PURM
Perspectives on Undergraduate Research & Mentoring

Promoting Undergraduate STEM Development through Multifaceted Mentorship

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Introduction

Decades of academic research has demonstrated that high-quality mentoring is a key mechanism supporting undergraduate students' entry into Science, Technology, Engineering, and Mathematics (STEM) fields and subsequent development along their scientific career pathways. The quality of mentorship experience, comprised of factors including instrumental support, psychosocial care, and culturally relevant practices, is associated with and predicts gains in scientific self-efficacy, identity, value, and commitment to STEM careers (Byars-Winston et al., 2015; Estrada et al., 2018; Haeger & Fresquez, 2016; Syed et al., 2019). Mentees who have received structured, attentive, and inclusive mentorship have reported significantly greater confidence in their ability to conduct research, increased clarity about their professional trajectories, and a stronger sense of inclusion in STEM fields (Byars-Winston et al., 2015). These gains associated with mentor-mentee relationships are not simply subjective; they have been shown to mediate key academic outcomes such as pursuit of graduate training in STEM fields and highlight the integral role of mentorship in nurturing the next generation of research scientists (Estrada et al., 2018).

Mentoring models are varied across universities in order to meet the specific needs of students (Karaferye, 2018). Traditional models of mentorship include the classic dyadic approach which involves top-down, face-to-face interactions between student participants and mentors who are teachers and/or specialists in the field, collaborating in a school-based setting (Alonso et al., 2024; Karaferye, 2018; Montgomery, 2017; Montgomery & Page, 2018). Through the years, traditional mentoring practices have expanded to include group-based mentoring, peer-to-peer mentoring, as well as electronic mentoring (or e-mentoring) conducted through digital platforms (Karaferye, 2018; Montgomery & Page, 2018; Nowell et al., 2017; Tinoco-Giraldo et al., 2020; Wright-Harp & Cole, 2008). Successful academic mentorship requires that mentees and mentors engage in a proactive teacher-student relationship with the goal of forming an alliance that aids the student's academic and professional development through participation in a faculty research laboratory, academic and career advisement, or other mentoring exchanges, that are coupled with psychosocial and/or socioemotional support (Montgomery, 2017; Montgomery & Page, 2018). Students who have participated in these traditional mentoring paradigms in the context of high-quality mentoring relationships tended to improve in areas such as responsibility, independence, and perseverance

(Alonso et al., 2024; Estrada et al., 2018; George & Rupert Mampilly, 2012; Joshi et al., 2019; Karaferye, 2018; Wright-Harp & Cole, 2008).

Research further demonstrates that one-on-one mentoring from faculty plays a particularly powerful role for students from historically underrepresented groups in STEM, including racial/ethnic minorities, first-generation college students, women, LGBTQ+ individuals, and those facing educational, personal, or economic disadvantages. These groups are less likely to enter and remain in STEM disciplines (NASEM, 2019), as limited access to supportive scientific communities and feelings of reduced belonging may impede academic and professional development (Rainey et al., 2018). Studies examining mentorship among underrepresented minority undergraduate students have found that these experiences were associated with greater science self-efficacy, scientific identity, and commitment to STEM (Chemers et al., 2011). Furthermore, culturally responsive mentoring promoted research and academic gains in diverse student populations while fostering more inclusive learning environments (Byars-Winston et al., 2015; Haeger & Fresquez, 2016). Collectively, findings highlight the importance of inclusive mentoring as a core feature of undergraduate STEM education, in turn, facilitating enhanced learning and superior academic outcomes across diverse student populations.

In recognizing the critical role of comprehensive and high-quality mentorship opportunities for diverse students, structured undergraduate research experience programs have been created to promote collaborative mentorship approaches and positive learning environments. For example, the National Science Foundation's (NSF) Research Experiences for Undergraduates (REU) program has been instrumental in promoting undergraduate education as well as retention in STEM (Bosman et al., 2024; Chowdhury et al., 2025; Hamilton et al., 2019; Linn et al., 2015). Specifically, these federally funded REU programs offer students from diverse backgrounds opportunities to engage in hands-on research experiences with faculty mentors, enhancing scientific inquiry (Bosman et al., 2024; Chowdhury et al., 2025; Linn et al., 2015; Seymour et al., 2004; Wilson et al., 2018). Research has demonstrated that participation in structured REU programs increased students' likelihood of pursuing higher education and STEM careers while providing opportunities to engage in supportive scientific communities with like-minded peers (Bosman et al., 2024; Zhang & Swaid, 2017; Alaee et al., 2021; Wilson et al., 2018). These mentorship programs are essential for supporting diverse students by alleviating feelings of isolation associated with classic dyadic mentorship approaches and positively impacting academic trajectories and future scientific pursuits (Driscoll et al., 2009; Seymour et al., 2004).

