ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #38290

Impact of Peer-Assisted Learning and Leadership Development on Undergraduate Students

Julie Fogarty (Assistant Professor)

Dr. Fogarty received her B.S. in Civil Engineering at Johns Hopkins University, M.S. degrees in both Civil & Aerospace Engineering, a Ph.D. in Civil Engineering, and a certificate in Engineering Education Research from the University of Michigan. She is currently an Associate Professor in Civil Engineering at California State University, Sacramento with research interests ranging from the seismic behavior of steel structures to improving/expanding the educational methods used in the formation of engineers.

Robin Altman

Dr. Altman received her B.S. in General Biology from the University of California, San Diego and her Ph.D. in Molecular, Cellular, and Integrative Physiology from the University of California, Davis. She is currently an Assistant Professor of Biological Sciences at California State University, Sacramento. Her research interests include the role of neurovascular dysfunction in diabetes mellitus and Alzheimer's disease, and the teaching and learning of physiology at the undergraduate level.

Jennifer Lundmark

I am a Professor of Biological Sciences with a specialty in Physiology (Ph.D. from UC Davis in 1996) at California State University, Sacramento. I developed the Peer-Assisted Learning (PAL) program in the College of Natural Sciences and Mathematics in 2012, and have worked with many campus partners over the years to ensure its continued success, including this partnership with the College of Engineering & Computer Sciences.

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Abstract

With college advisory boards and potential employers consistently voicing their desire for engineers and scientists who can communicate well, work effectively in teams, and independently problem-solve, the Colleges of Engineering & Computer Science (ECS) and Natural Sciences and Mathematics (NSM) at Sacramento State University, a large, public, primarily undergraduate institution, have deployed two programs to explicitly address these skills for undergraduate science, technology, engineering, and mathematics (STEM) students. The goals of the NSF-funded *Achieving STEM Persistence through Peer-Assisted Learning and Leadership Development (ASPIRE)* project are to increase retention and decrease time to graduation for STEM students, as well as increase retention of women and underrepresented minorities (URM) in the STEM workforce by implementing evidence-based practices to promote student success during two critical transitions: 1) from lower-division to upper-division coursework in engineering; and 2) from upper-division coursework to an entry-level STEM career.

ASPIRE aims to achieve these goals by: 1) adapting and implementing the NSM Peer Assisted Learning (PAL) program in gateway engineering courses; and 2) developing the Hornet Leadership Program which includes scaffolded opportunities for students to explore their leadership capacity and develop leadership skills. The main research questions for this study include: (1) Will the ECS PAL model and Hornet Leadership Program result in increased persistence and workforce readiness in STEM majors at a large, diverse university? (2) What attitude changes will this project have on students and faculty and the relationships between them? The first question is addressed through pre- and post-implementation student surveys and student course/GPA data. The second question is addressed through faculty surveys, faculty focus groups/interviews, and pre- and post-data from a faculty professional development workshop. In general, preliminary results from this study indicate the new ECS PAL program successfully attracts URM students and thus has the potential to support their persistence and STEM workforce readiness. Additionally, undergraduate students across both Colleges who participated in the inaugural Hornet Leadership Program gained non-technical skills and experiences directly linked to competitiveness and preparation for workforce entry and graduate programs. Finally, faculty surveys and the faculty professional development workshop indicate that faculty value student leadership development, but identify barriers to accomplishing this work.

Introduction

With native STEM students experiencing extremely low graduation (4-year: 13%) and retention rates (lower to upper division: 66-68%; see Table 1) and transfer STEM students experiencing similarly low graduation (2-year: 18-24%), but not ideal retention rates (lower to upper division: 88%), an intervention is needed at Sacramento State. A sense of belonging is difficult to foster for varying reasons: 1) the university boasts an ethnically diverse student body with over 73% non-white students (37% URM); 2) roughly 94% of STEM students live off campus; 3) 57% transfer into STEM majors with varying amounts of the major completed; 4) over a third are first generation students; and 5) women make up only 16% of the College of ECS. Underpinning this issue, faculty diversity has not kept pace with the rapidly changing student demographics and the majority of STEM instructors are part-time faculty (ECS: 9% URM, 16% women, 59% part-time; NSM: 6% URM, 45% women, 54% part-time). These characteristics are similar at other large, public institutions across the nation where a lack of perceived connection to STEM role models negatively affects student performance and retention (Cole and Espinoza 2008, Griffith 2010).

