Student Persistence Factors for Engineering and Computing Undergraduates

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Abstract
The research and evaluation team of an S-STEM project at a large, research-intensive Southeastern public university conducted a cross-sectional survey as a first step to compare factors which may influence undergraduate student persistence in engineering and computing. All engineering and computing students were invited to participate in the survey, and 282 (10.4%) provided responses. The respondents included 15 high financial need students who were participating in the S-STEM program, of which 7 were first-year students and 8 were sophomores. The remaining 267 respondents were undergraduates ranging from first-year to seniors. Survey questions were adapted from previously developed instruments on self-efficacy, sense-of-belonging, identity, community involvement, and overall college experience. Additional questions related to stress levels, academic life, use and effectiveness of academic supports, and the impacts of COVID-19 on their college experiences. The team compared responses by level of academic progression, declared major, gender, and race/ethnicity.

Student responses showed a variety of similarities and differences between subgroups. Overall, the students said that they often attended lectures (in-person or online) and came to class prepared. At the same time, students rated these activities as the least effective academic supports. On the other hand, the students rated working assigned or extra homework problems and studying for exams as their most effective activities. Consistently among the subgroups, the students said their community involvement and identity as developing engineers were relatively low while self-efficacy and team self-efficacy were seen as stronger personal skills. The students said they were highly stressed about their grades and academic success in general, and about finances and future careers. They reported feeling less stress about aspects such as living away from home and negotiating the university social scene. Students reported spending the most time preparing for class in their first year compared to students in later years.

Female students (104 responses) reported higher levels of community involvement, engineering identity, and engagement in college life compared to male students (142 responses) while there was little gender-related difference in self-efficacy and sense of belonging. Levels of self-efficacy and team self-efficacy did not show large differences based on year in college. Interestingly, first-year students expressed the highest levels of engineering identity while senior students the lowest. Senior students reported the lowest community involvement, sense of belonging, and engineering identity compared to other students. Overall, students from different races self-reported the same levels of self-efficacy. Black/African American students reported the highest levels of community involvement, college life, and identity. There were no substantial differences in self-efficacy among the different engineering and computing majors.

This study is a first step in analysis of the students' input. In addition to surveying the students, the team also conducted interviews of the participating S-STEM students, and analysis of these interviews will provide greater depth to interpretation of the survey results. Overall, the research and evaluation team's intention is to provide insight to the project's leadership in how best to support the success of first-year engineering and computing students.

Introduction

What do students in engineering programs at a research-intensive Southeastern university perceive to be the most helpful supports for student success? What kinds and levels of stress do they experience? How do they use their time? How do these perceptions relate to six identity-related factors? This paper summarizes some of the findings from a cross-sectional survey of engineering students, some of whom were participants in an NSF-funded S-STEM project (#1930492), that explored these questions. Invitations to the survey were sent by email to all engineering undergraduates at the institution, and 282 (10.7%) responded.

The S-STEM project provides tuition assistance to a select group of students with high financial need, most of whom are first-generation college students. In addition to financial assistance, the program supports program participants with a variety of academic and social supports. This survey was originally designed to collect data just from the participating students, but in the spring of 2022 the project team decided to broaden the survey data collection by inviting all undergraduate engineering majors to participate. This wider data collection has allowed the team to establish comparison groups.

Background

In academic year 2020-21, the higher education system was significantly disrupted by the effects of the global COVID-19 pandemic. Universities experienced a sudden drop in student enrollment and demands for tuition cuts as classes were moved online (Hubler, 2020). The college student experience was affected by concerns about the physical environment, student health, and mental health, in part due to adjustments to the remote learning experience (Kecojevic et al., 2020). Traditional-aged students were also deprived of the typical collegiate experience of living away from home and developing the skills to negotiate life as independent adults. With distancing requirements and other restrictions, many campus activities, sporting events, and the like were canceled or restricted.

These aspects of academic and social integration play critical roles in undergraduate student persistence (Bers & Smith, 1991), so this changed experience was of great concern. Academic integration involves strong connections with the college environment, academic peers and faculty, as well as their use of academic services such as peer tutoring and supplemental instruction (Terrion & Doust, 2011). The other side of the coin, social integration, revolves around affiliation with peers and others in social settings—college activities, student organizations, and the like (Nora, 1993). Although both forms of integration are important and interwoven in terms of students' sense of belonging (Pascarella and Terenzini, 1983), Tinto (1998) found that academic integration has greater impact on student success and persistence.

The project team was concerned that the COVID-19 pandemic and social distancing measures would have particularly negative impacts on the levels of academic support that first-generation college students in general and S-STEM participants in particular had access to. Previous research indicates that lack of both academic and social supports disproportionately affects historically marginalized students from lower socio-economic backgrounds, rural areas, and those who are first in their family to attend college (Soria et al, 2020). Historically, these students are more likely to have difficulty connecting socially and academically with the college environment. Students who are first in their family to attend college are often disadvantaged in terms of academic readiness as well as access to knowledge and resources to make proper academic decisions (Byrd & MacDonald, 2005). That results in higher anxiety, higher dropout rates at the end of freshman year, and less progress towards degree completion (DeAngelo & Franke, 2016). During the COVID-19 outbreak, first generation students were more likely to lack safe environments and suffer from emotional and physical abuse as well as food and housing insecurity (Soria et al., 2020). Those challenges added to the stress of the rush to online learning through less convenient access to technology, increased living and technology costs, cultural barriers with family members, and potential unexpected family responsibilities (Grineski et al.. 2021; Kiebler 2022).

This S-STEM project seeks to support students who need financial and academic support to be successful. To do that, the project team needed to understand more about the students' experiences as a first step to addressing their needs.

