help all groups of students regardless of their Math ACT scores; however, it appears to have the largest impact on those with lower Math ACT scores.

Background

In the 1990s, the U.S. Department of Education found that Supplemental Instruction (SI) participation is positively correlated to course grades, passing rates, and persistence. SI is a form of peer led learning that utilizes undergraduate students who have previously excelled in the course that is being offered [8, 9]. The general program goal is to help students succeed through collaborative learning [9].

SI at LSU is offered in sophomore-level engineering mechanics courses with historically high enrollment and high DFW rates. Typically SI is offered through one and a half hour sessions held bi-weekly where material is presented to students utilizing active learning strategies not common in lecture. Active learning requires more participation from students and can range from having students work problems on a board to having students get into groups to solve a problem [10].

SIs are chosen based on their previous success in engineering courses and their communication skills. Typically, SIs are required to have a written recommendation from the professor of the course they wish to teach and interview with the SI coordinator before being hired. Supplemental Instructors (SIs) create their own material, problems, and activities with guidance from the course professor, the program coordinator, and fellow engineering SIs.

Responsibilities of SIs include hosting biweekly sessions (the cornerstone of the program), as well as holding office hours, where students report feeling more comfortable asking questions. SIs also attend the course lectures, provide exam review sessions periodically throughout the semester, meet regularly with the course professor, and attend weekly SI meetings where active learning strategies are taught by the SI coordinator. Other responsibilities include monthly peer evaluations where SIs attend each other's sessions to review and learn about other active learning strategies, and biannual trainings which are half-day workshops held at the beginning of each semester. Though the implementation varies at each university, the basic principles of SI remain the same and data continues to support programs success [1-6, 8, 9].

The success of SI programs has been strongly implied [1,2,3], although frequently scrutinized by administrators funding Supplemental Instruction. Many question if SI's success is due to a motivation or self-selection bias [5, 6]. The implication is that "good students" are more likely to go to SI sessions, thus boosting the statistics and perceived program success, and that these "good students" would have been successful anyway. Contributing to this speculation is the lack of detail on how most data were compiled for analysis, such as how regular attendance (or a benchmark of attendance) was defined to see an impact on student grades.

Dawson et al. reported on several other groups' research utilizing similar benchmarks of attendance [5]. The author critiqued that rationales for "regular attendance" cutoffs or boundaries were often "arbitrary and unsubstantiated," if addressed at all, and that the intervals were usually determined after an effect was expected. Dawson's critique is also applicable to the previous reporting of this research team [4]. Therefore, in an attempt to better define why there is a difference, or to discover evidence for a cutoff, this research proposes a potential means of analysis for attendance cutoffs and attempts to further answer the question of whether the students who attend SI sessions were more likely to succeed regardless of session attendance.

It is also the intention of this research to present and test potential alternative methods of analysis of Supplemental Instruction or similar out of class programs. For a full description of the Engineering SI Program at Louisiana State University's College of Engineering see previous research [4].

Methods & Results: Part 1

This research explored two different modes of analysis to better determine the effectiveness of Supplemental Instruction by taking advantage of a large dataset at LSU. The aim of both of these analyses was to better understand and account for the possibility of student self-selection bias and program success. The first analysis was conducted in attempt to more accurately address Dawson's critique of unsubstantiated cutoffs to define regular attendance [5]; the number of SI sessions a student needs to attend in order to be considered a "regular attendee" varies greatly in the literature and can be defined to meet a researcher's preconceived notions of success. The second analysis used standardized test scores (Math ACT scores [7]) to create a model that would predict student success in certain courses and then determined if SI attendance would affect the modeled prediction.

Data collection began during each SI session where students were required to sign-in. This usually occurred a few minutes into the session in order to give time for late students to arrive. At the end of the semester, the number of times a student attended SI sessions was merged with student grades and other student data such as Math ACT scores.