Table 1. Sacramento State Demographics and Graduation Rates (2019)

	Student Demographics								
	URM	Women	Low Income	First Generation	Commuters	Native Grad Rate		Transfer Grad Rate	
						4-Year	6-Year	2-Year	4-Year
ECS	30%	16%	51%	33%	94%	13%	49%	18%	72%
NSM	36%	59%	57%	35%	94%	13%	54%	24%	70%
University	37%	56%	55%	38%	94%	20%	54%	44%	77%

Recent research shows that interventions which address social-psychological needs (e.g. self-actualization, esteem, and sense of belonging [Maslow 1987]) *in addition* to their academic needs (Solanki et al. 2019) improves performance and persistence of STEM majors. Both ASPIRE interventions foster academic communities and support networks to meet these needs.

To transition into a STEM career post-graduation, students must capitalize on their content knowledge and a suite of non-technical interpersonal and cognitive skills that often are not intentionally nurtured in their undergraduate programs (Paul and Cowe Falls 2015). Tenopir and King (2003) showed that engineers spend 60% of their time communicating with other people, yet most engineering programs include just one lower-division communication course, generally taken at the freshman level. Leadership competency is frequently noted as a vital skill set sought by employers, yet it is rarely included in an undergraduate experience (Crumpton-Young et al. 2010).

Within the college experience, all students grow and develop. A program like PAL, which is a modified version of Peer-Led Team Learning (PLTL), provides a unique “stretch” as it requires facilitators to work independently, solve problems with little immediate guidance, communicate clearly and effectively with a wide range of individuals, and do all of this with empathy,

kindness, and a disposition that inspires trust on the part of struggling students. The scholarship on teaching and learning has long recognized that undergraduates employed in peer support programs like the PAL Facilitators naturally develop a suite of leadership skills simply due to their job experience (Tenney and Houck 2004, Glover et al. 2018). Yet this development is often unintentional and not predictable to any large degree. Many students are not cognizant of their learned management or communication abilities. The Multi-Institutional Study of Leadership showed that formal leadership programs, regardless of the duration of contact, have a significant impact on leadership skills (Dugan and Komives 2007). Thus, we seek to purposefully develop and hone students' skills with the goal of creating a robust, self-aware group of diverse STEM leaders cognizant of their workforce skills and attributes.

Overview of Programs

ECS Peer Assisted Learning (ECS PAL) Program

The ECS PAL program adapts and builds on Sacramento State's successful NSM PAL program (NSF 1068383) which was first implemented in gateway chemistry and mathematics courses in 2012. This supplemental, one unit concurrent course encourages students to learn cooperatively under the guidance of trained students, called PAL Facilitators, who have been successful in the same course they facilitate, and who have been trained in group facilitation and pedagogy. Unlike PLTL, the NSM and ECS PAL programs include additional high impact educational practices that encourage students to work on education research projects that benefit other students on campus.

Hornet Leadership Program

Both colleges independently sought to improve formal training of communication, team-work, and problem-solving skills through pilot leadership programs starting in the 2018-2019 academic year. The Hornet Leadership Program supported by the grant united both pilot leadership programs into a single, experiential platform grounded in the Social Change Model for Leadership Development (SCM) theoretical framework. This framework develops leaders through a process that results in social change through values-based reflection and action at three levels: 1) individual (consciousness of self, congruence, commitment); 2) group (collaboration, common purpose, controversy with civility); 3) and community (citizenship) (Komives et al. 2017). Students voluntarily engage in the Hornet Leadership Program from their freshman to senior year by participating in one or more of the four different leadership experiences shown in Figure 1. The leadership learning experiences range from short (one-time seminar or workshop) to moderate and intensive/experiential (semester course or summer leadership experience) and build in complexity as students move through their academic career.