Methodology

To study the dimensions of student identity, use of time, levels of self-reported stress, and students' use and perceptions of a range of student supports, the project team has surveyed participants in the S-STEM project periodically during the time they have participated. Because the team wanted to establish comparison data, in April of 2022, survey invitations were emailed to all currently registered engineering students, a list of 2712 students. Of these, 282 students representing the range of student majors, class standing, and demographic characteristics, submitted responses, a response rate of 10.4%.

Scholarship recipient program participants were first-generation students in a cohort of seven freshmen (Cohort 2) and another cohort of eight sophomores (Cohort 1). Table 1 provides an overview of the characteristics of the students who responded to the survey.

Table 1: Summary of characteristics of students responding to the survey

	Cohort 1	Cohort 2	Freshman	Sophomore	Junior	Senior
Total responses (n = 282)	7	8	49	67	63	88
Gender						
Female	1		17	24	28	34
Male	3	6	27	36	28	41
Other/Prefer not to say			1	2	3	2
No response	3	2	4	5	4	11
Race/Ethnicity*						
American Indian				1		2
Asian		1	7	8	5	8
Black			4	1	3	3
Native Hawaiian					1	
White	4	4	32	50	49	67
Prefer not to say		1	3	4	2	1
No response	3	2	4	5	4	11
Major						
Aerospace Engineering			4	7	1	
Biomedical Engineering	1		4	7	9	12
Chemical Engineering			7	10	20	30
Civil Engineering		1	4	13	8	7
Computer Engineering			3	4	2	6
Computer Information Systems	1		3	1	2	3
Computer Science		3	14	10	8	9
Electrical Engineering	2			3	2	2
Integrated Information Tech			2	3	4	6
Mechanical Engineering	1	3	8	9	7	13
No response	2	1				

*Note: The race/ethnicity question allowed multiple selections, so numbers may add to more than the total number of responses.

The survey instrument consisted of 68 questions. Survey items were adapted from previously used and validated instruments. Sense of belonging and self-efficacy items were adapted from a study on the self-efficacy of women engineering students and a dissertation (Marra et al., 2009; Jordan, 2014). Identity, teamwork self-efficacy, and community involvement items were adapted from a study that investigated how underrepresented students' self-efficacy and identity impact their science career commitment (Chemers et al, 2011). Items about college life experience were adapted from the National Survey of Student Engagement (Kuh et al., 2011). The six factors we measured are as follows:

- Self-efficacy: Confidence in the participant's own ability to complete a degree and succeed in an engineering or computing career.

- Sense of belonging: Feeling part of the engineering or computing community.
- Identity: Being an engineer or computer scientist is an important part of the student's self-image.
- Teamwork self-efficacy: Confidence in ability to cooperate effectively with team members, and taking a leadership role when appropriate.
- Community Involvement: Participation in departmental and university-related study groups and social events.
- College life experience/student life expectations: Awareness of available support services in the college, opportunities for interaction with faculty, mental health and wellness, and effectiveness of academic support during the COVOD-19 pandemic.

Most items used Likert scale response options, "Strongly Disagree" (1), "Disagree" (2), "Slightly Disagree" (3), "Slightly Agree" (4), "Agree" (5), "Strongly Agree" (6). One set of items related to perceived stressors asked the respondents to rank a set of items. The survey also collected demographic information including gender, race, ethnicity, engineering major, and year in school.

This paper reports the results of summary descriptive analyses, comparing the responses of the two cohorts of first-generation student program participants and the responses of students from the general student body. Because the sizes of the cohorts were small, the team did not analyze the statistical significance of differences between participants and non-participants. The six factors are presented in spider graphs. Student perceptions of academic supports, use of time, and stressors were summarized and presented in bar graphs. Scale scores were computed for the six dimensions of student identity by averaging the responses on related items.

Results

Student Identity Factors

As detailed in the previous section, the survey asked students to respond to items designed to measure six aspects of personal attitudes and behavior. Figure 1 summarizes responses to these items, showing mean responses to strength-of-agreement items on a scale of "Strongly Disagree" (1) to "Strongly Agree (6).

