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Comparing the attitudes and outcomes of first-time, continuing, and first-generation students in an engineering undergraduate research program

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Comparing the attitudes and outcomes of first-time, continuing, and first-generation students in an engineering undergraduate research program (Research)

Abstract

Many researchers have implemented undergraduate research programs in STEM with the goal of investigating their impact on student success and persistence. These programs further aim to broaden participation in STEM and create pathways for first-generation undergraduate students to pursue a graduate degree in STEM. This paper builds on a previous work that developed an undergraduate research program targeted for first-generation or socioeconomically disadvantaged undergraduate students in engineering that comprised three key components: a lecture series, a research experience, and a research conference. In summer 2024, the program was expanded to include first-time undergraduate researchers and continuing undergraduate researchers. However, first generation or socioeconomic status was not a recruitment factor. The purpose was to uncover similarities and differences among the three different student backgrounds as well as to gain a better understanding on how the research program impacted students' motivation and persistence goals towards graduate education. A total of 9 undergraduate students (4 first-time, 5 continuing) in engineering were recruited for the research program. Each student and faculty mentor underwent a rigorous matching process that allowed both student and mentor to agree on the pairing and the proposed research project. Pre- and post-attitudinal surveys were administered to the students to evaluate how student attitudes evolved throughout the lecture series component and the overall research program. The results showed that first-time and continuing researchers' positive attitude toward STEM and satisfaction with STEM degree both increased, consistent with the trend observed among first-generation researchers. Student challenges in their STEM degrees also increased post-overall program. In contrast, student motivation to pursue their STEM degree decreased slightly, unlike the larger decrease for first-generation researchers. When the questions focused on graduate education, first-time and continuing researchers' attitudes toward graduate school increased post-overall program similar to the results observed for first-generation researchers. The results on student motivation to pursue graduate education decreased for first-time and continuing researchers, which was not expected. In addition, students completed the Undergraduate Research Student Self-Assessment (URSSA) before and after the research experience, in order to quantify how much students gained in their skillset and their ability to do scholarly research. The mean scores showed an increasing trend between all three student groups for all four factors. Thus, first-time researchers gained more compared to first-generation researchers, which highlights the increased challenges first-generation researchers face in undergraduate research experiences. The findings from this work will help improve the objectives of the undergraduate research program and its impact on a diverse STEM student population (first-generation, first-time, and continuing undergraduate researchers) and support their pursuit of a graduate STEM degree.

Introduction

Undergraduate research experiences provide students with unique opportunities to apply their core knowledge in meaningful research projects and work closely within the scientific community. The benefits of undergraduate research have been well documented in the literature. These include but not limited to increased student persistence within their degree [1], student retention in pursuit of science careers [2], and increased rate of graduate education [3]. In particular, researchers have noted that undergraduate research creates pathways for minority and underrepresented students to pursue careers in science and foster a diverse STEM workforce [2][4]-[5].

Mentorship is also viewed as a strategy that helps students define career pathways [6]. The combination of research experiences and mentorship has been shown to increase a student's interest in both learning and STEM that is sustainable [7]-[8]. For example, [7] found that faculty mentorship as an environmental factor led to positive outcomes on a student's motivation to achieve. The inclusion of faculty further helps to promote community-based participation in the student research experience and students are better supported and motivated to achieve their academic and professional goals [9].

However, undergraduate students that are starting their first research experience ("first-time" researchers) encounter several challenges that they must overcome, irrespective of their demographic background. Balster et al. [10] identifies three specific challenges: (i) learning how to identify and appropriately contact potential research mentors, (ii) transitioning from the classroom to a learning environment built around a research community, and (iii) learning how to integrate into the social structure of the research community. Several works have developed undergraduate research programs aimed at addressing some of these challenges [5][11]. For example, the research program developed in the previous work [11] designed a lecture series focused on the research process, finding and communicating with a research mentor, and assimilating into the research community they would be immersed in. The challenges of being an undergraduate student researcher with a first-generation background ("first-gen" researcher), and likely included first-time researchers, are further heightened due to their unfamiliarity with the research culture and the norms of the environment [12]. The National Science Foundation (NSF) has had a positive impact through its initiatives to broaden participation among minority students and first-generation students [13]-[14]. Yet, there are internal and external factors that create leaks in the pathway and negatively affect students' pursuit of STEM degrees [7][15]-[16].