In a previous analysis looking for impacts of SI on course passing rates, attendance data were grouped by: students who attended no sessions, students who attended a few sessions (1-3), and students who regularly attended (4 or more sessions) [4]. To determine if the cutoff (4 or more sessions) was unsubstantiated, a test for linear correlation between number of sessions attended and passing rates was created (Figure 1). Passing rates (%) were calculated as the number of students earning an A, B, or C out of the entire course enrollment. This figure shows a clear, positive correlation between number of SI sessions attended and average passing rate. The slope of this figure can be plotted (Figure 2) to indicate if there is a significant increase at any number of sessions. The major disadvantage of breaking up passing rates by the distinct number of sessions attended is that uncertainty (scatter) greatly increases due to the smaller sample size of students who attend numerous sessions. However, the dataset at LSU includes over 5000 students who have been offered SI in the College of Engineering and this dataset continues to grow.

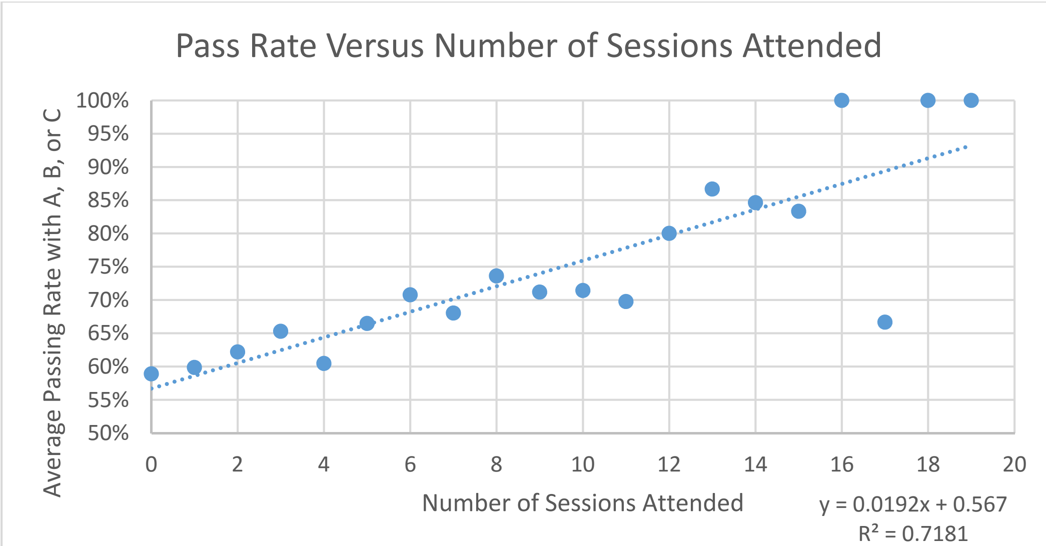

Figure 1: Passing rate of courses with SI offered compared to the number of sessions attended.

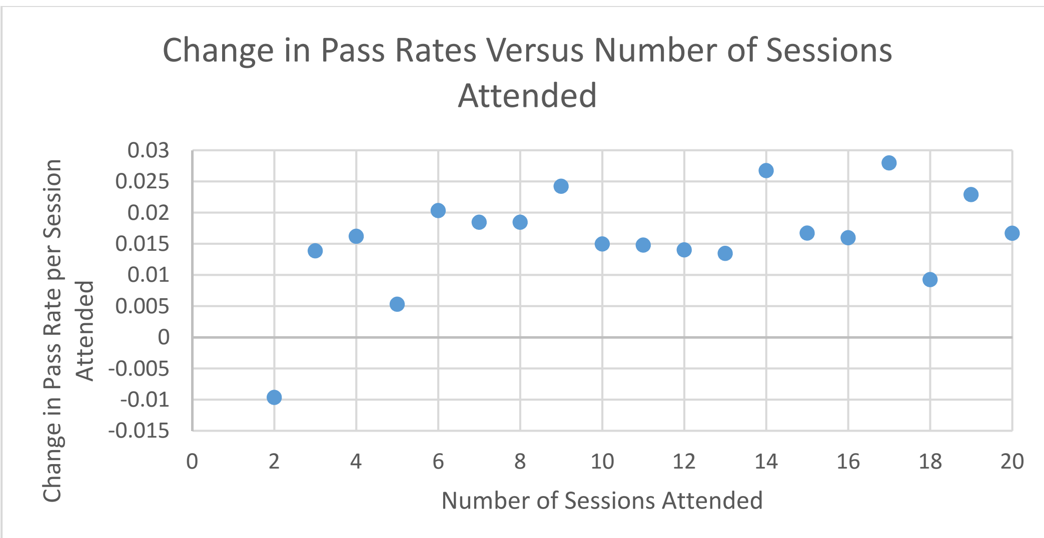

Figure 2: Change in pass rates per session attended compared to number of sessions attended to better understand if there is a cutoff where maximum results may be observed.