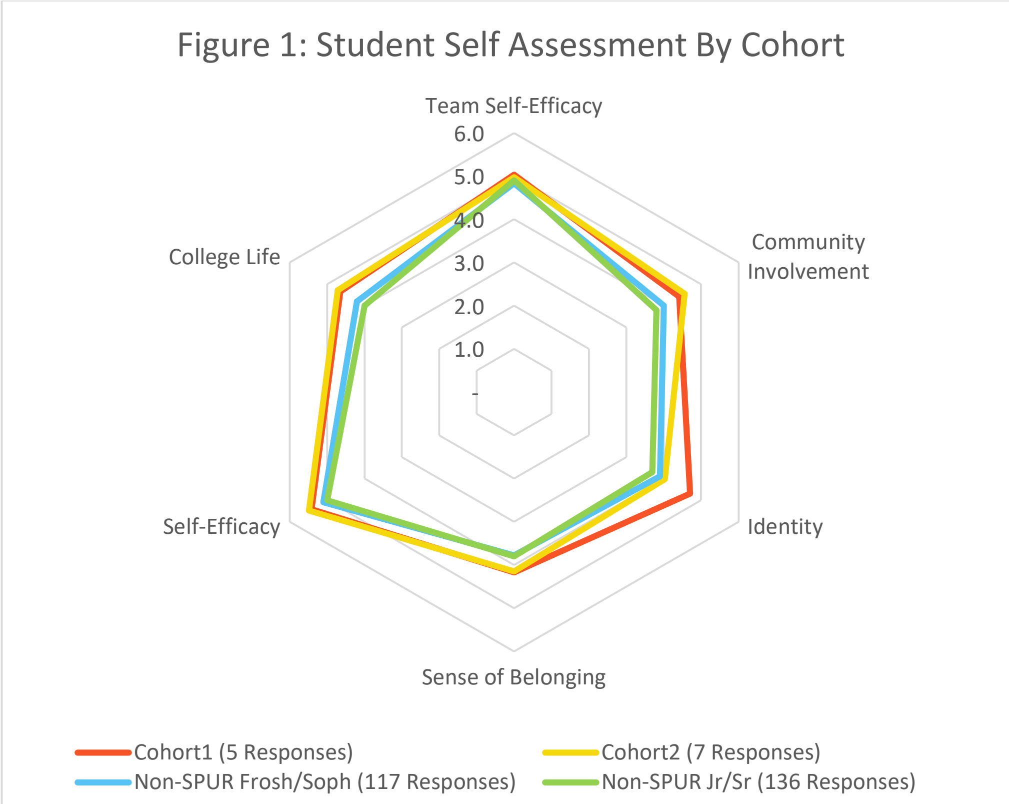
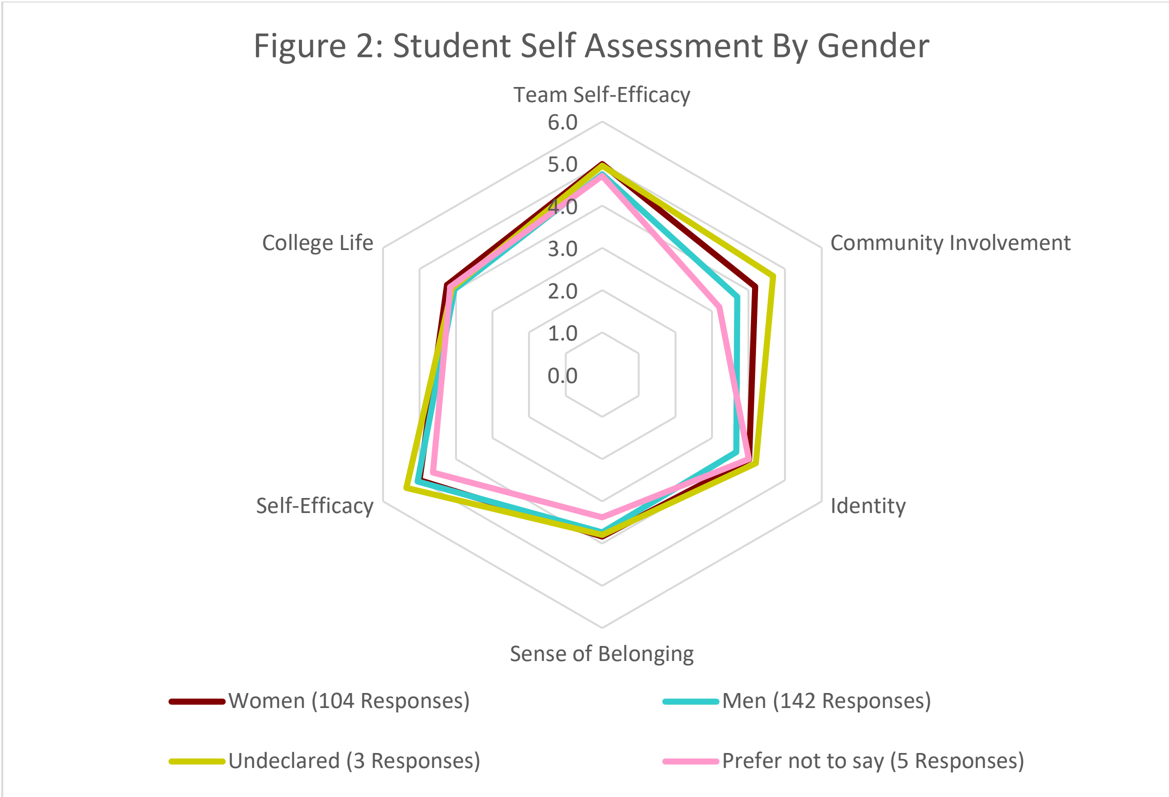
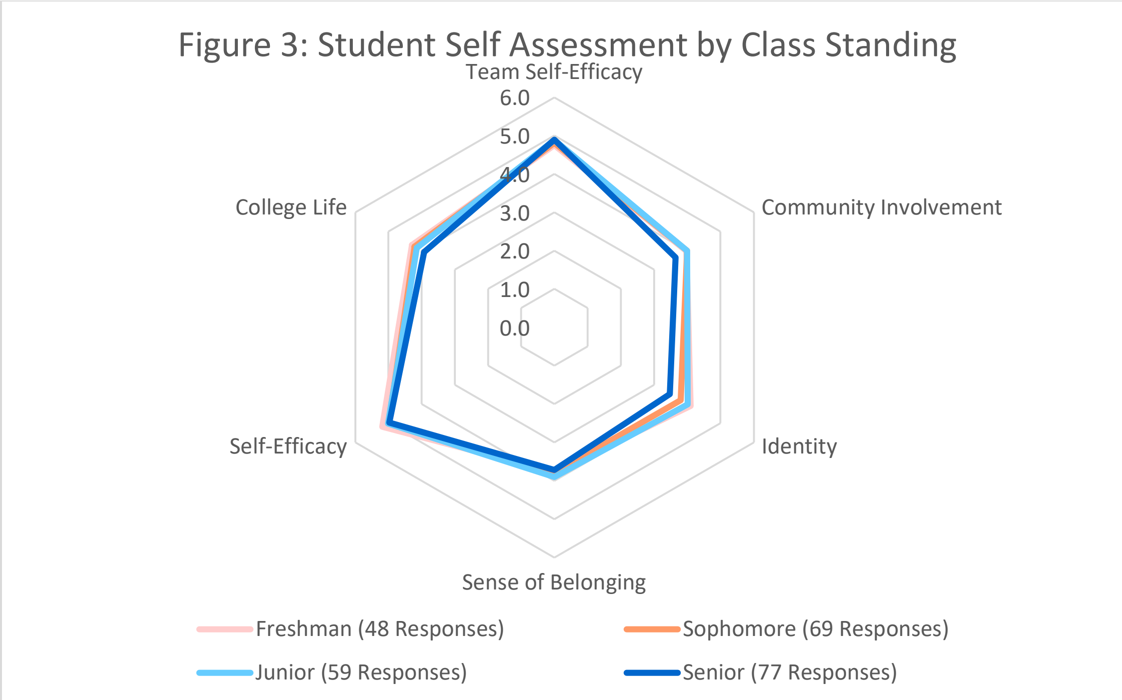


