Examining the Effectiveness of Scholars Assisting Scholars Program Among Undergraduate Engineering Students

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Rationale and Literature Review

Retaining engineering students is a critical issue in engineering education, especially in the first two years of college when the attrition rate in engineering has been stubbornly high.[1, 2] Peer tutoring and supplemental instruction are widely used techniques to help students succeed in challenging courses in universities.[3-5] Peer tutoring has shown to improve academic outcomes such as achieving higher GPAs, higher retention rates, and improving student engagement.[5-9] In this study, we focused on the effectiveness of a peer tutoring and supplemental instruction program implemented in the College of Engineering at Kansas State University, a Midwestern large land grant research institution.

Background and Need for the Study

In order to increase the retention rates of freshmen and sophomores, the College of Engineering developed and implemented a free tutoring program called Scholars Assisting Scholars, SAS. SAS was implemented in 2005 as a part of an NSF STEM Talent Expansion Program grant addressing barriers and adversity encountered by first year students. As we planned this program, we found a need for research regarding best practices for training tutors and the types of assistance offered by tutors, such as supplemental instruction, study skills, and time management.[3, 14] Previous researchers who examined the use and impact of tutoring on engineering achievement and success identified gaps in the literature about the impact of peer tutoring programs. They identified a need for studies of the organization, results, and accomplishments associated with the impact of peer tutoring programs to support development of accepted best practices and outcomes.[12, 15] Researchers called for studies into the frequency of use and types of students who used peer tutoring programs correlated with the impact of the programs on their academic success.[11, 12, 15]

Program Description

The Scholars Assisting Scholars tutoring program was designed to support student success and learning for students in first and second year core science, math and computer science courses. The SAS program was charged with providing effective tutoring that created a strong foundation for courses that followed in the engineering curriculum. The goals of the program were to help engineering students successfully complete first and second year engineering coursework. The SAS program employed

students who earned a 3.0 cumulative GPA and successfully completed tutored courses, receiving a grade of either an A or B in the course they were hired to tutor. The criterion for selection of SAS tutors was determined with input from students, faculty and staff. We wanted tutors who were highly successful in the course but were concerned that if we only included the highest achievers, students receiving grades of A, we would miss contributions from a broad section of students. We therefore included students receiving grades of B in our pool of potential SAS tutors. SAS tutors were given substantial responsibilities and were encouraged to take ownership of their position as a tutor. They scheduled regular tutoring times each week in a dedicated tutoring space, the Collaborative Learning Lab. SAS tutors were required to attend a specific lecture section of a course and serve as a tutoring resource to all students enrolled in the course. The tutors were trained in effective teaching techniques and in working with students on improving conceptual understanding and problem solving skills.[10] Tutors worked with faculty to provide assistance consistent with course instruction and lead review sessions before each exam.

Over time, the SAS program staff developed improvements and additional services based on feedback from students and faculty, and research from tutoring programs at other institutions.[11, 12] Tutors were trained to provide student support beyond course content and problem solving.[13] Training sessions in best practices for student success guided tutors to take on mentoring and coaching roles.[12, 14, 15] Tutors were trained to coach students on time management and study skills.[5, 14] Further, tutors encouraged students to make connections and build learning communities with their peers, a recommended intervention practice for underrepresented student groups.[11, 14] In Fall 2015, the SAS program moved to a dedicated room. The change in location and a new sign-in system allowed more accurate tracking of students who used SAS. As a result of changes in the program and better tracking of students, the SAS program team began a comprehensive evaluation of the program beginning with a study of the first year outcomes of the Fall 2016 Calculus 1 class. Calculus 1 was selected as the first course examined in the study because of its critical position in the curriculum. The College of Engineering required students to earn a C or better in Calculus 1 before they were allowed to enroll in Calculus 2. Calculus 2 was a corequisite for Engineering Physics 1 & 2. Thus Calculus 1 served as a foundational course in the curriculum.

Research Objectives

Previous researchers who examined the use and impact of tutoring on engineering achievement and success identified the need for studies of the organization, results, and accomplishments of peer tutoring programs to support development of accepted best practices and outcomes.[12, 15] Researchers called for studies into the frequency of use and

types of students who used peer tutoring programs.[11, 12, 15] We found a need for research regarding best practices for training tutors and the types of assistance offered by tutors, such as supplemental instruction, study skills, and time management.[3, 14] We seek to contribute to the literature to increase the available information for development of effective tutoring practices and programs. We wish to examine the impact of multiple facets of our tutoring program with regard to courses tutored, targeted skills, outcomes, training, and organization.[14, 15] For this paper, we chose to examine whether and to what extent attending the SAS program influenced the academic achievement among engineering students in Calculus 1.[1, 3] Learning about the usefulness of the SAS peer tutoring program can inform the researchers how to improve the SAS program and make it an effective approach in helping engineering students succeed academically.