Though REU programs have helped undergraduates build foundational STEM skills, wide gaps in age or training level between faculty mentors and mentees may hinder relatability as well as reduce mentees' satisfaction (Goldinger & Nesher, 2021). Additionally, competing faculty responsibilities and institutional demands may limit mentors' capacity to provide timely support (Limeri et al., 2019; Johnson et al., 2015). As these research opportunities play an important role in preparing learners for higher education and building an identity as a scientist, diversifying student support systems is essential. Employing a multilevel mentorship approach can yield greater impacts than classic dyadic models by engaging learners in collaborative interaction among diverse, skilled people, exposing the mentees to a wider variety of perspectives and information (Nicholson et al., 2018). Furthermore, current literature indicates that impactful mentorship of undergraduates can come from individuals of varying career stages (Chavez et al., 2025; Keller & Lindwall, 2020; Marshall et al., 2021; Nicholson et al., 2018). Outside of the traditional mentorship model, students are likely to benefit from multiple sources of mentoring such as graduate students and post-doctoral graduates, as well as peers who offer support across social, educational, research, and career settings (Keller & Lindwall, 2020; Chavez et al., 2025; Montgomery & Page, 2018; Evans et al., 2025; Burnett et al., 2023).

Adopting a multifaceted mentorship approach comprised of varying perspectives can promote student research gains by diversifying their mentorship experience, as well as creating comprehensive and multidimensional networks for different mentoring needs (Montgomery, 2017; Nicholson et al., 2018). Through use of secondary mentors, including graduate students and postdoctoral fellows, REU programs can help fill the gaps in current academic practices, offer better relatability through near-peer role models, and allow for greater opportunities for undergraduate participation, leading to positive and satisfactory research experiences and environments. Though multifaceted approaches that utilize diverse mentors have potential to improve the quality of an REU (or similar structured research) experience, their utilization is not well documented. The aim of the present study is to describe the multi-mentorship model at our REU program and examine the resulting student gains across academic, professional, and personal domains. Using a mixed-method approach, we assess the perceptions of undergraduate students regarding the benefits gained through intensive multifaceted mentorship opportunities via both quantitative assessments and qualitative surveys post program.

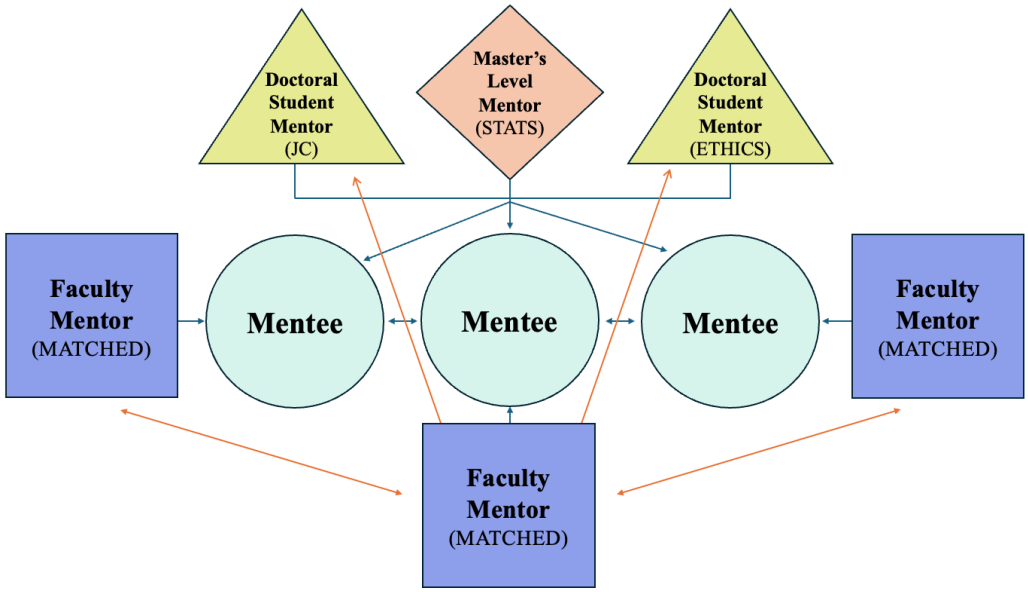
Methods

Overview of the REU Program

Our Psychology and Neuroscience REU site is funded by the National Science Foundation (NSF). The program aims to boost STEM pursuit and retention by engaging students from two-and-four-year institutions in the New York (NY) metropolitan area in an intensive, 15-week-long mentored research and professional development experience. The REU program does not require students to have substantial research training prior to the program, thus, our students typically have little or no previous research training. Additionally, as many REU participants are primarily recruited from local public colleges and non-research-intensive institutions, almost all commute from their homes. Students first apply to the program by submitting relevant application information (i.e., CV, two academic letters of reference, official transcripts). Herein, selected applicants have access to the college's active research faculty who have external grant funding and extensive experience mentoring students at all levels of training (high school, undergraduate, masters, doctoral, postdoctoral), and students are subsequently matched with mentors depending on research interests and intended field. Of note, mentor approaches are informed by mentee-centered pedagogy focused on working with historically underrepresented student populations. All selected students engage in a personalized research project with their matched mentor where they are instrumental in collecting, analyzing, and communicating their findings to an audience of peers and faculty at the college's annual Science Research Day. Students also attend weekly seminars meant to bolster scientific thinking and communication. It is important to note that several of our cohorts were impacted by the COVID-19 pandemic, particularly those participating in 2020 and 2021. In response to pandemic-related restrictions, all program activities (e.g., seminars, ethics trainings) were delivered virtually. Despite this shift, fundamental student outcomes, such as engaging in research and presenting first-authored posters, were successfully completed through virtual platforms. During this time, every effort was made to preserve the quality and rigor of the program and availability of mentors.