Perhaps there is no perfect cutoff for a maximum perceived improvement. It appears that the probability of a student passing the class increases in an incrementally linear pattern as session attendance increases which leads to Figure 2 having no apparent slope. After attending two sessions, each additional session attended is correlated to about a 1.5-2% increase in chance of passing.

After the initial analysis plotting pass rate versus number of sessions attended (Figure 1), the authors realized that there are several differences in the final count of sessions between semesters and courses (ranging between less than 10 and more than 20). Percent attendance bins seemed to be a reasonable replacement for number of sessions attended in order to put students into more even groupings across separate classes. For example, it may be argued that a student who attended 3 out of 10 sessions offered may not be an equal comparison to one who attended 3 out of 20 sessions. Eleven different bins were created starting at 0% and increasing by 10% up to 100%. Summary data for these bins can be seen in Table 1 and in Figure 3. Utilizing the percent attendance groupings has increased the correlation between the two variables and decreased the scatter. Table 1 shows very high passing rates for high percentage of attendance, but also reveals that few students go to this many sessions.

Summary Data for Session Attendances								
Bin Low	Bin High	Pass	Fail	Pass Rate	Error	Course GPA	Passing Rates Normalized	Normalized Error
0.00%	0.00%	2136	1490	58.91%	0.83%	1.80	-5.14%	-0.07%
0.01%	10.00%	593	393	60.14%	1.59%	1.82	-1.02%	-0.03%
10.01%	20.00%	465	311	59.92%	1.79%	1.89	1.02%	0.03%
20.01%	30.00%	242	118	67.22%	2.64%	2.04	8.98%	0.35%
30.01%	40.00%	146	72	66.97%	3.39%	2.01	9.70%	0.49%
40.01%	50.00%	134	54	71.28%	3.65%	2.24	15.34%	0.78%
50.01%	60.00%	66	28	70.21%	5.16%	2.18	11.61%	0.85%
60.01%	70.00%	71	19	78.89%	5.27%	2.43	19.28%	1.29%
70.01%	80.00%	56	8	87.50%	6.25%	2.70	27.30%	1.95%
80.01%	90.00%	28	6	82.35%	8.57%	2.65	29.56%	3.08%
90.01%	100.00%	19	2	90.48%	10.91%	2.81	32.02%	3.86%

Table 1: Summary data for Spring 2013 through Summer 2015 Engineering SI attendance at LSU.