Figure 1 summarizes the responses of the two cohorts of participating students and compares these to the non-participating students, divided into lower division (first-year and sophomores) and upper division (third and fourth year) students who responded to the survey. The results indicate that the non-participating students had slightly lower self-assessments in all areas than the participants had, although these differences were not large. Because the cohorts were small in size, we did not assess the statistical significance of the differences between groups.

The two types of self-efficacy (individual and team) had the highest self-assessed levels, at about the “Agree” level. Students in the first cohort indicated the highest levels of engineering identity—almost at the “Agree” level, compared to the non-participants, whose average response was “Slightly Agree.”



The results based on respondents' genders (Figure 2), showed the only relatively large differences between females and males were community involvement and engineering identity. In both instances, women indicated higher levels of community involvement and somewhat stronger engineering identity. Undeclared individuals and those choosing "Prefer not to say" differed from males and females in their responses on several of the dimensions, but there were very few individuals in these categories, so these results may not be indicative of anything but the individuals who categorized themselves this way.



There was little difference between students relative to their class standing (Figure 3), although seniors showed slightly lower levels of community involvement and engagement in college life—perhaps understandable as they prepared to transition to careers or graduate school after graduation. more puzzling was their lower levels of engineering identity. It appears that there is relatively little change in the six factors as students progress through their degree programs.

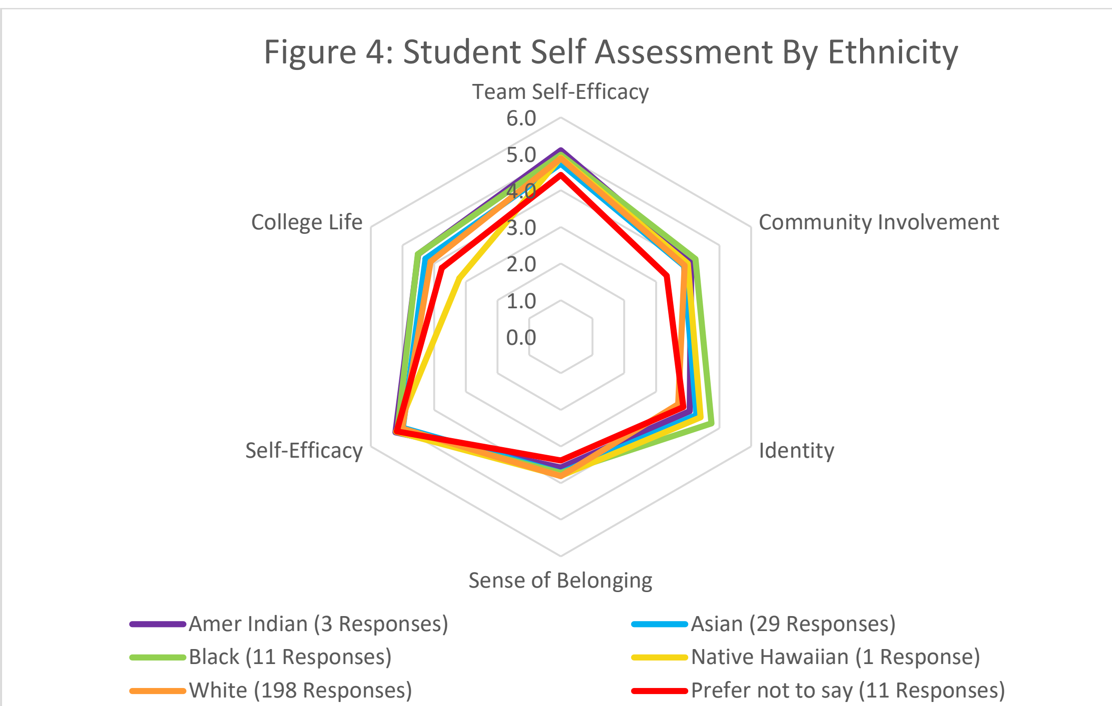


Figure 4 shows the survey results by the racial categories chosen by the respondents. Those who did not indicate an ethnicity or racial background are not included in this chart. Note also that a few respondents chose two categories, and these were included in the means of both. Two of the categories (American Indians and Native Hawaiians) included very small numbers of responses (3 and 1 responses respectively), so their results should be interpreted with that in mind.