As a longstanding program, the present REU has had the unique opportunity to incorporate feedback from earlier cohorts in order to shape a better learning experience for incoming students. Specifically, in the past, we had received important insight from some students stating how the time constraints of having a single faculty mentor diminished their overall experience. As a result, we adopted a multi-mentor system approach and enlisted graduate students and postdoctoral fellows to serve as co-mentors and instructors, allowing students to learn directly from faculty mentors as well as trainees at various levels as seen in Figure 1.

Figure 1. Multilevel Mentorship Model of the REU Program



Note: The figure illustrates the multifaceted mentorship structure within the deployed REU program. Blue arrows indicate the direct and indirect mentorship relationships experienced by student participants, whereas orange arrows represent the direct mentoring interactions among faculty that support the mentoring infrastructure. Mentee= REU student participant, Matched= faculty mentor matched to the REU undergraduate student, JC= Journal Club, Stats= Statistics course, Ethics= Ethics course.

Within our multi-mentor system, REU students engage in group-based mentorship through immersive learning seminars instructed by three mentors outside the mentees' designated laboratory. These include: 1) a doctoral level student mentor who facilitates weekly journal club sessions focused on critically evaluating published studies and supporting research communication, professional development, and research skill-building; 2) a master's level instructional staff member who provides extensive, hands-on mentorship in descriptive and inferential statistics and aspects of research methodology weekly; and 3) a doctoral level student mentor who leads a two-part research ethics training where real-world ethical dilemmas are discussed in depth. Students also participate in peer-to-peer mentorship with cohort-mates through consistent engagement in scholarly discussion across seminars. Additionally, students often seek advice from one another outside of the classroom, as well as join laboratories where they can create close relationships with near-peers, doctoral students, and post-doctoral mentors.

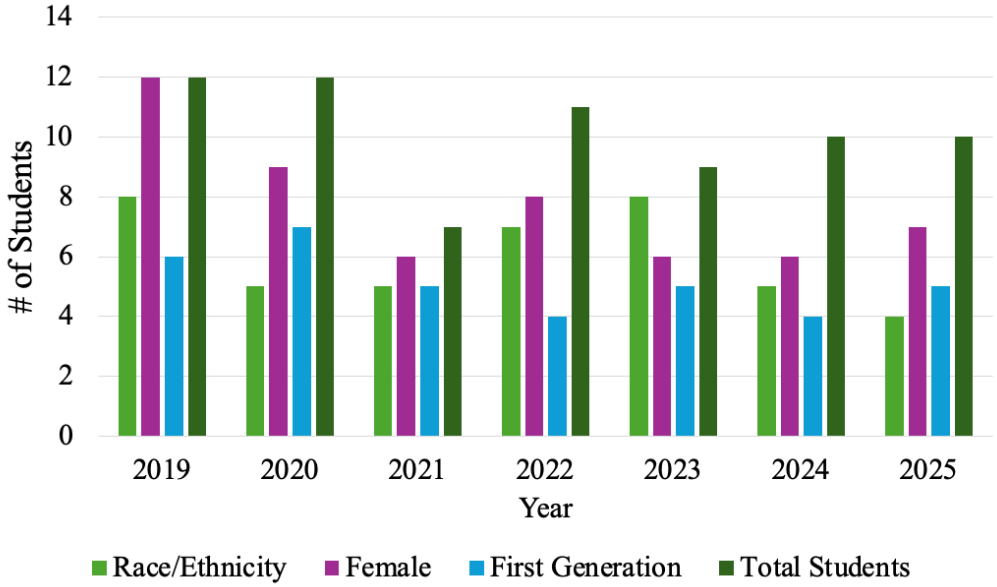
As a requirement of the program, all students complete formal assessments of research competencies to gauge abilities and confidence at the beginning (Week 1) and at the end of the academic semester (Week 15). Additionally, students from the 2023 and 2024 cohorts piloted an optional post-program assessment, comprised of open-ended satisfaction questions regarding the program, which could be completed in-person at the end of the semester (Week 15) or virtually at a different time.

REU Program Sample

Our REU program strives to support 10 students per year, which allows the program to provide individual attention and close mentoring without overburdening resources. Of each cohort, at least

half of the students come from institutions where research training is limited. Additionally, many REU students are from groups underrepresented in STEM research including ethnic/racial minorities, women, and first-generation college students (see Figure 2).