We addressed two research questions in this study. The first research question was: Did students who attended the SAS program and those who did not differ on their academic achievement measured by passing rates in Calculus 1 course, GPAs and retention rates? Furthermore, we examined the characteristics of students who attended the SAS program, specifically, whether students from different backgrounds were equally likely to attend the SAS program. The second research question was: Did students from different sexes, first generation statuses, and ethnicities differ on their likelihood of attending the SAS program and completing Calculus 1 course with a C or better?

Methods

Participants

This quantitative study took place at the College of Engineering at Kansas State University, a Midwestern large land grant research institution. Participants consisted of 581 students from College of Engineering who enrolled in Calculus 1 course during Fall 2016 semester. In this study, we focused specifically on students enrolled in the Calculus 1 course for two reasons: a) Calculus 1 was a required course for all engineering students, and b) success in Calculus 1 has been a robust predictor of whether a student will be retained in engineering.

Design and Variables

In this quasi-experimental study, we used post-test only nonequivalent comparison group research design.[16] Given the nature of the intervention, it was unethical to force participants into either attending or not attending the SAS program. Therefore, random assignment of the subjects to research groups was not used, which could limit the ability to infer causality.[17]

The semester long SAS program served as the intervention/treatment in this study. The independent variable was whether or not a student attended the SAS program for Calculus 1 course (1 = Yes, 0 = No). There were three dependent variables, all measured after the intervention (post-test). The first dichotomous dependent variable was whether a student completed Calculus 1 with a C or better (1 = Pass, 0 = Fail). For the purposes of this study, a grade of C or better was considered a passing grade because a C or better was required by the College of Engineering before a student could advance to enrollment in Calculus 2 and Engineering Physics 1. The second dichotomous dependent variable was student retention status defined by whether a student remained in an engineering degree program at the end of the fall semester (1 = retained, 0 = not retained). The third continuous dependent variable was cumulative GPAs (on a 4-point scale) at the end of the fall semester.

Furthermore, in order to see whether the SAS program had different effects on various demographic groups, three demographic variables were included: gender (1 = Female, 0 = Male), first generation status (1 = First generation, 0 = Not first generation), and ethnicity (1 = Underrepresented Minority; 0 = Non-Hispanic White). We coded ethnicity into a dichotomous variable because the extremely small sample sizes for certain underrepresented minority groups would have violated the statistical assumption of parametric statistics.[18]

Data Collection

Data were collected using two methods. First, all participants' demographic information and academic performance records were retrieved from the College of Engineering's main student database. Second, the visit data of students who used the SAS program for Calculus 1 were recorded electronically by Academic Success Center. Two datasets were merged and cross-referenced. An identifier variable was created in the main dataset to indicate whether a student used the SAS program.

Table 1 *Percentage of Students Passing Calculus 1 with a C or Better Based on Usage of the SAS Program*

	Pass Calculus 1	Fail Calculus 1
Used SAS program	92%	8%
Did not use SAS program	80%	20%

$\chi^2(1) = 10.158$, $p = .001$, Cramer's $V = .132$

Results

Question 1. Did students who attended the SAS program and those who did not differ on their academic achievement measured by passing rates in Calculus 1 course, GPA, and retention rates?

We used Pearson's Chi-square test to compare the likelihood of passing Calculus 1 course between those who attended the SAS program and those who did not. Table 1 provided the percentages of students who passed Calculus 1 course with a C or better based on whether or not they attended the SAS program. The results of Pearson's Chi-square test indicated that using SAS had a statistically significant association with whether a student passed Calculus 1 or not, with a robust effect size. $\chi^2(1) = 10.158$, $p = .001$, Cramer's $V = .132$. Table 2 presented the retention rates among students who attended the SAS program and those who did not. The results of Pearson's Chi-square test indicated that using SAS had a statistically significant association with whether or not a student was retained at the end of the fall semester, with a robust effect size. $\chi^2(1) = 7.853$, $p = .005$, Cramer's $V = .116$. The results of analysis of variance (ANOVA) showed that students using SAS had statistically significantly higher cumulative GPAs ($M = 3.10$, $SD = .77$) than those who did not use SAS ($M = 2.78$, $SD = 1.07$), $F(1, 310.53) = 10.43$, $p < .001$.