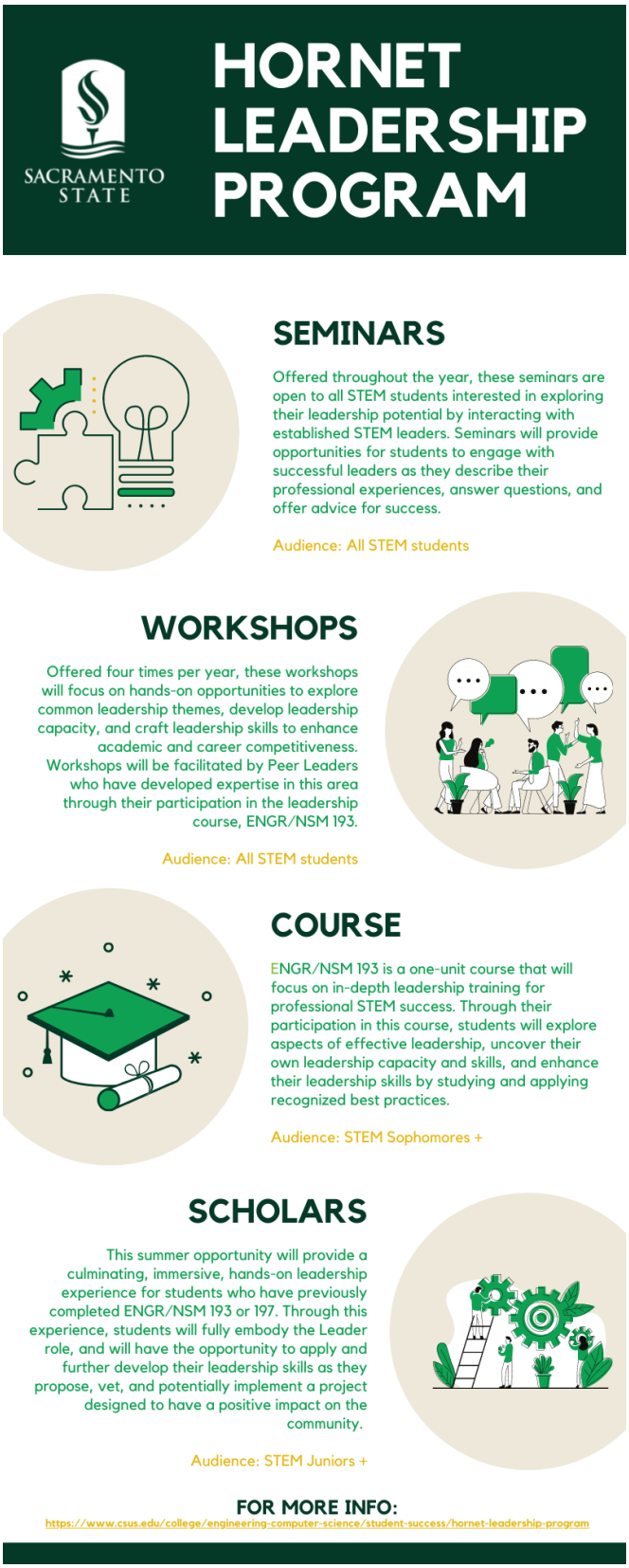

Figure 1: Hornet Leadership Program Infographic

Research Design

Research Questions

The overall research objective is to identify what factors best support students before and during critical transitions. The questions motivating this research are: (1) Will the ECS PAL model and Hornet Leadership Program result in increased persistence and workforce readiness in STEM majors at a large, diverse university? (2) What attitude changes will this project have on students and faculty and the relationships between them? To answer these questions, data is collected related to the following project outcomes:

Short & Intermediate Term:

S1. Increase academic performance (course grades, pass rates) to decrease time to graduation
S2. Increase student self-efficacy (as it relates to belief in the ability to continue in/complete a STEM degree/pursue a STEM career), sense of belonging, and intentions to persist in STEM
S3. Increase student leadership opportunities and develop student non-technical communication, self-initiative, and teamwork skills.
S4. Increase faculty expectations regarding student ability to serve in a leadership role.