This paper examines the impact of an undergraduate research program [10] that was expanded to include first-time researchers and students that have prior research experience ("continuing" researchers). As discussed above, first-gen researchers and first-time researchers face similar challenges, so a comparison will be made using survey instruments to assess STEM outcomes and their pursuit of graduate education. The purpose is to uncover similarities and differences between student researchers with three different backgrounds as result of their experience in the undergraduate research program [11], as well as to understand how the program impacted students' motivation and persistence goals towards graduate education.

In the sections that follow, the details of the expanded undergraduate research program and its participant demographics will be discussed. This will be followed by the results and discussion of the two survey instruments used in this study. The paper will conclude with the major findings from this work and identify possible areas for improving the program in future deployments.

Adapted undergraduate research program

The undergraduate research program (UGRP) in [11], originally targeted for first-generation students, was expanded for first-time and continuing research students in summer 2024. The program goals aimed at increasing participation in graduate education and to motivate students to persist in STEM fields. Thus, two research questions were considered and stated as:

- What is the impact of an undergraduate research program on student research skills between first-time, continuing, and first-generation research students?
- What is the impact of an undergraduate research program on their pursuit of graduate education between first-time, continuing, and first-generation research students?

In the present work, only two out of the three components of the UGRP were used in the program deployment: a lecture series and a research experience. Attending the lectures and completing the research experience were both requirements for participating in the program. The lecture series involved a total of eight lectures, taught across four weeks during summer 2024 and accompanied with homework to provide students the opportunity to practice the skills they were learning. The lectures used an active learning approach and covered topics, such as writing a research question, creating effective search strings, communicating technical subject matter, and finding a research mentor. The research experience occurred concurrently over 10-weeks.

Student recruitment

Undergraduate students were recruited for the adapted UGRP by email announcement to registered students in the Cockrell School of Engineering at The University of Texas at Austin. Students were incentivized to apply for the program by being offered a stipend, if accepted, that would be competitive compared to a paid summer internship in engineering. The reasoning here was to draw a competitive pool of students. Interested students submitted an application that included their academic background, research experience, ranked list of interested faculty research projects (discussed further in the next two sections), program interest essay, resume, and two letters of recommendation. The minimum requirements to apply included: U.S. citizenship or permanent residency (international students were eligible), enrolled as a student at UT Austin, entering junior or senior year in the fall semester, and a minimum cumulative GPA of 3.0.

Faculty mentor recruitment

Faculty within the Cockrell School of Engineering were recruited by announcement at faculty meetings prior to the spring semester and by follow up email. Interested faculty mentors were asked to submit their project title, a short description of the research activities, and specific skills or experience that was preferred or required to conduct the research. A selection process of the faculty mentors was not performed or required since the number of submitted projects was low. Faculty were incentivized to become mentors in the program by being offered to receive half of

the stipend funds to support the potential undergraduate research student. In other words, the student stipend was composed of half of the faculty mentor's own research funds and half from the UGRP. Thus, the research projects were meaningful to both the faculty mentor and the potential student conducting the research. Faculty mentors did not receive formal training or a refresher course on research mentoring best practices. The faculty's research lab was typically large enough, such that senior graduate students could be involved to help with mentoring.

Student-mentor matching process

Students were paired with a faculty mentor through a rigorous matching process. During the program application process, students ranked their preferences of the projects that were submitted by faculty mentors. These rankings were communicated to faculty mentors detailing which students ranked their project first, second, and third. Faculty mentors were given two weeks to vet interested students by reviewing their application materials and reaching out to students to perform interviews. Then, faculty mentors submitted their ranked top 3 students to the program to confirm that the selection process would not encounter issues, such as the same student being ranked first across multiple projects. The students that were ranked first were contacted to let them know that they were selected for X project led by potential mentor Y and students were given 1 week to formally accept or reject the offer. If the student accepted the offer, then the faculty mentor was notified of the final pairing. If the student rejected the offer, then the second ranked student was contacted and also given 1 week to accept or reject the offer. A third round occurred if needed and similar to the other two rounds. After the matching process ended, both mentor and mentee completed an agreement form detailing the research duties, expectations, and project deliverables. The regularity of check-in meetings and its format (e.g., at lab group meetings, one-on-one, in-person, or virtual) to provide research updates were decided between the mentor and mentee.