Figure 2. Number of Students from Underrepresented Groups in Each Cohort

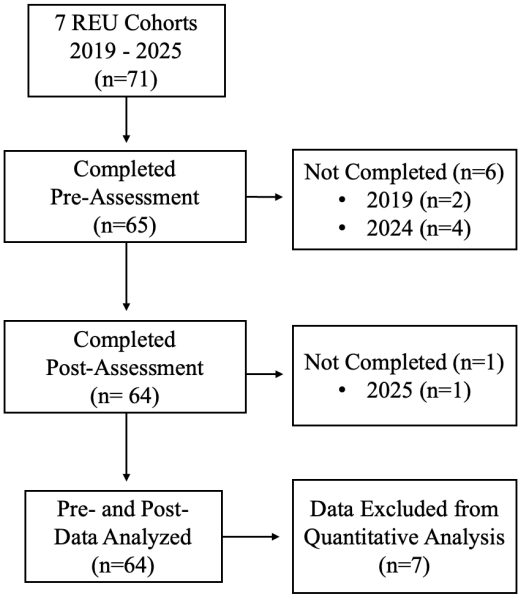


Note: The figure above depicts the number of REU students recruited during the most recent years of the program (2019-2025) who identify as belonging to one or more groups underrepresented in STEM. Because students could be represented in multiple demographic categories based on their self-identified characteristics, the plotted values reflect overlapping identities rather than unique individuals (and totals across categories exceed the total number of students represented).

Although over 100 undergraduate students have participated in our REU program since its inception in 2013, earlier cohorts of the program (2013-2018) completed differing measures of student gains, leaving data unavailable to be compared to newer cohorts. As a more standardized assessment of student gains was updated and implemented in 2019, data for the following analyses will focus on these later cohorts. Across seven cohorts (2019-2025), 71 students completed the REU program at our institution. Students who did not complete either the pre- or post-assessment were excluded from the analyses, as illustrated in Figure 3.

To further evaluate students' experiences, optional open-ended survey questions regarding their perceptions of the program, mentorship, and overall satisfaction were piloted in the 2023 and 2024 cohorts, as previously described. Responses from these two cohorts (n=16) were included in the qualitative analyses. Students who did not complete the optional qualitative survey were excluded from these analyses. Demographic variables for both samples were summarized using descriptive statistics.

Figure 3. Quantitative Analytical Sample



Note: The following flow-chart outlines the analytical sample, including students who did and did not complete the pre- and post-program quantitative assessments.

Measures of Student Gains

Quantitative Assessment of Student Gains

Assessments pertaining to self-efficacy in statistical understanding and confidence in research abilities were utilized to measure student gains from the intensive mentorship program. Pre-assessment of student gains was completed at Week 1 of the program and the post-assessment was completed at Week 15. At both time points, the quantitative assessments were accessible through an online platform, Qualtrics, via a direct link to the students and completed in-person on a computer in the presence of a doctoral student mentor.

In order to assess self-efficacy related to various statistical concepts over the course of the program, students completed the *Current Statistics Self Efficacy* (CSSE) measure (Finney & Schraw, 2003; Larwin, 2014). The CSSE is a 14-item measure that assesses confidence in employing appropriate measurement scales, statistical procedures, and inferential statistics in research scenarios. Items are rated on a 6-point Likert scale (1="no confidence at all" to 6="complete confidence").

In order to assess confidence in research self-efficacy over the course of the program, students completed the *Undergraduate Research Skills Self-Assessment* (URSSA) measure (Weston & Laursen, 2015). The URSSA is a 35-item tool used to measure ability and self-efficacy in scientific skills and knowledge gained as a result of the deployed program (e.g., analyzing data for patterns, writing scientific reports). Items are rated on a 5-point Likert scale (1="none/not likely" to 5="great/a great deal/extremely likely") with answers representing degrees of confidence or ability. The URSSA can be divided into four core domains (thinking like a scientist, personal gains, skills, attitudes) and one optional subdomain (satisfaction) that together provide further insight into the skills gained by students as seen in Table 1.

Table 1. Subdomains of the URSSA

URSSA Subdomain	Subdomain Focus	Sample Questions
Thinking and Working like a Scientist	This domain measures the self-perceived level of knowledge in employing key steps of the scientific research process.	"Analyzing data for patterns." "Formulating a research question that could be answered with data."
Personal Gains Related to Research Work	This domain measures overall confidence and self-efficacy in conducting scientific research independently or part of a team.	"Confidence in my ability to do research." "Confidence in my ability to do well in future science courses."
Skills	This domain measures gains of technical skills associated with conducting scientific research.	"Writing scientific reports or papers." "Defending an argument when asked questions."
Attitudes and Behaviors as a Researcher	This domain measures perceived attitudes and behaviors related to cultivating a scientific identity.	"Engage in real-world science research." "Feel like a scientist."
Satisfaction	This domain measures satisfaction with the research experience, spanning from the project to the mentorship received through direct mentors or others.	"The amount of time I spent doing meaningful research." "The research experience overall."

Note: The following table outlines the subdomains of the Undergraduate Research Skills Self-Assessment (URSSA) measure developed by Weston and Laursen (2015).

Analysis of Quantitative Student Gains

Statistical analyses were performed using version 2.3.28.0 of Jamovi (The Jamovi Project, 2025) and pre- to post-program differences were evaluated using paired-samples *t*-tests. Statistical significance was set at $p < 0.05$ and a Bonferroni correction was applied to adjust for multiple comparisons when necessary. Effect sizes were reported using Cohen's d for paired-samples *t*-tests.