Long Term:

L1. Increase the number of transfer students, women and URM that persist in lower to upper division courses and engineering majors and narrow achievement gaps.
L2. Increase workforce readiness and entry level job attainment of women and URM in STEM workforce.
L3. Generate new knowledge regarding the extent to which the underlying theories guiding ECS PAL and the Hornet Leadership Program have on student engagement, degree attainment, and workforce transitions.

Participants

All students enrolled in an ECS or NSM major are eligible to participate in the Hornet Leadership Program activities and were sent an annual survey gauging their experience with the grant activities as well as self-efficacy, sense of belonging, and intentions to persist in their STEM major or pursue a STEM career. All students enrolled in the courses with concurrent ECS PAL offerings are eligible to participate in the PAL program. Demographics for participants in the grant activities are shown in Table 2 and demographics for survey participants are shown in Table 3.

Table 2. ASPIRE Activities Participant Demographics

Student Participant Demographics

	URM	Female	Number of Students
ECS PAL Students	47%	20%	95 (Spring & Fall 2021)
ENGR 197 (ECS PAL Facilitators)	20%	58%	20 (Spring & Fall 2021)
ENGR/NSM 193 (Leadership Course)	45%	20%	30 (Fall 2021)
HLP Scholars	23%	62%	13 (Summer 2021)

Faculty Participant Demographics

	URM	Female	Tenure-Track	ECS Faculty
Faculty Workshop	15%	50%	65%	30%

Table 3. Student and Faculty Survey Demographics

Survey Participant Demographics

	N	URM	Female	ECS	Transfer	First Generation	Pell-Eligible
Students	588	37%	40%	61%	46%	37%	58%
Faculty	81	16%	37%	40%	-	-	-

Limitations

This grant was awarded in June 2020 and as such the data related to the project has been impacted in two major ways due to COVID-19: 1) ability to reach out to students to complete surveys and 2) ability to encourage participation in the grant activities to increase the sample size. Baseline data was collected during the fully online Fall 2020 semester which likely impacted student sense of belonging given that some students have still never physically been on the Sacramento State campus. The ECS PAL program began during the fully online Spring 2021 semester and about half of the sections went to in-person in Fall 2021. However, most courses were still being offered virtually in Fall 2021 which negatively impacted enrollment in the in-person sections as students were either not physically able to come to campus or uninterested in coming for a single one-unit course.

Results

Will the ECS PAL model and Hornet Leadership Program result in increased persistence and workforce readiness in STEM majors at a large, diverse university?

The ECS PAL program addresses outcomes S1, S2, L1 and L3. Given that the first ECS PAL courses were offered in Spring 2021, only outcome S1 will be addressed in this paper. It should be noted that outcome S2 for the NSM PAL program is captured in the baseline data which will hopefully be replicated by the ECS PAL program. Those who participated in NSM PAL courses for lower division math and science courses were statistically significantly more likely to indicate they had plans to pursue a STEM graduate degree, pursue a career as a health professional, and/or that they intend to practice, conduct research in, or teach in a STEM-related discipline for at least three years after graduation.

While none of the values from the ECS PAL program are statistically significant at this point due to a small population size and inability to do propensity-score matching, encouraging trends are seen in Table 1 including the following: 1) over the two semesters, the average course grade for PAL students is higher than the course grade for students who did not participate in PAL regardless of whether or not the average GPA of students participating in PAL was less than, equal to, or greater than those not participating and 2) in all but one course below, a greater percentage of Hispanic students are participating in PAL than would be expected based on the percentage of Hispanic students enrolled in the required course.