UGRP participants

Nine research projects were submitted by faculty (3 female, 6 male) and a total of 98 student applications were received. The 9 students that were selected to participate in the program comprised 4 first-time researchers and 5 continuing researchers. Figure 1 shows that students represented different STEM disciplines: Mechanical Engineering (6), Aerospace Engineering (1), Computational Engineering (1), and Chemistry (1); 3 students were female and 6 were male.

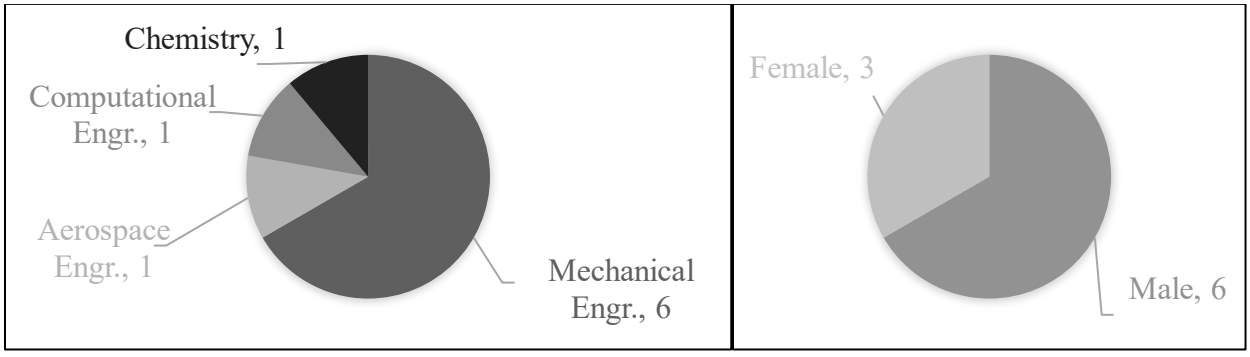


Figure 1. Distribution of engineering disciplines (left) and gender (right) reported by program students ($N = 9$).

Based on undergraduate program credit, 5 students were juniors and 4 students were seniors. UT Austin is a 4-year research and Hispanic serving institution. As of fall 2023, its student population is 56.3% women and 43.6% men; 33.0% white, 25.2% Hispanic, 22.0% Asian, and 4.5% Black [17]. At the program level, Mechanical Engineering (25% women, 21% underrepresented), Aerospace Engineering (25% women, 33% underrepresented), Computational Engineering (34% women, 25% underrepresented), and Chemistry (unpublished data) [17].