Qualitative Assessment of Student Gains

Students from recent cohorts (2023-2024) were asked open-ended questions about their satisfaction with aspects of the program, and survey responses were collected and recorded through an online platform at the end of the academic semester (Week 15). Thematic analysis followed the process outlined by Naeem et al. 2023. Specifically, text responses to the open-ended question "What did you like about the REU program?" were reviewed by four of the authors who familiarized themselves with the data. Student responses to the question were then reviewed independently for general interpretations and selection of keywords. Keywords were coded and collated into related concepts, and then final thematic concepts were reviewed by the raters as a group. In the event that raters categorized responses differently, discrepancies were discussed by the coders and resolved through consensus.

Results

REU Program Participant Demographics

Quantitative analyses were conducted on data from 64 REU students who completed both the pre- and post-program assessments (see Table 2). Overall, a majority of the REU students were upper-level students (82.8%), most often in their 4th year of university (Seniors). The mean age of students was 23.3 (*SD*= 4.5), with the minimum age being 18 years old and the maximum age being 45 years

old. Data also showed that 75.0% of REU participants were under 25 years old (18-24) and 25.0% identified as adult learners (25 and above).

Table 2. Demographic Characteristics of the Quantitative Analytical Sample (n=64)

Characteristics		n	Percent (%)
Gender	Male	12	18.8
	Female	49	76.5
	Gender Non-Conforming/Non-Binary	3	4.7
Race/Ethnicity	White/Caucasian	26	40.6
	Asian/Pacific Islander	9	14.1
	Hispanic/Latino	4	6.3
	Black/African American	15	23.4
	MENA (Middle Eastern/North African)	9	14.1
	Two or More Races	1	1.5
First-Generation Status	First Generation	34	53.1
	Not First Generation	30	46.9
Academic Level	Freshman	4	6.3
	Sophomore	7	10.9
	Junior	22	34.4
	Senior	31	48.4
Academic Major	Psychology	42	65.6
	Biology	9	14.1
	Forensic Science	4	6.2
	Health Sciences	4	6.2
	Neuroscience	3	4.7
	Chemistry	1	1.6
	Undecided	1	1.6

For the qualitative component, students from the 2023 and 2024 cohorts (19 in total) were invited to complete optional open-ended questions about their experience in the program; 16 students completed the survey. Sample characteristics of this sub-sample reflected the wide participation of diverse students, found in the larger sample. Ages ranged from 18-38 years old (M_{age} = 21.9, *SD* = 4.6) and 68.8% of these students were upper-level (i.e., Juniors and Seniors). Furthermore, 62.5% of students identified as female. Lastly, 62.5% of students identified as ethnically diverse, and 37.5% as first-generation college students.

Quantitative Study of Student Gains

Paired sample *t*-tests showed a significant improvement in self-reported confidence in completing statistical analyses, which revealed a pre-program mean of 3.23 (*SD*= 1.04) (“a fair amount of confidence”) and a post-program mean of 4.06 (*SD*= 1.10) (“much confidence”), $t(63) = 5.96$, $p < 0.001$, $d = 0.75$.

In regard to confidence in research self-efficacy over the course of the program, paired sample *t*-tests revealed a significant increase in overall confidence in research skills and knowledge from pre- to post-program, with mean scores increasing from 3.72 (*SD*= 0.66) to 4.19 (*SD*= 0.59), $t(63) = 4.38$, $p < 0.001$, $d = 0.55$. Additionally, paired-sample *t*-tests were conducted for each subdomain of the URSSA and a Bonferroni-adjusted alpha level of 0.01 (α of 0.05/5 tests) was used to correct for multiple comparisons. Here, there were significant increases in subjective scientific thinking skills ($t(63) = 4.43$, $p < 0.001$, $d = 0.56$), personal gains ($t(63) = 2.90$, $p = 0.005$, $d = 0.36$), and skills ($t(63) = 4.28$, $p < 0.001$, $d = 0.54$) (see Table 3). These subdomains showed improvement from pre- to post-program, though it is worth noting that the attitudes related to research ($t(63) = 2.39$, $p = 0.020$, $d = 0.30$) and satisfaction ($t(63) = 1.46$, $p = 0.149$, $d = 0.18$) subdomains did not show significant changes.