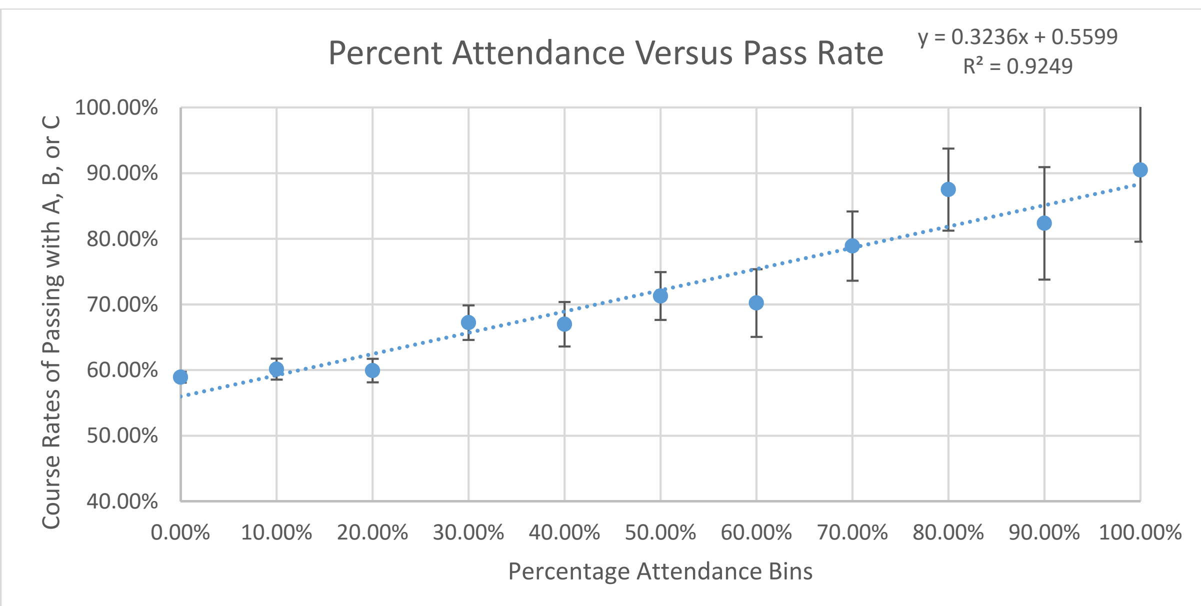

Figure 3: Percent passing rates versus percentage of attendance.

Lastly, it was decided that a normalization of course difficulty was necessary as a final method of minimizing data scatter. This normalization was accomplished by subtracting course average passing rates from all of the students in that course each semester before being averaged with other students in that bin of attendance. This allows one to compare courses with average passing rates of 80% more equally with courses that have average passing rates of 20% (Figure 4). For example, in the summer semester of 2015, 65% of students passed the Mechanics of Materials. If a student passed this course and attended 75% of the sessions, their representative value would be 1.00-0.65= 0.35. This number would be averaged with all of the students who attended 70.01% to 80.00% of sessions throughout the programs history. Had the student failed, their representative value would have been 0.00-0.65= -0.65. Once the level of difficulty is accommodated, there is a strong correlation, scatter is greatly reduced, and a clear statement becomes apparent–increased SI attendance, regardless of cutoffs, is correlated with increased passing rates.

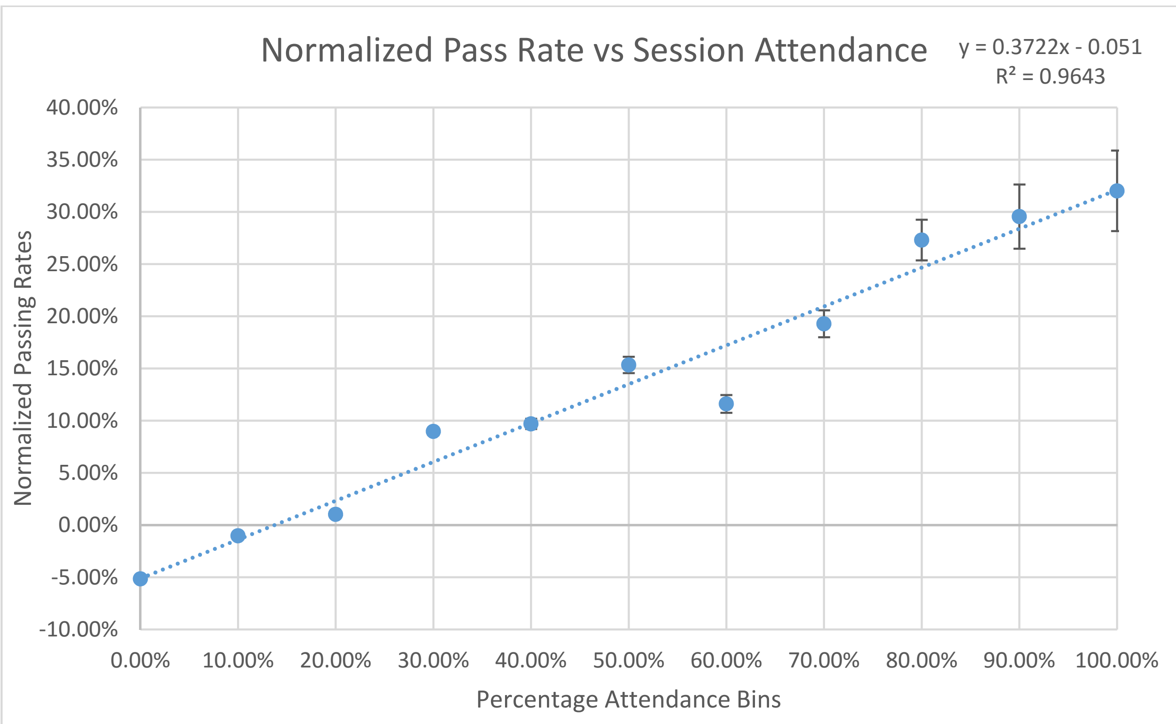

Figure 4: Normalized passing rates versus percent attendance.