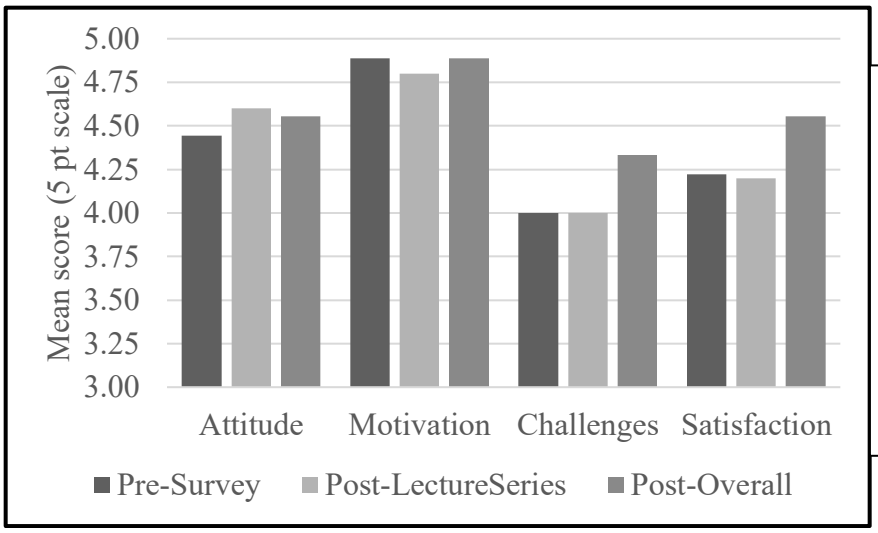
Results and discussion

Attitudinal survey results

Attitudinal surveys were used to assess a student's motivation to remain in STEM and their pursuit of a graduate STEM degree. Pre- and post attitudinal surveys were administered to evaluate student perceptions and how they changed throughout their experience in the adapted UGRP [11][18]. The pre-survey was given the week prior to the start of the first lecture and the post-surveys given the week after the completion of the lecture series and overall program, respectively. Students were given two weeks to complete the post-surveys and all 9 students responded to all the surveys. Specifically, the attitudinal surveys assessed the impact of the lecture series and the overall program (lecture series + research experience) on a student's pursuit of a STEM degree (attitude, motivation, challenges, and satisfaction) and their pursuit of graduate school (attitude and motivation). The combined results for first-time and continuing researchers are shown in Figs. 2 and 3. All survey data was analyzed internally; no external researchers were involved. The responses were coded as follows:

- Q1/Q5: Very negative (1), Negative (2), Neutral (3), Positive (4), Very positive (5)
- Q2/Q6: Not very motivated (1), Not motivated (2), Neutral (3), Somewhat motivated (4), Very motivated (5)
- Q3: Not very challenging (1), Not challenging (2), Neutral (3), Somewhat challenging (4), Very challenging (5)
- Q4: Not very satisfied (1), Not satisfied (2), Neutral (3), Somewhat satisfied (4), Very satisfied (5)

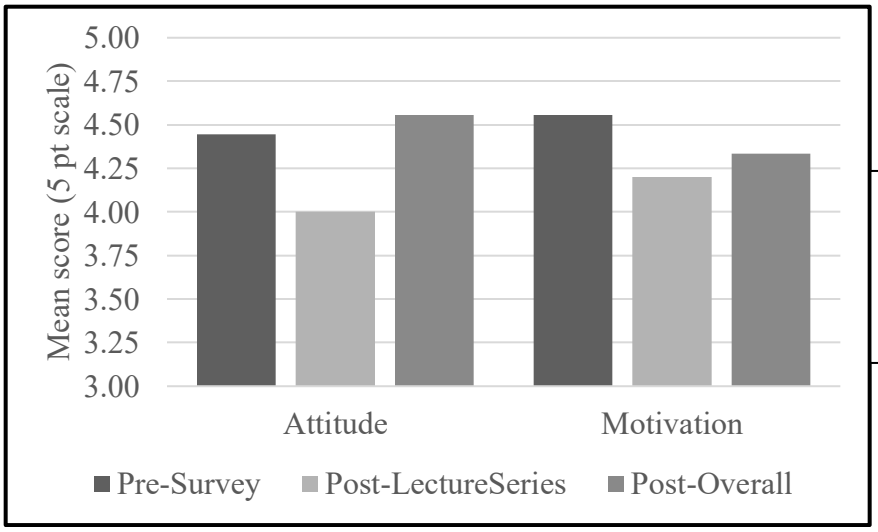
First-time and continuing researchers' attitudes toward STEM experienced a positive increase, 3.5% post-lecture series vs. 2.5% post-overall program. These results are consistent with the trend observed among first-gen researchers [11]. First-time and continuing researchers perceived STEM more positively after the lecture series compared to the research experience that was completed concurrently. Follow up survey data showed that 8 out of 9 students stated they would likely recommend the lecture series to another student. One student saying, "I think the lecture series was the most impactful because it gave me a general overview about the research process." However, student motivation post-lecture series showed a minor decrease (1.8%) down to a mean score of 4.8, whereas motivation remained the same post-overall program. Comparatively, this decreasing trend was more significant (7.8%) among first-generation researchers and reached a much lower mean score of 4.0 [11].



Q1. What is your current attitude toward STEM?
Q2. What is your current level of motivation to pursue a STEM degree?
Q3. What is the level of challenges that you face in your STEM degree?
Q4. How satisfied are you with the degree that you chose to study?