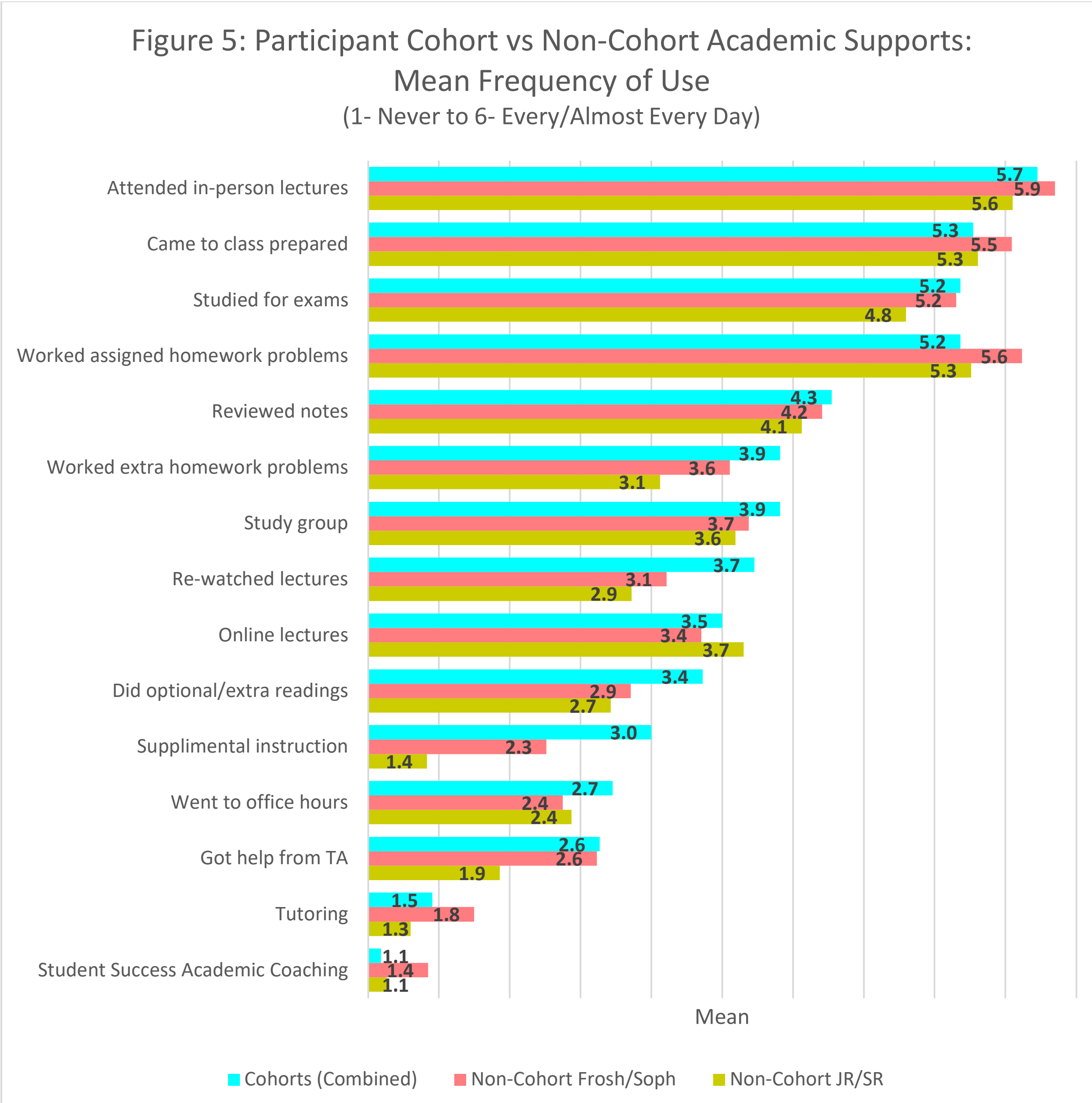
All categories of students chose about the same levels of individual self-efficacy. There were slightly more differences between categories regarding engagement in college life, team self-efficacy, community involvement, and sense of belonging, but with the exception of those who chose "Prefer not to say," their response were quite similar, on average. Those who chose "Prefer not to say" indicated lower levels of agreement on all categories, except regarding self-efficacy. African American and Black students indicated the highest levels of engineering identity and White students the lowest.

Summary Regarding the Six Factors

Although there were a few differences to note when looking at different categories of students, possibly the most noteworthy aspect of these results is the similarities among the different groups of students. Most students indicated high levels of self-assessed individual and team self-efficacy. The relatively low levels of engineering identity suggest that the School of Computing and Engineering could increase student retention by finding ways to nurture this form of identity development.

Students' Use of Academic Supports

The survey asked students three related questions about a list of supports and behaviors that support student learning: how often they used those supports; how valuable they believed them to be, and whether they wished they had used or done them more. Figure 5 summarizes the responses to the first question, ranked by the mean response of the program participants. Perhaps not surprisingly, the students were most likely to have attended lectures, come to class prepared, studied for exams, and worked assigned homework problems. Differences between participants and non-participants were minor.



The students' assessments of the effectiveness of these supports, and their wishes to have used them more were quite different from their frequency of use, however. For example, attending in-person lectures was cited as their most frequent behavior, but ranked last in the students' assessment of effectiveness, and the students were least likely to say they wished they had done this more. Other supports or behaviors that were less-frequently used were assessed as more effective and the responses expressed the wish to have done them more. Interestingly, the ranks for the students' assessments of effectiveness and wish they had done them more were the same. Table 2 compares the students' frequency of using the support or behavior to their assessment of their effectiveness and wish to do them more.

Table 2: Comparison of students' use of learning supports/behaviors and their assessment of effectiveness/wish to use them more.