Table 3. Pre- and Post-Test Mean URSSA Scores and Standard Deviations

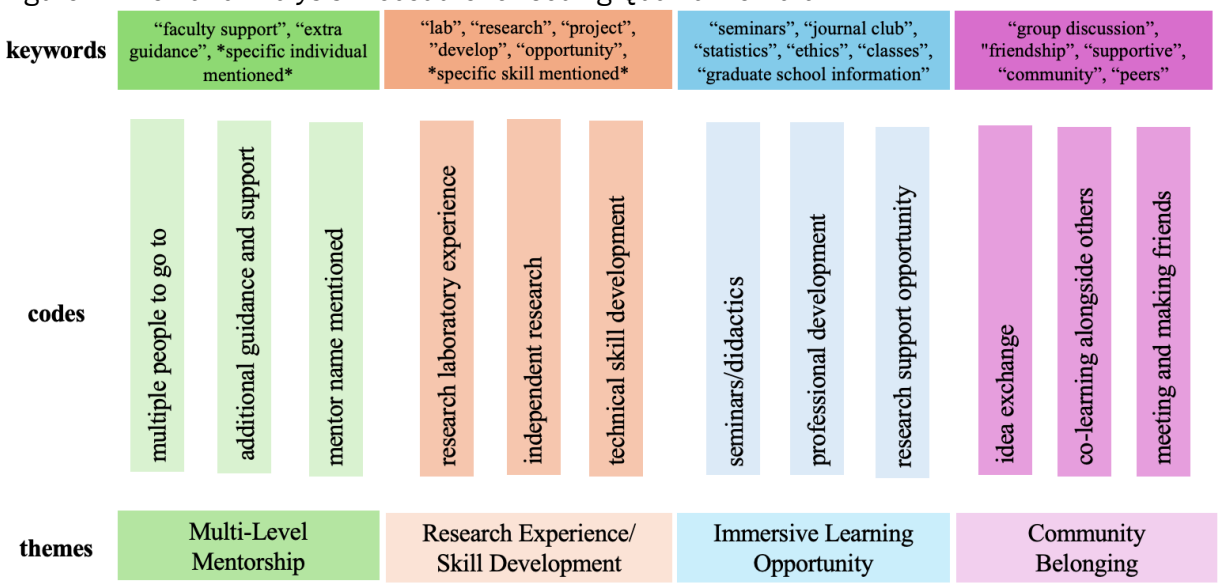
	Pre-Program		Post-Program		
URSSA	**Mean Score**	**SD**	**Mean Score**	**SD**	**p value**
Subdomain					
Thinking like a Scientist	4.0	0.7	4.4	0.6	< 0.001
Personal Gains	4.3	0.7	4.5	0.7	0.005
Attitudes	3.8	1.0	4.0	0.9	0.020
Skills	3.8	0.8	4.2	0.7	< 0.001
Satisfaction	2.9	0.7	3.0	0.9	0.149
Overall	3.7	0.7	4.2	0.6	< 0.001

Note: The table above depicts students' performance on the subdomains of the Undergraduate Research Skills Self-Assessment (URSSA).

Qualitative Study of Student Gains

After reviewing the thematic qualitative data with respect to student gains from the program in 2023 and 2024, four prominent themes emerged (see Figure 4). For confidentiality purposes, specific names of faculty members and instructional staff members were removed from text comments below and replaced with brackets identifying their specific role in the REU program.

Figure 4. Thematic Analysis Procedure for Coding Qualitative Data



Note. This figure illustrates the coding procedure used to analyze the qualitative responses.

Theme 1: Multilevel Mentorship

When asked about the REU program overall, students indicated that the opportunity to learn from others, not just their primary research advisor, was a strength of the program. Keywords mentioned guidance in terms of "multiple," "different," "many," or "extra," mentioned "mentorship" or "mentors," or named specific secondary mentors. Some verbatim text comments included:

> "I also liked that we had multiple people to go to with questions, if any."
> "…faculty are supportive, [mentor] is awesome, [post-doctoral mentor] is awesome."
> "…having the extra guidance made it much easier and less stressful."

Theme 2: Research Experience and Skill Development

Hands-on research experiences and the subsequent research skills developed during the experience were also frequently discussed. Keywords mentioned scientific experiences including "project," "lab," "research," "opportunity," and "independent research." Among these responses, students reported growth in research and statistical skills and self-efficacy using action terms ("developed," "learned") or mentioned "skills" or a specific skill like "critical thinking" in the context of their research experience. Some verbatim text comments included:

> "I like the opportunity to work in an actual research lab and do a project of my own."
> "…allowed me an opportunity to think like a scientist and critically think to answer a research question."
> "I got to learn so so much and was given such amazing opportunities! I learnt tips, tricks, skills, oral presentation and poster making…"

Theme 3: Immersive Learning Opportunities

Participation in interactive and immersive seminars offered by the program was often described by student respondents. Keywords included the seminar courses mentioned by name such as "journal club," "statistics," or "ethics," or words synonymous with seminar including "didactics," "class," or "meetings." Students frequently mentioned their enjoyment of the classes and specific topics covered (i.e., professional development) as well as the benefits of participating in staff-led seminar sessions. Some verbatim text comments included:

> "[I liked] a lot! journal club foremost, statistics was moderately-high helpful, really helped support my research…"
> "I liked how interactive the classes were. It wasn't just filled with lectures, rather students were able to present to one another as well as employ their learning towards the completion of statistical tests."
> "I liked the weekly meetings, especially the discussions during journal club didactic."

Theme 4: Community Belonging

Collaboration and community building were highlighted and greatly appreciated by student respondents. Keywords included terms notating other participants in the program including "cohort," "students," "peers," or "friends", mentioned direct interactions with others in their cohort such as "collaboration" or "exchange," or spoke about community overall. Among these responses, students reported community connectedness and a strong sense of support within their cohort. Some verbatim text comments included:

"I enjoyed the collaborative feeling of getting to know my cohort, as well as [doctoral level graduate student] and [instructional staff in the program]. Everyone is supportive of each other and although it was intensive, it did feel like a community."

"I liked being able to talk with my peers about our projects and other research and I made friends."

"I especially enjoyed it when we met in person with our cohort."