Figure 2. Attitudinal survey results comparing STEM outcomes before the program, after the lecture series, and after the overall program ($N = 9$).

The results for student challenges among first-time and continuing researchers were noteworthy, remaining constant post-lecture series, while increasing 8.3% post-overall program. Some possible reasons for this increase in student challenges are that the research experience uncovered knowledge gaps, raised more questions than answers, and identified deficiencies in their skills. In a similar trend, student satisfaction with their STEM degree stayed relatively the same post-lecture series and increased 7.9% post-overall program. If student challenges and satisfaction are considered collectively, first-time and continuing researchers welcomed the challenges they encountered through their research experiences and received the affirmation they needed for why they chose their degree.



Q5. What is your current attitude toward graduate school?
Q6. How motivated are you to pursue graduate school?

Figure 3. Attitudinal survey results comparing students' pursuit of graduate school before the program, after the lecture series, and after the overall program ($N = 9$).

When the focus of the survey questions was shifted to graduate school, first-time and continuing researchers' attitudes toward graduate school decreased post-lecture series (10%), but increased

slightly post-overall program (2.5%). Similarly, student attitudes among first-gen researchers increased by 4.9% post-overall program [11]. The results for student motivation to pursue graduate education were not expected for first-time and continuing researchers, decreasing 7.8% post-lecture series and 4.9% post-overall program. Despite the very positive student motivation to pursue a STEM degree (mean score >4.75), the program had a negative impact on their motivation to pursue graduate school. Some questions to consider: Does this mean that these students are less likely to pursue graduate school? Or is this result based on what they now know and learned from the program? A limitation of this work is the low sample size of students in each group, so the significance and effect of these results cannot be determined.

URSSA survey results

The Undergraduate Research Student Self-Assessment (URSSA) was used to assess the perceptions of a participant's own learning using four factors [19]: Thinking and Working Like a Scientist, Personal Gains, Skills, and Attitudes and Behaviors. The survey was administered the week before the research experience started and the week after the research experience and overall program ended. Students had two weeks to complete the post-survey and all 9 students responded. All survey data was analyzed internally; no external researchers were involved.

URSSA: First-time vs. continuing research students

Figure 4 shows the pre- and post-URSSA survey results. The results were split to compare the research skills gained for first-time and continuing researchers. In all four factors, there was an improvement (or gain) for both groups of student researchers, more so for continuing vs. first-time researchers. For the latter, there was a less than 1% improvement in Personal Gains and Skills factors. However, there was a 9.5% and 10.6% improvement in Thinking and Working like a Scientist and Attitudes and Behaviors factors, respectively. These gains are notable for students that are new to working in a scientific community and conducting scientific research.