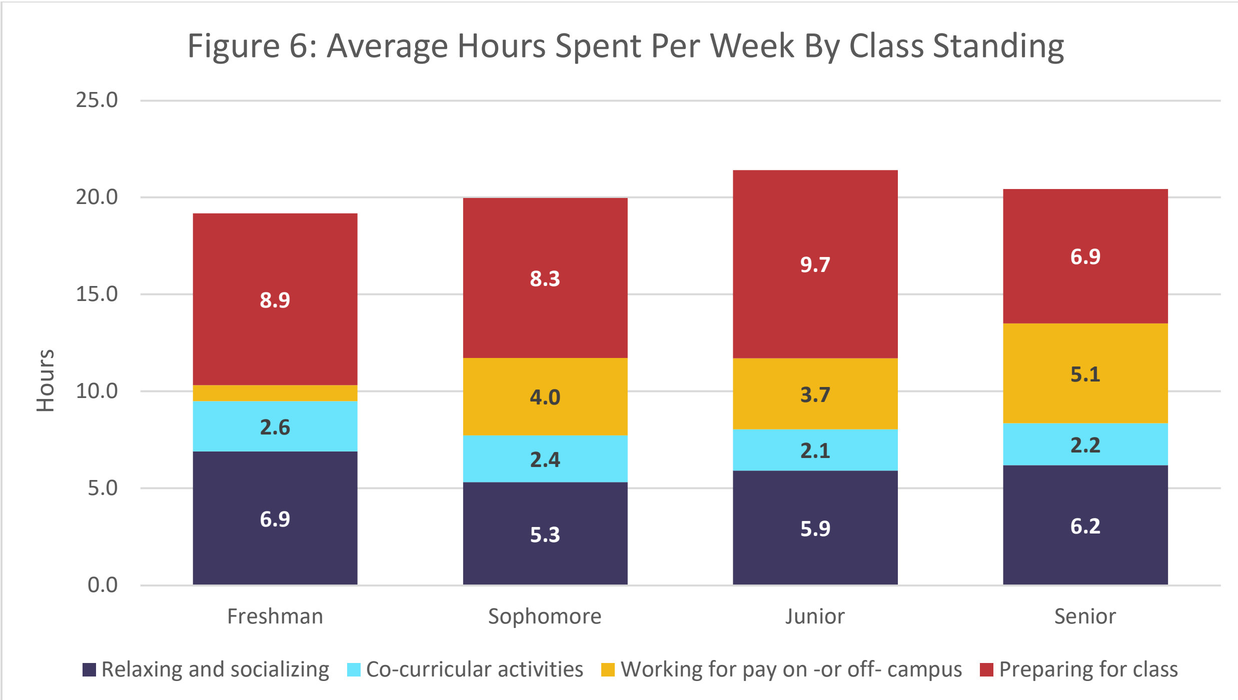
Frequency of Use (Rank)	Support	Assessment of Effectiveness (Rank)	Wish to do it more (Rank)
1	Attended in-person lectures	15	15
2	Came to class prepared	13	13
3	Studied for exams	2	2
4	Worked assigned homework problems	4	4
5	Reviewed notes	6	6
6	Worked extra homework problems	3	3
7	Study group	7	7
8	Re-watched lectures	5	5
9	Online lectures	14	14
10	Did optional/extra readings	1	1
11	Supplemental instruction	11	11
12	Went to office hours	12	12
13	Got help from TA	10	10
14	Tutoring	9	9
15	Student Success Academic Coaching	8	8

This table illustrates that in many cases there was wide divergence between how often students engaged in these supports and behaviors and their assessment of their value.

Students' Use of Time

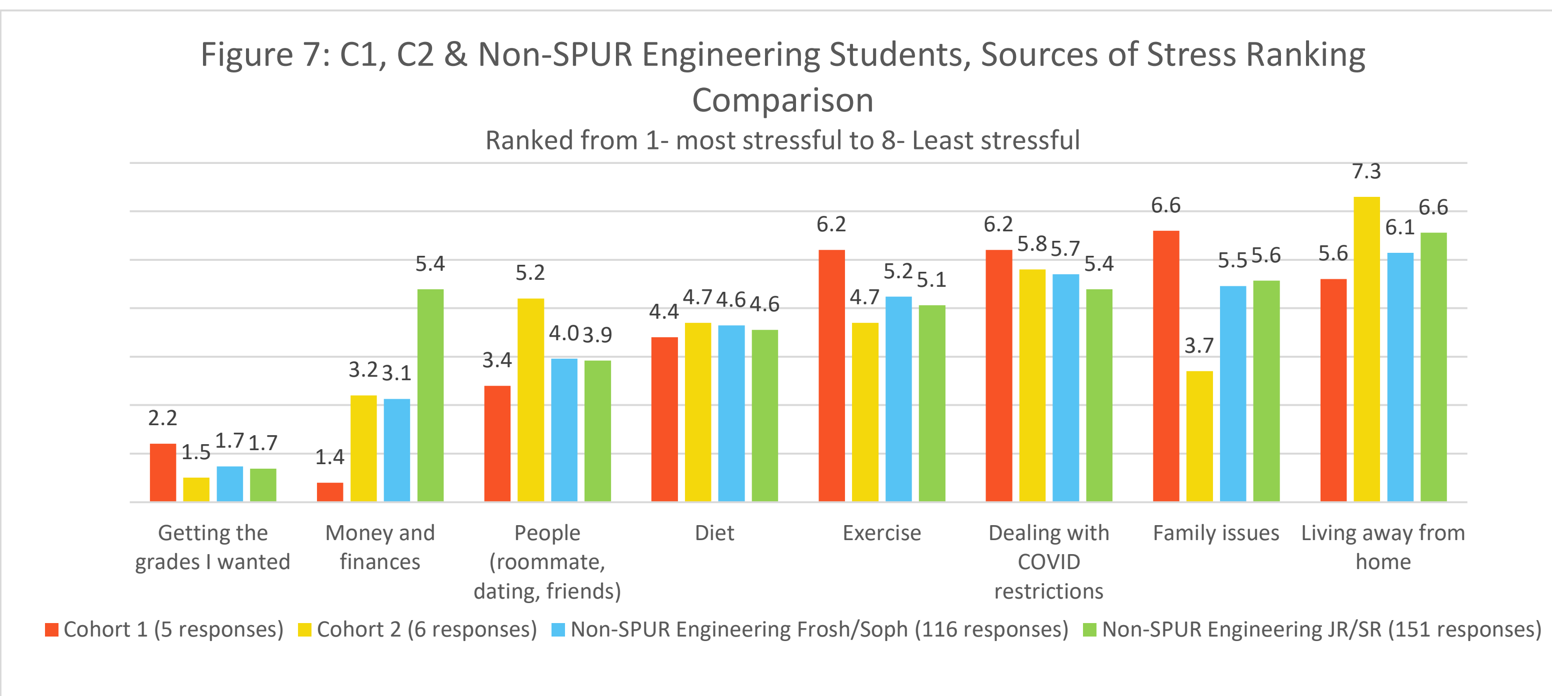
The survey asked several questions about how many hours the students spent per week in four categories of activities, including preparing for class, working for pay, engaging in co-curricular activities, and relaxing and socializing (Figure 6). Overall, juniors said they spent the most time (about 22 hours) engaged in these activities, followed by seniors (just over 20 hours), sophomores (20 hours), and first-year students (19 hours). Surprisingly, seniors said they spent the least amount of time (under 7 hours) preparing for class, while juniors said they spent almost 10 hours doing so.

