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NSF RIEF: Influence of Self-Efficacy and Social Support on Persistence and Achievement in Chemical Engineering Sophomores: Measuring the Impact of an Intervention

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Abstract

As part of our study examining the factors that influence the academic performance and persistence of second-year chemical engineering students, we are assessing the impact of an intervention (a two-day voluntary workshop) on the specific factors of self-efficacy and social support. This workshop, called the "ChemE Camp", is held just before the start of fall classes and includes team-building exercises, presentations from faculty about upcoming classes, a lab tour, presentations from upper-level students and alumni about their experiences in the curriculum and in industry, information about academic advising and the career fair, and some recreational games. Students who attend the camp can learn more about chemical engineering courses and the profession and also have the opportunity to meet peers and interact with faculty and upper-level students. It was hypothesized that the activities included in the camp would have a positive impact on students' self-efficacy and social integration, factors which have been shown in other studies to significantly influence student experience and student success.

To assess the effect of the intervention, surveys were administered to students at the start of the camp. These surveys included published subscales used in the study of self-efficacy and social and academic integration. These same surveys were also administered to all second-year chemical engineering students at the beginning of the academic year (three days after the beginning of the camp) and the end of the academic year (approximately eight months later). Data collected from the previous two academic years indicate a statistically significant increase in the chemical engineering self-efficacy, coping self-efficacy, and social and academic integration ratings for students who attend the camp. These effects appear to largely be maintained throughout the sophomore year and are distinct from the results observed for non-attendees.

Introduction

Many chemical engineering programs experience significant attrition in student enrollment over the course of the curriculum [1,2], and much of it occurs in the sophomore year, when students typically first encounter the Material and Energy Balances (MEB) course. Students typically take this course in the fall of their second year, and this MEB course and other major-specific courses often represent a considerable increase in rigor compared to first-year courses. Performance in such barrier courses often determines whether a student persists in engineering [3,4]. With the prevalence of common first-year engineering curricula, chemical engineering students can often enter this second year not knowing many chemical engineering classmates or faculty.

Several studies have shown positive correlations between the factors of student self-efficacy and social support and the outcomes of academic performance and student success [5-17]. Much of this research in STEM fields has focused on first-year students [18-21], so our research aims to find out to what extent these factors are still relevant in the second year. This is our first research question: what are the impacts of self-efficacy and social support on the outcomes of

achievement and intent to persist for second-year chemical engineering students? Additionally, we are trying to determine whether participation in a voluntary two-day workshop has lasting effects on students' self-efficacy and social support. This is our second research question: how are self-efficacy and social support influenced by participation in a two-day intervention? Our current data set is not yet large enough to power the analyses needed to address the first research question, so this paper will focus on the second.

Intervention

Since 2016, we have offered a voluntary two-day workshop ("ChemE Camp") at our institution for rising chemical engineering sophomore students just before the start of classes in the fall. The workshop includes team-building exercises, a hands-on project, career fair information, a lab tour, presentations from faculty and upper-level students about upcoming classes, the curriculum, and internship opportunities, and some recreational games. A detailed description of the camp and its activities can be found in previous publications [22,23]. The workshop allows students to learn more about chemical engineering courses and the profession and also serves as an opportunity for them to meet peers and interact with upper-level students and faculty. Since the types of activities comprising the camp are not closely tied to our university or necessarily specific to chemical engineering, other programs or other institutions could feasibly adopt a similar workshop aimed at improving the experience of their own students.

In the first six offerings of the workshop at our institution, 73 students have participated. This represents 31.9% of eligible first-time sophomore chemical engineering students. The percentage of eligible students participating has increased over time since the inception of the camp, from 20.4% in 2016 to 37.9% in 2021. Female students make up 39.7% of the participating students, and 15.1% have been from under-represented minority groups, compared to 31.1% and 14.9%, respectively, in the chemical engineering sophomore student body at our institution during this time.