Methods & Results: Part 2

For the second method of analysis, in order to better understand the impact of SI on the engineering courses at LSU, a separate prediction method of course pass rates was needed to compare to SI attendance, ideally exploring if only "good students" go to SI. Common prediction tools that are used are the pre-engineering inventory test [11], high school GPA, university placement tests, and analyzing students grades in freshman year math and science courses [12]. Though these methods present promise, Math ACT scores were used, as literature supports that it is the strongest predictor of success in engineering for large data sets [7]. In Figure 5, the correlation of passing rates and Math ACT scores are plotted showing a positive trend. When examining this relationship and the relationship of attendance with passing rates from the first analysis independently, students who regularly attend SI sessions as well as students with higher ACT scores are more likely to pass a given course. So it seemed likely that one would see a positive correlation between SI attendance and Math ACT scores (Figure 6). However, it was found that Math ACT and SI session attendance were inversely correlated. This inverse correlation has a lower R^2 value when compared to the previous positive correlations, but the trend is present.

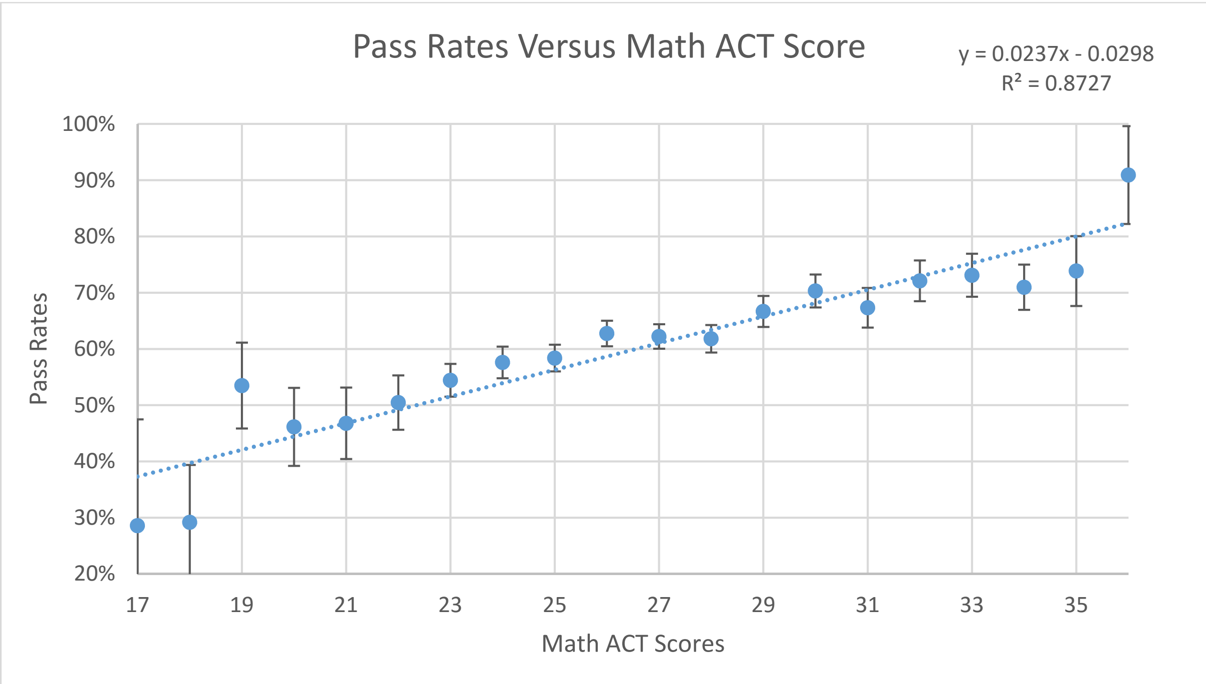

Figure 5: Percentage passing rates versus Math ACT scores.