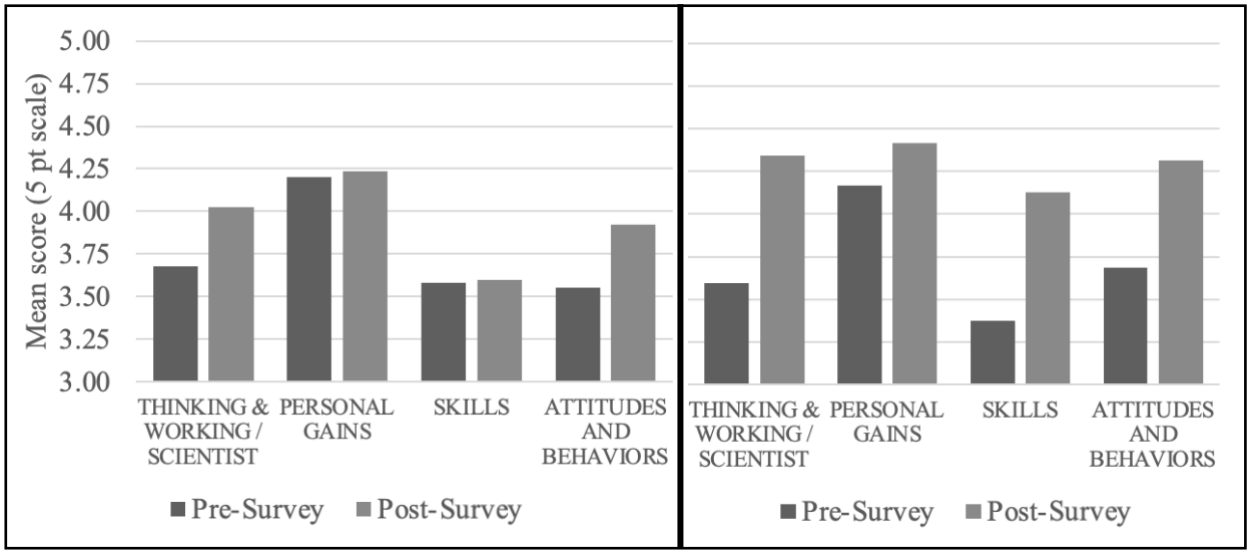


Figure 4. Pre- and post-URSSA survey results of the impact on student research skills gained for first-time (left) and continuing (right) research students.

On the other hand, continuing researchers exhibited the largest gains across all four factors: 20.9%, 6.0%, 22.2%, and 16.9%, respectively. Weston et al. [19] has shown that the factors Thinking and Working Like a Scientist, Personal Gains, and Skills are highly correlated. Thus, it is encouraging to observe the positive impact that the program had among students that are experienced with conducting scientific research.

URSSA: First-time and continuing vs. first-generation research students

Table 1 lists of the post-URSSA survey data for first-time and continuing researchers in comparison to first-gen researchers reported in [11]. A close examination of the mean scores shows an increasing trend for all four factors. First-time researchers had higher mean scores than those for first-gen researchers, while continuing researchers had higher mean scores than first-time researchers. The latter results can be expected considering the knowledge and experience of continuing researchers. The former results are more significant, where first-time researchers scored higher compared to first-gen researchers. This emphasizes what is known about the additional challenges that first-gen researchers encounter in undergraduate research experiences, unlike other students [7][12]. The conclusions here are also limited by the small sample sizes in all three student groups.

Table 1. URSSA post-survey results comparing first-time and continuing researchers vs. first-generation researchers.

Factor		2024 Post-Survey (First-generation)	2025 Post-Survey (First-time)	2025 Post-Survey (Continuing)
Thinking and Working Like a Scientist	Mean	3.925	4.025	4.344
	Std. dev.	0.468	0.120	0.214
	Valid N	5	4	5
Personal Gains	Mean	4.033	4.233	4.417
	Std. dev.	0.213	0.137	0.186
	Valid N	5	4	5
Skills	Mean	3.450	3.600	4.125
	Std. dev.	0.561	0.365	0.239
	Valid N	5	4	5
Attitudes and Behaviors	Mean	3.900	3.925	4.313
	Std. dev.	0.510	0.244	0.165
	Valid N	5	4	5

Conclusions

This paper presented the details of an adapted undergraduate research program developed in a previous work. While the program was originally targeted for first-generation students, this work examined the impact that the adapted program would have on first-time and continuing researchers. The results of the attitudinal surveys showed increases in positive attitude,

challenges, and satisfaction towards their STEM degree for both first-time and continuing researchers. This agreed with the positive increase reported for first-generation researchers. However, the pursuit of their STEM degree showed slight decreases in student motivation, whereas there was a larger decrease for first-gen researchers. Student attitudes toward graduate school increased post-overall program for first-time and continuing researchers, like first-gen researchers. Unexpectedly, student motivation to pursue graduate education decreased for first-time and continuing researchers. The URSSA survey results showed mean scores that trended positively between all three student groups for all four factors. First-gen researchers scored at the bottom, thus consistent with the literature that first-gen researchers likely faced increased challenges in their undergraduate research experience. Future deployments of the undergraduate research program will aim to address the decreases in student motivation to understand how the program can be further improved to support first-gen and first-time researchers' pursuit of a graduate STEM degree.

References

[1] B.A. Nagda, S.R. Gregerman, J. Jonides, W. von Hippel, and J.S. Lerner, "Undergraduate student-faculty partnerships affect student retention," *Review of Higher Education*, vol. 22, no. 1, pp. 55-72, Sept. 1998.