First year program participants (cohort 2) said they spent considerably more time (almost 29 hours) engaging in these activities. Second year (cohort 1) participants' reported use of time was more similar overall (18 hours vs 19.5 hours for their peer freshmen), but the distribution of time was considerably different, with non-participants reporting spending more than 9 hours preparing for class, compared to 5.3 hours reported by the first year participants.

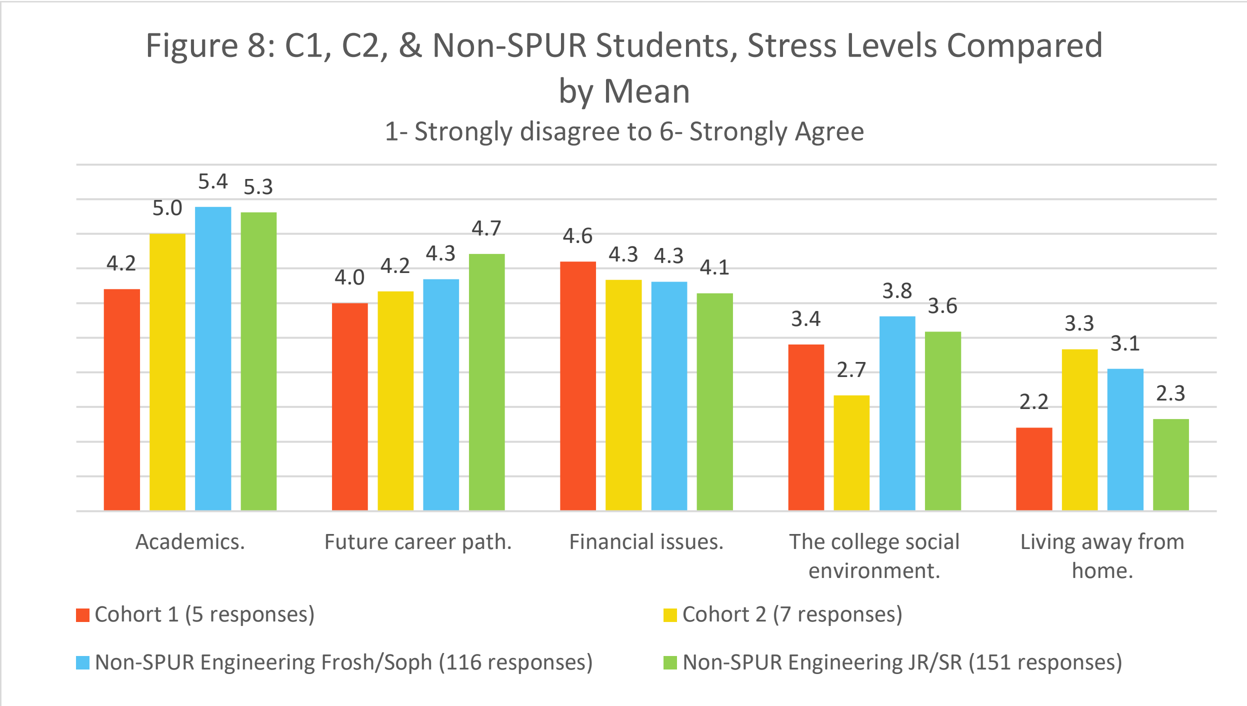


Stressors

We asked the respondents to rate their levels of stress in two ways. First, we gave them a list of eight possible stressors and asked them to rank the stressors from highest stress (1) to lowest (8). Figure 7 shows the average ranking for each of the stressors. With slight variation among the participants, the most stressful items were "Getting the grades I wanted" and "Money and finances."



We also asked the students to indicate their levels of agreement with statements about stress factors, from (1) Strongly Disagree to (6) Strongly agree. Figure 8 summarizes their responses to these items. The strongest levels of agreement (that is, the highest levels of stress) were stress about academic issues, future career path, and financial issues, with social factors rated as less stressful.