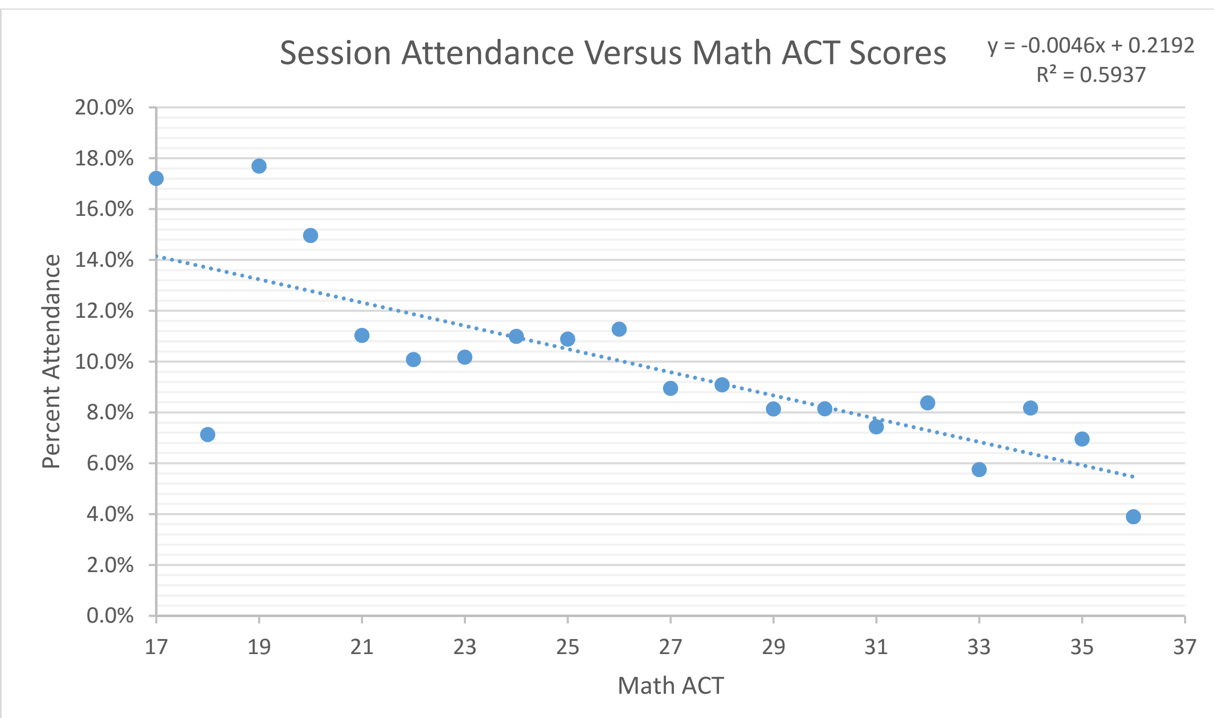

Figure 6: Students' SI attendance compared to their Math ACT scores.

To better understand this relationship, the initial analysis was repeated with students divided into categories based on their Math ACT scores. Math ACT bins were created in an effort to keep equal intervals of students in each grouping. Bin ranges were: 20 or less, 21-24, 25-26, 27-28, 29-30, and 31-36. Once in bins, normalized passing rates were plotted against SI session attendance. As with the first analysis, passing rates were normalized for course difficulty. In all cases, a positive trend appears–as students go to more SI sessions, their passing rates increase regardless of their Math ACT scores. For example, the students with a 20 or less on the Math ACT pass a course at a lower rate than the course average unless they attend 21% or more of the SI sessions. Alternatively, students with a 32 or higher score on their Math ACT are all more likely to pass a course than the average student, but they pass at an even higher rate as they attend more SI sessions.