The second trend is particularly encouraging given the data shown in Figure 2. While the average overall entering GPA for URM students is the same whether they participate in PAL or not, those who participate in PAL have a better course grade that is approximately the same on

average as their non-URM counterparts. This indicates that this program has the potential to close the opportunity gap seen in the non-PAL participants in the same figure.

Table 3: Comparison of PAL and Non-PAL Students

		PAL Students				Non-PAL Students			
	Course	Hispanic	GPA	Course Grade	# of Students	Hispanic	GPA	Course Grade	# of Students
Spring 2021	ENGR 30	29%	3.21	2.93	14	57%	2.97	2.73	115
	ENGR 112	35%	2.94	2.62	25	44%	3.07	2.37	144
	CSC 15	22%	3.44	3.36	13	29%	3.03	2.91	166
Fall 2021	ENGR 30	34%	3.00	2.62	14	21%	3.00	2.29	123
	ENGR 112	37%	3.12	2.37	29	38%	3.02	2.13	114

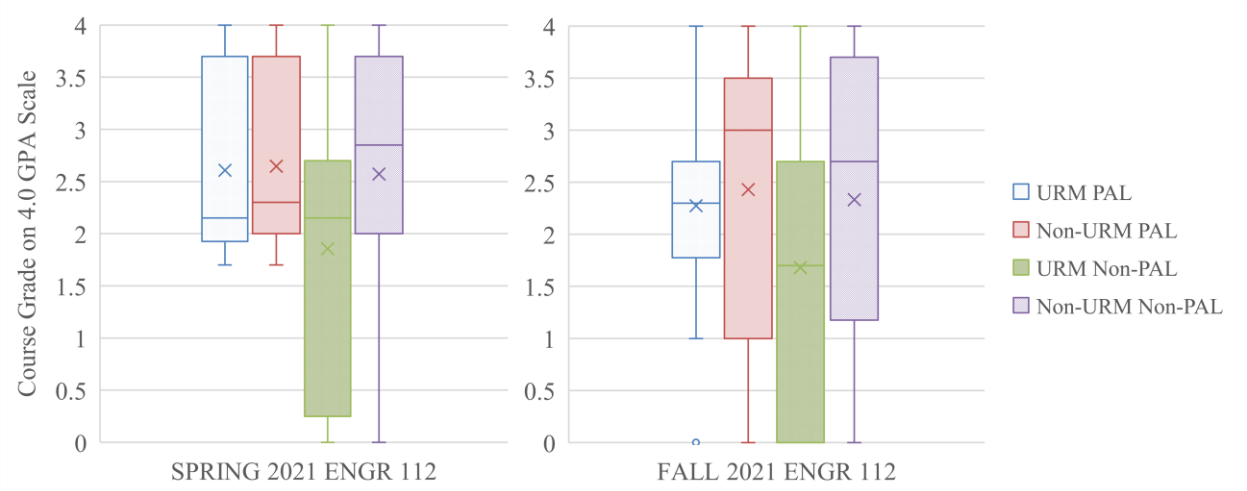

Figure 2: Comparison of URM and Non-URM students

The Hornet Leadership Program (HLP) address S1, S2, S3, and all the long-term outcomes. Outcome S2 is initially captured by the baseline data from the student survey which shows that any formal leadership training or experience at Sacramento State are linked to increases in the following: self-efficacy, sense of belonging, GPA, and intentions to persist in a STEM career. Future work will focus on the specific impact of the HLP activities on these measures in the student survey.

Outcome S3 is addressed from data related to the HLP Scholars. Student participants in the HLP Scholars leadership experience during Summer 2021 were asked to reflect on their motivation for participating in the experience and whether they achieved their desired goals by the end of the experience. Of the ten student responses, seven expressed a high degree of satisfaction with the Scholars experience, unequivocally responding that yes, they got what they hoped out of the experience. Only one student expressed disappointment with their summer experience.