For all groups, academic and financial issues were at the forefront of concerns that caused them stress. For juniors and seniors, perhaps not surprisingly, their future career path was also of greater concern. Social issues (negotiating college life and living away from home) were of less concern among all students.

Future Analysis

Having completed the initial descriptive analysis of the data, the research and evaluation team plan to conduct additional quantitative analysis. An analysis which compares students reporting high levels of stress with those experiencing lower levels has already begun. Other potential approaches may include data reduction and cluster analysis to help identify groups of students who have similar needs. In addition, student participants in the project cohorts have also participated in interviews with the research and evaluation team, and we plan to combine the interview data with survey responses to provide a richer understanding of our participants' experiences.

A significant limitation of this study has to do with the small size of the two cohorts (15 participants in all). That reduced the team's ability to draw conclusions about differences between the participants and nonparticipants. Since the survey was conducted, the project has added another, somewhat larger cohort of participants, which will allow the researchers to use inferential techniques to analyze future survey data.

Conclusions

This preliminary analysis of survey results from the spring 2022 survey of engineering and computing students at a large research-intensive public university in the Southeastern US provides insight into the perceptions, self-reported behaviors, and some of the characteristics of these students. The project team set out to learn more about what academic supports might be of greatest help to first-generation engineering and computing students and how academic perceptions and behaviors might influence their use of these supports.

As the university emerges from pandemic-related restrictions, it is important to know how the experiences of students who entered the university in 2020 and 2021 were affected by the experience, which in many cases involved a year that lacked the social supports and networking that help first-year students to connect with the institution and their peers.

The engineering and computing students' levels of self-efficacy were relatively strong, a finding that the project, and the School can build on as they continue their efforts to improve student persistence and success.

The team's next steps include using these findings to improve the S-STEM project to try to better meet the participants' needs, and to share some of them with faculty in Engineering and Computing.

References

Barber, P. H., Shapiro, C., Jacobs, M. S., Avilez, L., Brenner, K. I., Cabral, C., ... & Levis-Fitzgerald, M. (2021). Disparities in remote learning faced by first-generation and underrepresented minority students during COVID-19: insights and opportunities from a remote research experience. Journal of microbiology & biology education, 22(1), ev22i1-2457.

Bers, T. H., & Smith, K. E. (1991). Persistence of community college students: The influence of student intent and academic and social integration. Research in higher Education, 32, 539-556.

Byrd, K. L., & MacDonald, G. (2005). Defining college readiness from the inside out: First-generation college student perspectives. Community college review, 33(1), 22-37.

Chemers, M.M., E.L. Zurbriggen, M. Syed, B.K. Goza, and S. Bearman," The role of efficacy and identity in science career commitment among underrepresented minority students", *Journal of Social Issues* Vol. 67, No. 3, 2011, pp. 469-491.

DeAngelo, L., & Franke, R. (2016). Social mobility and reproduction for whom? College readiness and first-year retention. *American Educational Research Journal*, *53*(6), 1588-1625.

Grineski, S. E., Morales, D. X., Collins, T. W., Nadybal, S., & Trego, S. (2021). Anxiety and depression among US college students engaging in undergraduate research during the COVID-19 pandemic. *Journal of American College Health*, 1-11.

Hubler, S. (2020). As colleges move classes online, families rebel against the cost. *The New York Times*, *15*.

Jordan, K.L., *Intervention to improve engineering self-efficacy and sense of belonging of first-year engineering students*: The Ohio State University, 2014.

Kecojevic, A., Basch, C. H., Sullivan, M., & Davi, N. K. (2020). The impact of the COVID-19 epidemic on mental health of undergraduate students in New Jersey, cross-sectional study. *PloS one*, *15*(9), e0239696.

Kiebler, J. M., & Stewart, A. J. (2022). Student experiences of the COVID-19 pandemic: Perspectives from first-generation/lower-income students and others. *Analyses of Social Issues and Public Policy*, *22*(1), 198-224.

Kuh, G. D., Hayek, J. C., Carini, R. M., Ouimet, J. A., Gonyea, R. M., & Kennedy, J. (2001). *National survey of student engagement : the college student report : NSSE technical and norms report. Bloomington, IN :Indiana University Center for Postsecondary Research and Planning.*

Lohfink, M. M., & Paulsen, M. B. (2005). Comparing the determinants of persistence for first-generation and continuing-generation students. *Journal of College Student Development*, *46*(4), 409-428.

Marra, R.M., K.A. Rodgers, D. Shen, and B. Bogue," Women engineering students and self-efficacy: A multi-year, multi-institution study of women engineering student self-efficacy", *Journal of engineering education* Vol. 98, No. 1, 2009, pp. 27-38.

Nora, A. (1993). Two-year colleges and minority students' educational aspirations: Help or hindrance? *Higher Education: Handbook of Theory and Research, 9,* 212-247.

Pascarella, E. T., & Terenzini, P. (1983). Predicting voluntary freshman year persistence/ withdrawal behavior in a residential university: A path analytic validation of the Tinto model. *Journal of Educational Psychology, 52*(2), 60-75.

Soria, K. M., Horgos, B., Chirikov, I., & Jones-White, D. (2020). First-generation students' experiences during the COVID-19 pandemic.Tinto, V. (1998). Colleges as communities: Taking research on student persistence seriously. *The Review of Higher Education, 21*(2), 167-177.

Terrion, J. L., & Daoust, J. L. (2011). Assessing the impact of supplemental instruction on the retention of undergraduate students after controlling for motivation. *Journal of College Student Retention: Research, Theory & Practice*, *13*(3), 311-327.