Methods

Data Collection

Students attending the ChemE Camp are given written surveys to complete at the very start of the workshop, prior to any activities taking place. These are known as the "Pre-Camp" surveys. The same surveys are administered to all chemical engineering sophomores at the beginning of fall classes (the "Pre-Soph" surveys) and again near the end of spring classes ("Post-Soph"). These surveys include subscales from several published instruments aimed at assessing students' Chemical Engineering Self-Efficacy, Coping Self-Efficacy, Social Integration and Academic Integration, and Intent to Persist [24-27, 8]. A description of these subscale items and a copy of the survey used are provided in a previous paper [23]. The surveys also include free response questions soliciting feedback regarding as to why they chose to (or not to) attend the camp, why they chose chemical engineering as a major, and which workshop activities worked well and which could be improved. Some of these responses are used for formative assessment to improve the camp, others are used in a thematic analysis to help interpret the quantitative results. Student grades in chemical engineering courses and graduation rates are also collected via academic records.

Analysis

To determine the effects of a two-day intervention on self-efficacy and social support, the survey responses of students attending the ChemE Camp at two time points will be directly compared using paired Student's t-tests and linear regression to adjust for factors such as gender, race, and GPA. The immediate effects of the ChemE Camp will be assessed by comparing survey results from just before the camp (Pre-Camp) and just before the MEB course (Pre-Soph), a period of 3 days. Any changes in self-efficacy or social support ratings deemed statistically significant would suggest that the intervention had an impact on these outcomes.

To test whether any immediate ChemE Camp intervention effects were lasting, the Pre-Soph survey results will be compared to the Post-Soph results using paired Student's t-tests. Any such changes will be compared to the average changes observed from the non-camp attending cohort from Pre-Soph to Post-Soph. For consistent analysis of the same cohorts over time, only campers that completed the Pre-Camp, Pre-Soph, and Post-Soph surveys will be included in the pair-wise comparisons. P-values <0.05 are considered statistically significant.

Preliminary results

Although the camp has been offered at our institution since Fall 2016, the original surveys largely assessed the effectiveness of various workshop activities and were not grounded in any fundamental learning theories. Over time and with the help of our RIEF Mentor, our survey instrument has been revised and improved. By 2019 we had incorporated published subscales used to assess chemical engineering self-efficacy, coping self-efficacy, intent to persist, and social and academic integration into our surveys. The full survey instrument is shown elsewhere [23], with chemical engineering self-efficacy rated on a 6-point Likert scale [1 = completely uncertain, 6 = completely certain] and coping self-efficacy, social and academic integration, and intent to persist all rated on a 7-point Likert scale [1 = strongly disagree/not at all, 7 = strongly agree/very true].

A total of 22 students attended the camp in Fall 2019 and Fall 2020, compared to 43 non-camper students taking the MEB course for the first time. The coronavirus pandemic reduced the usable data in two ways. First, since classes were meeting online during Spring 2020, the effort required for students to complete the post-soph survey was more than usual (students must choose to click a link on their own time vs. being given class time to complete a physical copy). Thus, fewer students completed the post-soph survey than was anticipated. Second, upon returning to campus in Fall 2020, the fact that no one knew quite what to expect (general procedure, mask requirement, use of outdoor spaces during hot weather, etc.) is believed to have discouraged some who otherwise would have attended. Therefore, the cohorts for which we have complete survey data (i.e., Pre-Camp, Pre-Soph, and Post-Soph for campers and Pre-Soph and Post-Soph for non-campers) are limited to 14 campers (average Pre-Soph GPA of 3.67, standard deviation of 0.31) and 22 non-campers (average Pre-Soph GPA of 3.59, standard deviation of 0.33). These 36 responses are analyzed and presented below.

The self-efficacy results for the 2019-2020 and 2020-2021 academic years are shown in Figure 1. The data reflect an improvement of the campers' self-efficacy from Pre-Camp to Pre-

Sophomore. The effect is pronounced, and statistically significant, for both chemical engineering self-efficacy (0.30 point increase, p=0.01) and coping self-efficacy (0.43 point increase, p=0.02). Campers show very slight increases in both chemical engineering and coping self-efficacy rating from Pre-Soph to Post-Soph (0.08 point increase, p=0.72, and 0.04 point increase, p=0.80, respectively) while the non-campers exhibit a decrease in both (0.14 point decrease, p=0.52, and 0.16 point decrease, p=0.28, respectively), although these changes were not statistically significant. The unique conditions of the Spring 2020 academic quarter, with students at our institution leaving campus and course instruction rapidly shifting to remote/online delivery, could certainly affect student responses, but it is interesting to observe that the two cohorts appear to be impacted differently.