Table 2 *First Semester Student Retention Rates Based on Usage of the SAS Program*

	Retained	Not Retained
Used SAS program	93%	7%
Did not use SAS program	83%	17%

$\chi^2(1) = 7.853$, $p = .005$, Cramer's $V = .116$

Table 3 *Percentage of Students Passing Calculus 1 with a C or better by Gender*

	Used SAS program	Did not use SAS program
Female	39%	61%
Male	20%	20%

$\chi^2(1) = 19.241$, $p < .001$, Cramer's $V = .182$

Question 2. Did students from different gender, first generation status, and ethnicity differ on their likelihood of attending the SAS program and completing Calculus 1 course with a C or better?

A total of 24% of the 581 participants in our sample utilized SAS program for Calculus 1 course during Fall 2016, which was consistent with findings from other similar programs.[3, 14] Men and women showed statistically significant difference in their likelihood to use the SAS program with women being significantly more likely to use the SAS program than men (Table 3), χ^2 (1) = 19.241, $p < .001$, Cramer's $V = .182$. There was no difference in the likelihood of using the SAS program among first generation and non-first generation students. Similarly, there was no difference in the likelihood of using the SAS program among Non-Hispanic White and Underrepresented Minority students.

We further conducted a logistic regression analysis to examine *among those who used the SAS program,* whether gender, first-generation status and ethnicity predict the likelihood of completing Calculus 1 course with a C or better. The results showed that none of the three abovementioned variables significantly directly predicted or moderated using the SAS program and the likelihood of completing Calculus 1 course with a C or better. In other words, *among those who used the SAS program, it* worked equally well to help all students completing Calculus 1 course with a C or better regardless their gender, first-generation status, and ethnicity.

Discussion

In this study, we compared grade outcomes for students in Calculus 1 who used the SAS tutoring program with those who did not use SAS tutoring. We found that students who used SAS tutoring were more likely to complete Calculus 1 with a C or better. This outcome is critical to the academic progress of students through the engineering curriculum.[19-21] At Kansas State University, earning a C or better in Calculus 1 was a prerequisite for Calculus 2 and by extension, Engineering Physics 1 along with most engineering science courses such as statics and dynamics. Thus it became the first in a series of courses that built on preceding content. Students could be advised to take algebra followed by pre-calculus before taking Calculus 1, based calculus placement exams, but the engineering curriculum effectively began with Calculus 1. While sometimes termed a gate-keeper or high-risk course, we preferred to consider Calculus 1 a foundational course.[19] Previous studies connected success in the first mathematics course to retention and graduation.[3, 19, 21] The SAS program was charged with providing effective tutoring that created a strong foundation for courses that followed in the engineering curriculum.

We also examined the characteristics of students who used the SAS program.[11, 15] We found women were more likely than men to attend the SAS program whereas first generation and underrepresented minority students were equally likely to attend it as their peers. Furthermore, *among students who attended the SAS program*, women, first generation and underrepresented minority students, were just as likely to complete Calculus 1 with a C or better as majority, male, and non first generation students, suggesting that the SAS program worked equally well for students of varied backgrounds.

Future research

As called for by previous researchers we intend to study multiple areas of the SAS tutoring program to contribute to the knowledge of accepted best practices and outcomes for effective tutoring programs.[12, 15] We plan to examine the frequency of use, types of students who used peer tutoring programs, and the effect of peer tutoring on long term (2^{nd} – 6^{th} years) academic performance and retention rates.[11, 12, 15] We also plan to examine the impact of courses tutored, targeted skills, outcomes, training, and organization.[14, 15]

To guide further research, we surveyed students using SAS tutoring as a resource with respect to what they believed contributed most to their success in Calculus 1, what they thought the tutors did well, and what they believed tutors needed to improve. Students who used SAS gave the tutors positive reviews. Voluntary comments frequently attributed success in all coursework to the assistance of SAS tutors. While non-content related practices such as helping students develop effective time management, study skills, and learning communities were considered important, students frequently identified knowledge of the content area and the ability to explain concepts in a way that students could understand as an important characteristic of effective tutors. These results confirmed the need for clear conceptual understanding and *suggested training in providing clear and concise conceptual explanations might be appropriate for future tutors*. These findings and additional attitudes of students toward tutoring will be examined in follow-up studies.

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