[2] D. Lopatto, "Survey of undergraduate research experiences (SURE): First findings," *CBE-Life Sciences Education*, vol. 3, no. 4, pp. 197-277, Dec. 2004.

[3] R.S. Hathaway, B.A. Nagda, and S.R. Gregerman, "The relationship of undergraduate research participation to graduate and professional education pursuit: an empirical study," *Journal of College Student Development*, vol. 43, no. 5, pp. 614-631, Jan. 2002.

[4] F.P. Collea, "Increasing minorities in science and engineering. A critical look at two programs," *Journal of College Science Teaching*, vol. 20, no. 1, pp. 31-34, Sept. 1990.

[5] M. Fechheimer, K. Webber, and P.B. Kleiber, "How well do undergraduate research programs promote engagement and success of students?" *CBE-Life Sciences Education*, vol. 10, no. 2, pp. 156-163, Summer 2011.

[6] K.A. Griffin, D. Pérez II, A.P.E. Holmes, and C.E.P. Mayo, "Investing in the future: The importance of faculty mentoring in the development of students of color in STEM," *New Directions for Institutional Research*, vol. 2010, no. 148, pp. 95-103, Dec. 16, 2010.

[7] P.R. Hernandez, P.W. Schultz, M. Estrada, A. Woodcock, and R.C. Chance, "Sustaining optimal motivation: A longitudinal analysis of interventions to broaden participation of underrepresented students in STEM," *Journal of Educational Psychology*, vol. 105, no. 1, Feb. 1, 2013.

[8] C. Pfund, C.M. Pribbenow, J. Branchaw, S.M. Lauffer, and J. Handelsman, "The merits of training mentors," *Science*, vol. 311, no. 5760, pp. 473-474, Jan. 27, 2006.

[9] C.L. Bowker, "A history of broadening participation within the national science foundation," Published Jun. 15, 2020. [Online]. Available: https://stem.colostate.edu/broadening-participation-best-practices/. [Accessed: Dec. 10, 2024].

[10] N. Balster, C. Pfund, R. Rediske, and J. Branchaw, "Entering research: A course that creates community and structure for beginning undergraduate researchers in the STEM disciplines," *CBE-Life Sciences Education*, vol. 9, no. 2, pp. 71-140, June 2010.

[11] A. Rodriguez, “Mentoring and motivating first generation undergraduate students in engineering to conduct research and persist in STEM (Work-in-Progress),” ASEE Annual Conference, Portland, OR, June 23-26, 2024.
[12] M.K. Boyd and J.L Wesemann, “Broadening participation in undergraduate research: Fostering excellence and enhancing the impact,” Washington, DC: Council on Undergraduate Research, 2009.
[13] National Science Foundation, “Broadening participation in STEM,” Published Apr. 22, 2023. [Online]. Available: https://new.nsf.gov/funding/initiatives/broadening-participation. [Accessed: Dec. 9, 2024].
[14] C.L. Bowker, “A history of broadening participation within the national science foundation,” Published Feb. 10, 2020. [Online]. Available: https://stem.colostate.edu/a-history-of-broadening-participation-within-the-national-science-foundation/. [Accessed: Dec. 10, 2024].
[15] National Academies of Sciences, Engineering, and Medicine, *Rising Above the gathering storm: Energizing and employing America for a brighter economic future*, Washington, DC: The National Academies Press, 2007.
[16] T.D. Snyder and A.G. Tan, *Digest of education statistics 2005*, NCES 2006-030, U.S. Department of Education, National Center for Education Statistics, Washington, DC: U.S. Government Printing Office, 2006.
[17] The University of Texas at Austin, “Facts & Figures,” Published Sept. 24, 2024. Available: https://www.utexas.edu/about/facts-and-figures. [Accessed: Feb. 10, 2025].
[18] E.L. Lewis and E. Seymour, “Attitudinal survey,” Published Aug. 19, 2019. Available: https://archive.wceruw.org/cl1/flag/extra/download/cat/attitude/attitude.pdf. [Accessed: Dec. 10, 2023].
[19] T.J. Weston and S.L. Laursen, “The undergraduate research student self-assessment (URSSA): Validation for use in program evaluation,” *CBE-Life Sciences Education*, vol. 14, no. 3, Oct. 2017.