Discussion

Through both quantitative and qualitative approaches, this study examined the academic, professional, and personal gains of undergraduate students immersed in a federally funded REU program that utilizes a multifaceted mentorship model. Consistent with prior literature illustrating the importance of high-quality mentoring in STEM (Byars-Winston et al., 2015; Estrada et al., 2018; Linn et al., 2015; Syed et al., 2019; Wilson et al., 2018), students reported significant improvements in various domains including research self-efficacy, statistical confidence, scientific thinking, and professional preparedness following participation in our program. These findings match current evidence that structured undergraduate research experiences contribute meaningfully to the development of core scientific competencies (Linn et al., 2015; Wilson et al., 2018), while also extending previous work by investigating gains within multilevel mentoring opportunities.

Quantitative analyses revealed significant increases across multiple subdomains of the URSSA measure, such as thinking and working like a scientist, personal gains, and research skills, suggesting that students reported feeling more capable in various aspects of research after participating in the program. Despite improvements across most URSSA subdomains, satisfaction remained stable from pre- to post-program. This finding may reflect the demanding nature of the program, which requires students to balance intensive research activities, coursework, and other commitments (Gasiewski et al., 2010). Alternatively, because this domain assesses students' perceptions of external aspects of the research experience, including mentorship, the research project, and the overall research environment, the absence of a statistically significant change may indicate that these program components were viewed consistently throughout the program, even as students reported gains in other domains. Similarly, improvements in attitudes and behaviors as a researcher were no longer statistically significant after applying Bonferroni corrections, likely reflecting the reduced statistical power associated with the modest sample size. Selection bias may also have contributed to this result. Indeed, the program is competitive, and students selected for participation are highly motivated candidates and already committed to pursuing research careers; as such, they may enter the program with well-formed attitudes and behaviors related to research and their intended field (Bangera & Brownell, 2014). In addition, most REU participants were upper-level undergraduates (i.e., Juniors and Seniors) who may have already developed a well-established scientific identity and strong commitment to pursuing STEM careers, leaving less opportunity to observe measurable gains in the domain over the course of the program. In regard to statistical knowledge, gains in statistical self-efficacy were notable, suggesting that active and structured instruction on research methodology delivered by a dedicated statistics mentor may play a critical role in strengthening students' confidence in data analysis. These findings are consistent with previous studies which demonstrated that hands-on experiences and direct support bolster scientific self-efficacy (Chemers et al., 2011; Fey et al., 2020). Of note, academic and professional gains were observed across heterogeneous students including first generation students and those from historically underrepresented backgrounds in STEM, populations where direct and high-quality mentorship has been shown to be especially impactful (Chemers et al., 2011; Haeger & Fresquez, 2016). Furthermore, acquiring and honing research specific skills was mentioned by students in qualitative surveys as a strength of the program and emerged as a key concept during thematic analysis. Many students in the program described their enjoyment of developing technical skills across their matched laboratory and seminars alongside implementing the skills that they gained in

their own independent research project, adding to the rich literature that speaks to the positive impacts of research experiences on undergraduate student gains (Alaee et al., 2021; Chowdhury et al., 2025; Linn et al., 2015; Seymour et al., 2004; Wilson et al., 2018; Zhang and Swaid, 2017).

Apart from technical skills, qualitative findings provided further insight into how engaging in a multifaceted mentorship network may shape student experiences. Thematic analysis revealed the following central components of the program described by recent students outside of research: multilevel mentorship, immersive learning seminars, and community belonging. Students highlighted the value of having access to multiple mentors (i.e., faculty mentors, instructional staff, graduate students), demonstrating the benefit of receiving guidance from individuals at differing career stages. These findings support established literature suggesting that mentorship from near-peers, graduate students, and post graduate mentors can enhance relatability, accessibility, and psychosocial support, while alleviating pressures placed on faculty in traditional dyadic relationships (Chavez et al., 2025; Evans et al., 2025; Keller & Lindwall, 2020; Montgomery & Page, 2018; Nicholson et al., 2018). Although the present findings support the value of a multiple mentor model, its effectiveness may also depend on characteristics and the quality of mentor-mentee relationships. The present study, however, did not collect demographic information for faculty and other mentors, and therefore we are unable to examine whether mentor representation of shared identities influenced student outcomes. Nonetheless, prior research suggests that demographic concordance between mentors and mentees may increase perceived support, although objective academic outcomes remain unchanged (Blake-Beard et al., 2011). Other work further indicates that factors such as mentor cultural awareness, shared values, and relational factors foster high-quality mentoring relationships beyond demographic similarities (Tuma & Dolan, 2024). Future research should examine how these mentor- and relationship-level characteristics influence student outcomes within multiple mentor models. Notably, students described the seminar components of the program such as journal club, statistics course, and ethics training, as integral to their growth in various domains. These structured group-based mentorship experiences appear to reinforce learned technical skills as well as offer secondary psychosocial support. The integration of hands-on experiences and structured teaching, with concurrent interactive professional opportunities may help explain the observed gains in scientific thinking and self-efficacy. Additionally, it is important to note that as students participate in our forementioned seminars, they are exposed to many key elements of the program such as developing research skills (e.g., presenting findings, conducting literature reviews, completing data analyses, etc.), working with different mentors and peers, and engaging in scientific and scholarly conversation. This makes it difficult to discern direct or additive gains of each program element independently. What is recognized, however, is that by positioning students within a larger network of mentors through immersive seminars and peer interactions, the program transcends the traditional mentorship model and potentially strengthens both scientific confidence and identity development as seen in other studies (Evans et al., 2025; Keller & Lindwall, 2020).