The commonly cited knowledge and skills gained by satisfied participants are shown in Figure 3. Although the sample is small, it is encouraging that the self-identified knowledge/skills align

well with the aim of outcome S3 to increase student leadership opportunities and develop student non-technical communication, self-initiative, and teamwork skills.

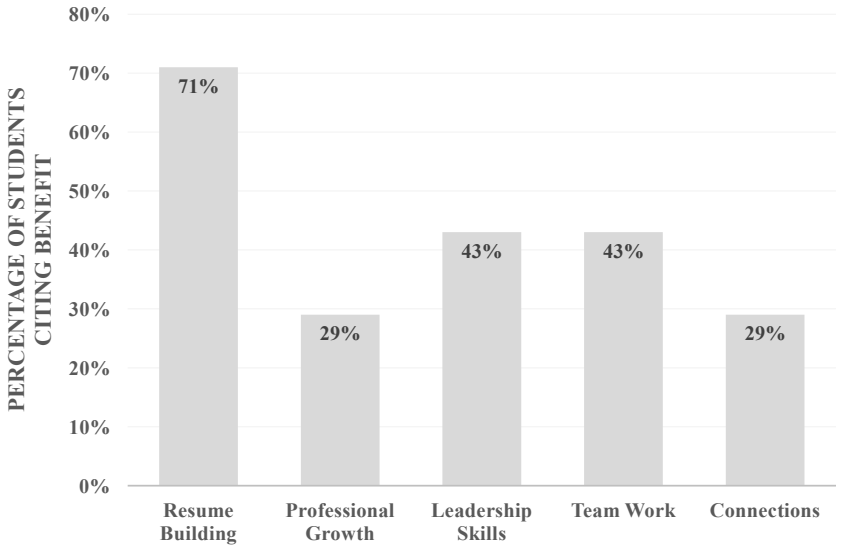

Figure 3: Student Identified Benefits of HLP Scholars Experience

What attitude changes will this project have on students and faculty and the relationships between them?

While many HLP Scholars expressed their appreciation for the freedom they were given to truly lead a project of their own devising, future cohorts will be given pre and post surveys to explicitly capture any attitudes or beliefs they have regarding student leadership and their perception of faculty attitudes on student leadership. Student attitudes and their relationships to faculty will also be further addressed by student focus groups.

Table 4 highlights faculty perceptions of student capabilities from the baseline faculty survey. While there is agreement with the positive impact of peer interactions and developing leadership skills, the grant activities will focus on shifting more faculty into the strongly agree response by showcasing data related to the impact of the ECS PAL and HLP programs. Only 26% of faculty believe students take the initiative on learning and developing leadership skills and only 24% of faculty believe students like to think about questions for which no single solution exists. These are attitudes that can be adjusted through showcasing student participation in HLP activities and inviting faculty to the poster sessions highlighting HLP Scholars and PAL Facilitators open-ended projects.

Table 4: Faculty Perceptions of Student Capabilities

	N	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Have a better grasp of course concepts when they discuss concepts with peers	87	63%	31%	5%	0%	1%
Understand the material better when they also hear course concepts explained by peers	85	49%	34%	14%	1%	1%
Benefit from course activities that help them develop leadership skills	87	44%	39%	14%	2%	1%
Are better prepared for the job market if their college coursework emphasized leadership skills	86	47%	36%	12%	5%	1%
Value opportunities to develop peer teaching and/or teamwork skills	89	19%	39%	26%	12%	3%
Like to think about questions for which no single authoritative solution exists	89	12%	20%	29%	22%	16%
Take the initiative to learn and develop leadership skills	87	6%	20%	30%	40%	5%