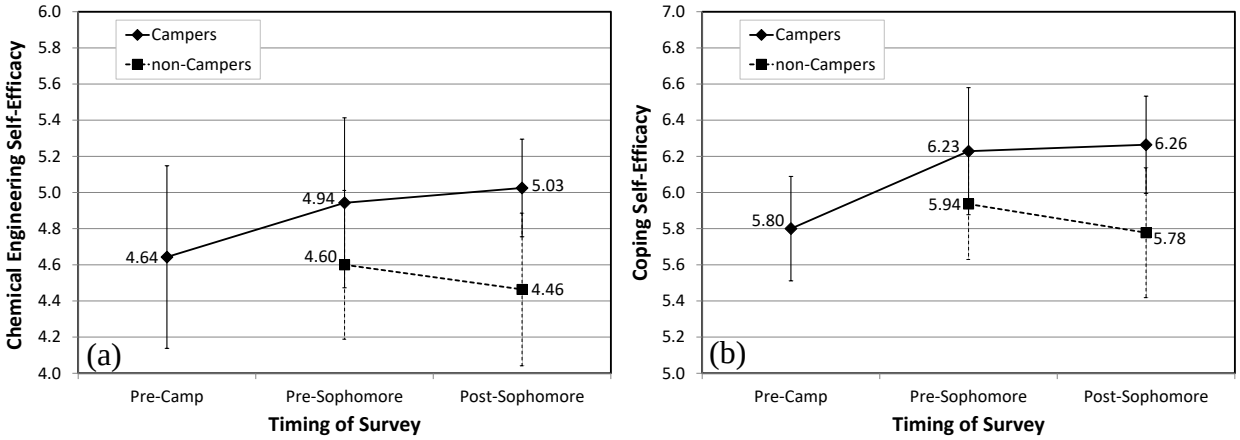

Figure 1. Average student survey ratings of (a) chemical engineering self-efficacy and (b) coping self-efficacy for the 2019-2020 and 2020-2021 academic years. Error bars indicate the 95% confidence interval.

Figure 2(a) shows the average student ratings of social integration and academic integration for the 2019-2020 and 2020-2021 academic years. Campers showed a marked, statistically significant, increase in this rating from Pre-Camp to Pre-Soph (0.52 point increase, p=0.01). The camper cohort's average rating decreases throughout the sophomore year from Pre-Soph to Post-Soph (0.14 point decrease, p=0.24) while the non-camper cohort's average rating showed a very slight increase (0.07 point increase, p=0.58), though neither change is statistically significant. Figure 2(b) show the average student ratings of intent to persist. Campers exhibited a small increase in average rating from Pre-Camp to Pre-Soph (0.11 point increase, p=0.56) and a larger increase from Pre-Soph to Post-Soph (0.34 point increase, p=0.10). The non-camper cohort showed a decrease in average rating over this span (0.24 point decrease, p=0.34). None of these changes were statistically significant.