The emergent theme of community belonging also underscores the value of the multifaceted mentorship model. Students frequently referenced peer collaboration, shared learning, and cohort support academically and personally as meaningful aspects of the program. This sense of community may be of importance for students from underrepresented backgrounds, for whom belongingness and inclusion are key mediators of STEM engagement and retention (Estrada et al., 2018). Although students are not formally assigned peer mentors in the program, informal and organic peer-to-peer mentoring relationships may develop throughout the semester. Peer mentoring amongst undergraduate students has been found to be instrumental in developing competencies related to career development and broader knowledge (Marshall et al., 2021). Specifically, students in the program take active roles in promoting research gains in their peers through discussing research methodology, sharing constructive feedback on oral presentations, consulting on ethical dilemmas in independent research projects, and providing overall advice and support. While

literature on informal peer mentorship between undergraduates is limited, research depicts the strengths of this mentorship model across varied learning environments, such as professional organizations and academia (Cree-Green et al., 2020; Gregoric & Wilson, 2015; Ragins & Kram, 2007). Moreover, upon review of the demographic compilation of the cohorts, students were immersed in dynamic learning opportunities with diverse peers, possibly fostering the sharing of different perspectives and cultivating an enriching learning environment as seen in other research studies (Bowman et al., 2023; Lau, 2022; Wolfe & Fletcher, 2013). The broad representation of racial and ethnic diversity not only highlights the program's reach across diverse communities but also aligns with overarching goals of promoting equity, access, and inclusion within the academic pipeline. Furthermore, cohorts consisted of students across varying phases of their undergraduate studies, possibly supporting the integration of diverse perspectives within the program and amongst peers. The inclusion of adult learners, while not widely spread in the program, also introduces different life and professional experiences, enriching the learning environment, and may lead to more dynamic peer-to-peer interactions. By integrating undergraduate research within a diverse and collaborative system rather than a traditional dyad, the program may help to stimulate organic peer support opportunities, foster a collective scientific identity, and promote edifying learning opportunities. Although our study design and the absence of an appropriate comparison group preclude conclusions regarding the superiority of this mentorship structure over traditional dyadic models, our findings are consistent with a growing literature demonstrating that multilevel mentorship models, where students receive structured support from faculty, graduate mentors, and peers, are associated with gains in research self-efficacy and scientific identity (Aikens et al., 2016; Keller & Lindwall, 2020).

The multi-mentor approach is valuable based on the survey data; however, this study cannot attribute observed student gains solely to participation in the outlined multilevel mentorship model. It is possible that the observed gains reflect other factors, including mentor demographics, mentor-mentee demographic concordance, previous coursework, activities outside the program, access to external resources and support networks, or individual motivation. These and other potential influences warrant further investigation. The absence of a comparison group, including students who did not participate in the program or those engaged in alternative REU mentorship models, limits the ability to determine whether similar outcomes would have been observed under differing mentoring or program approaches. Future research using comparison groups, such as psychology and neuroscience students within the department participating in dyadic mentorship relationships, students from other REU programs, or students without formal research mentorship, would help clarify the unique contribution of multifaceted mentorship to students' academic, research, and professional gains. Incorporating objective assessments of research understanding and statistical knowledge would also extend self-reported findings by providing quantifiable, performance-based evidence of student learning before and after the program. Additionally, future studies should employ qualitative approaches that deliberately explore both the strengths and limitations of mentoring programs, as prompts emphasizing positive experiences may not fully capture student concerns, challenges, or more neutral perspectives. Lastly, because data from earlier cohorts (2013-2018) were unavailable for analysis, the sample size was limited. In addition, several cohorts included in the current analysis were impacted by the COVID-19 pandemic, during which program activities were transitioned to a virtual format in response to public health related restrictions. Although extensive efforts were made to maintain the quality and rigor of the research experience, the online format may have influenced certain aspects of the REU program, including peer interactions, networking, and community building. Because outcomes were not examined by cohort year, it was not possible to determine the extent to which the pandemic influenced program outcomes.

Conclusion

Students who completed our REU program, who received diverse mentorship opportunities from faculty, instructional staff, graduate students, and senior lab members, reported growth in research and statistical skills, self-efficacy, and professional development. We are finding that such a multi-mentorship model helps create a supportive learning environment and sense of community that not only fosters academic and professional gains, but personal growth as well. This approach allows our students to gain experiences needed to succeed academically while also receiving the multidimensional support needed to navigate professional goals, strengthen their scientific identity, and feel connected to a broader community of peers.

Acknowledgements

We thank the REU students, supporting staff, and mentors for their contributions to this program and study. We also thank Ellie Grossman for her efforts in developing a training program focused on the mentorship of diverse students, as well as crafting materials in order to collect data related to mentorship in the program. This work was supported by the National Science Foundation (NSF) Research Experiences for Undergraduates (REU) program (Award Number(s): 2050755; 2349686).

Conflicts of Interest

None

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