As part of the grant, a faculty workshop is held annually to address faculty attitudes related to student leadership (outcome S4). The first workshop focused on introducing the ASPIRE activities available to students and the Social Change Model for Leadership Development. All 20 faculty who participated indicated that they had a better idea of how they could facilitate student leadership development as a faculty member. In particular, participants indicated that they have a better of idea of how to facilitate student leadership development as a faculty member in their role as a: classroom instructor (100%), research mentor (68%), and/or career/academic advisor (32%). While both the faculty focus group and faculty survey indicate agreement with the importance of student leadership development, many faculty in the workshop expressed barriers surrounding their ability to actively support that development. Figure 4 shows that the workshop reduced all but one of those identified barriers. After the workshop, faculty concerns were primarily focused on student resistance and not having enough time as opposed to not knowing how to support student leadership development which was the most frequently cited barrier along with not enough time in the pre-workshop survey.

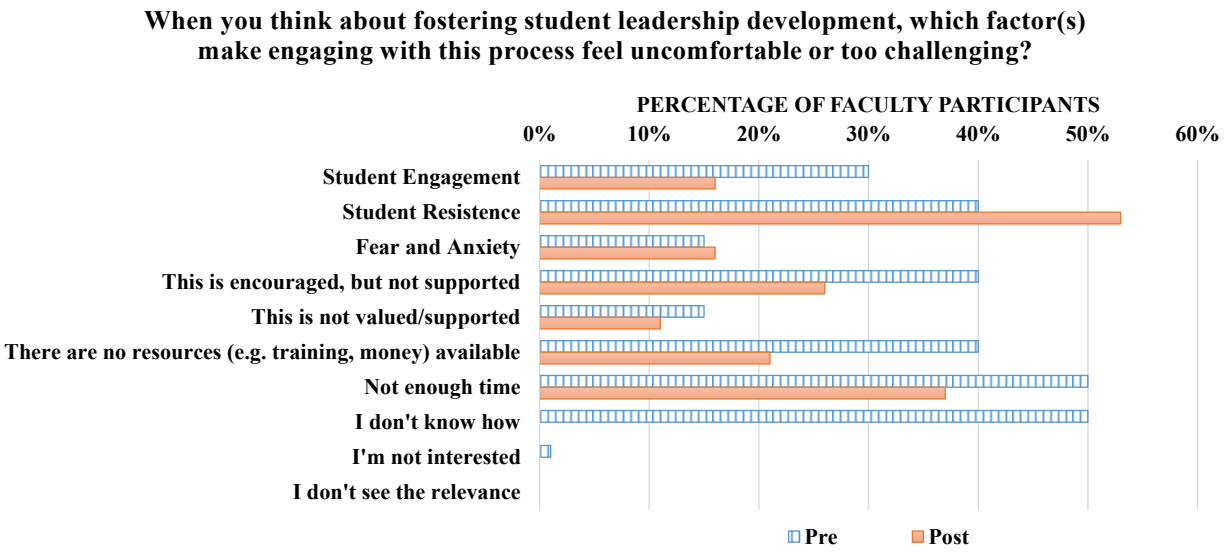

Figure 4: Faculty Identified Barriers to Supporting Student Leadership Development

Future Work

While all grant activities have begun as of Fall 2021, there is limited data due to small sample sizes making it unclear if the interventions are having the intended impact. Despite this, encouraging trends are being seen, such as the high level of participation by the target populations (URM and women). Targeted recruitment to obtain more diverse student populations to participate as ECS PAL Facilitators and HLP Scholars will take place in the future. Student focus groups will also take place to obtain additional data related to student attitudes on leadership and faculty expectations.

Although faculty attitudes are relatively positive related to peer-interaction and student leadership development, barriers identified by workshop participants will be explored with internal and external advisory board members and addressed in future annual faculty workshops.

Acknowledgement

This work was supported by NSF Grant No. 1953752. Any opinions, findings, conclusions, and recommendations expressed in this paper are those of the author and do not necessarily reflect the views of the university.

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