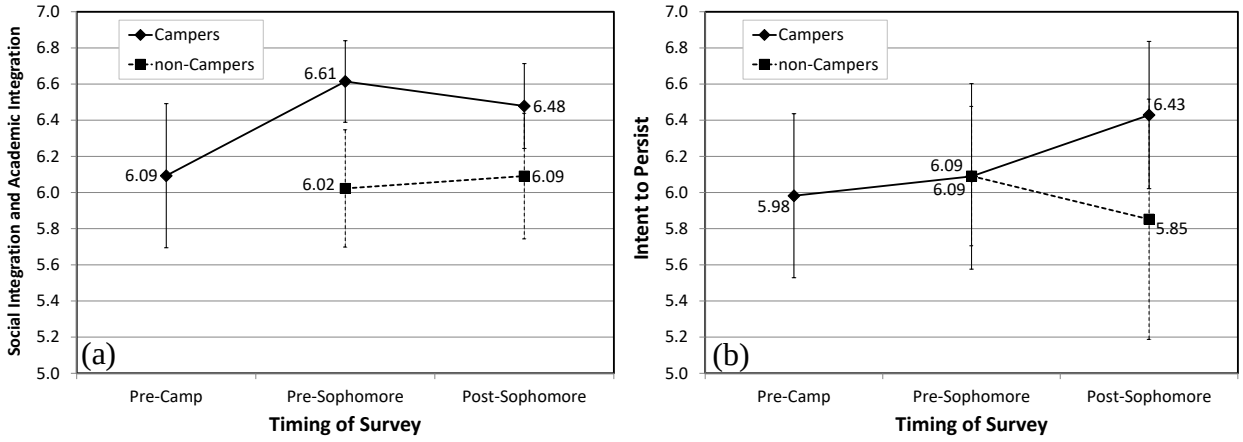

Figure 2. Average student survey ratings of (a) social integration and academic integration and (b) intent to persist for the 2019-2020 and 2020-2021 academic years. Error bars indicate the 95% confidence interval.

Some interesting observations can be made from the data shown in Figures 1 and 2. Before camp, the camper cohort and the non-camper cohort had similar ratings. After camp, the camper cohort's ratings increased to a statistically significant degree in three of the four areas, so that the campers began sophomore classes at notably higher levels in those areas. Additionally, the data for both types of self-efficacy, as well as for intent to persist, suggest that the camper cohort does a better job maintaining and improving upon the Pre-Soph factor ratings throughout the sophomore year than the non-camper cohort does.

Feedback about the intervention

Feedback about the workshop from the students who attend has been overwhelmingly positive. In free-response sections of the surveys, camp-attendees have cited many aspects of the camp to be beneficial: meeting and getting to know other students and faculty, hearing from upper-level students about their internship experiences, learning more about the curriculum, receiving advice regarding Career Fair, and getting tips on building better study habits. Testimonials from students who participated in the camp have been recorded (as shown in Figure 3) and will be included in a short advertisement video describing the camp activities and the observed benefits of the camp. This video will be distributed to student and faculty leaders of AIChE, student diversity organizations, and other STEM professional societies.

Figure 3. A screenshot from a dissemination video which includes testimonials from past camp attendees.

Mentoring

A key aspect of the Research Initiation in Engineering Formation program is to provide mentorship for new engineering education researchers. The project team met regularly throughout the academic year to discuss project next steps, prepare academic products (a conference paper submitted to the ASEE annual meeting), and conduct mentoring activities. The team has met nearly weekly to discuss reading assignments from Clemson's "Theories of Learning in Engineering, Science, and Mathematics" course taught by the RIEF mentor and

project Co-PI. The graduate research assistant (who had previously taken the course) led many of these discussions, giving her an opportunity both to mentor and be mentored. The PI and Co-PI also participated in the NSF RIEF Virtual Community of Practice meetings led by Julie Martin, Karin Jensen, and Kelly Cross for the benefit of current RIEF awardees.

The regular meetings between the RIEF mentor (Co-PI) and the mentees (PI and other senior personnel) have been helpful in deepening the mentees' understanding of the framework of Social Cognitive Theory and other learning theories that are germane to the research project. The team attended has attended recent ASEE annual meetings to learn about research being done at other institutions and to present our ongoing work. Participation in the RIEF virtual community of practice has allowed us to hear from current and former RIEF participants about their experiences and advice.

Future work

We plan to continue to compare the Pre-Camp and Pre-Soph survey responses of camp-attending students to determine whether the camp impacts the factors of chemical engineering self-efficacy, coping self-efficacy, social integration, and academic integration. Ongoing comparison of the Pre-Soph and Post-Soph ratings of the camp-attending and non-attending cohorts will help establish whether any observed changes in these factors are lasting. Once our data set becomes sufficiently large, we plan to employ a path analysis to assess whether the factors of chemical engineering self-efficacy, coping self-efficacy, social integration, and academic integration have a significant impact on the achievement and persistence of chemical engineering sophomore students. These results can inform efforts to develop and modify interventions like this workshop to improve student success.

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