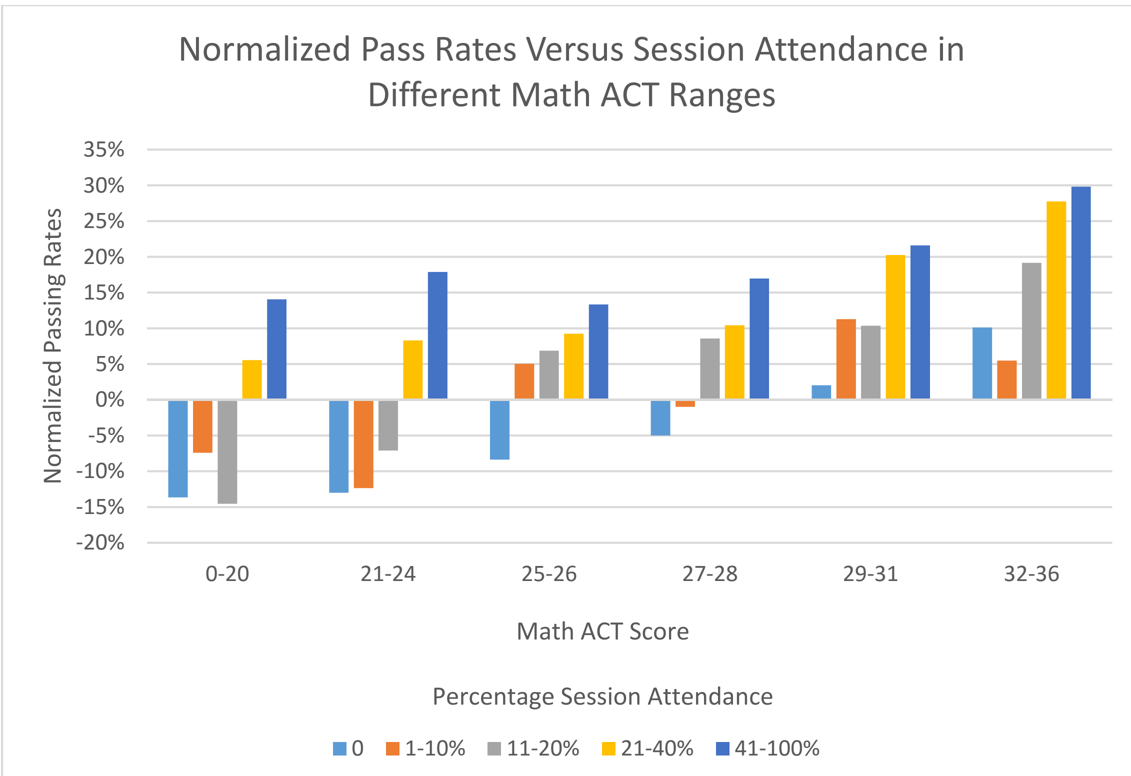

Figure 7: Normalized pass rates versus SI attendance for different Math ACT ranges.

Conclusions

In the previous study reported by the authors, the cutoff of four sessions attended to be considered a regular SI attendee was chosen based loosely on an assumed average of once a month attendance and/or more than at least the exam reviews [(4)]. This reality made the findings in the literature review hard hitting, as Dawson's comments were accurate [(5)]. When pass rates were normalized for course difficulty and attendance data were placed in percentage bins the relationship shows any cutoff (including 1 or more sessions) would have shown higher passing rates (Figure 4) with increased attendance.

Positive correlation between session attendance and grades, but negative correlation between session attendance and Math ACT indicates that SI is helping students who are less likely to otherwise pass the class (Figures 5 and 6). However, according to the final figure, higher SI attendance is positively correlated with higher passing rates in all Math ACT scoring bins, likely indicating that SI is helping all groups of students with increased attendance, having the largest impact in the lower ACT performance groups. It is not just the “good students” who attend SI sessions, and all attendees appear to benefit from this program.

The finding of an inverse relationship between Math ACT and session attendance was consistent with previous qualitative findings of an outside evaluator published in the initial analysis by the authors (4). When the evaluator asked students who attended few or no SI sessions why they did not go to more, most responded that they did not think that they needed it. Based on the results illustrated by Figures 6 and 7, students with high Math ACT scores are passing their classes regardless of whether or not they attend SI sessions, which serves to support their beliefs. This could be further explored with a non-blind qualitative analysis that matches student’s own perception of the value of SI with known values of their Math ACT, GPA, and other success predictors. A study like this could also explore other demographics and their relationship to perceived benefits of SI.

Looking forward, it is the intention of the authors to use prerequisite courses that do not have similar active learning models as additional indicators of success as well as grade point averages before and after taking the courses in question. It seems reasonable that prerequisites, as more recent than Math ACT scores, may be even better predictors of success in engineering courses. Plans are to include courses such as introductory calculus and the introductory physics series, both of which are requirements for nearly all sophomore-level engineering courses at Louisiana State University.

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