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Evolving Strategies for Enhancing URM Student Success in STEM: A Formative Evaluation of a Multi-Institutional Undergraduate Research Program from 2019 to 2024

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Introduction

Research continues to show a disparity in degree attainment and advancement into graduate studies among underrepresented minorities and underrepresented groups (e.g., African-Americans, Hispanics, or Latinos/Latinas, American Indians/Native Americans, Alaskan Natives, Mixed-Race, women, people with disabilities, and members of the LGBTQ communities) in Science, Technology, Engineering and Mathematics (STEM) fields [1], [2], [3]. Despite numerous initiatives to increase representation, underrepresented groups in STEM continue to face poor recruitment and retention [4]. Given this trend, many researchers have identified key program components related to the success of STEM students from underrepresented minorities and groups. For example, research experiences and mentorship have been shown to be positively related to the integration of underrepresented minorities and groups into STEM fields of study [5].

Previous research highlights the critical role of research experience and mentorship in promoting the socio-academic integration of underrepresented minorities into STEM fields [5]. Studies consistently demonstrate that research experience positively influences career choice, preparation, and placement, while programs incorporating research experiences are linked to increased degree completion and academic persistence [4], [6], [7]. Similarly, mentorship has been shown to significantly enhance academic achievement, productivity, and persistence [8]. Providing students with resources, networking opportunities, and encouragement has proven particularly effective in fostering academic success and resilience. Furthermore, undergraduate research not only cultivates excellence but also expands participation in sustainable programs, creating a more inclusive and dynamic academic environment. The current study assesses a summer research program from 2019 to 2024. The current study evaluates a summer research program that operated from 2019 to 2024, was designed to increase degree retention and attainment for STEM students while promoting their advancement into graduate students. This program engaged students in high impact practices aimed at fostering professional development, affinity for their STEM discipline, and research skills.

Each year, student cohorts participated in an eight-week research project under the supervision of university or community college faculty members. Depending on institution of origin, previous research experience and academic standing, students were recruited and selected to participate in one of three summer research tracks: on-campus undergraduate research, student-initiated research abroad, faculty-initiated research abroad, or faculty-student team at a national laboratory. Students with no prior record of participation in summer research activities were recruited for introductory research tracks while students with one prior research experience were placed in advanced tracks designed to deepen their research skills and knowledge.

For on-campus research and research abroad, the preferred mentoring model in the program's summer research experience was the traditional mentor-protégé dyad [5]. Each student (protégé) was assigned a faculty mentor or doctoral student who provided guidance, training, and

encouragement throughout an eight-to-ten-week period. Students met with their mentors weekly to report progress, receive feedback, and discuss the next steps. For students conducting research abroad, pre-departure programming was provided during the semester before their travels, covering topics such as housing logistics, cultural adjustment, and travel preparation.

The second most utilized model was the small cohort mentoring model in which one or two professors mentored a group of proteges while working on related projects [5]. In this model, students were given programming that helped them with the research they were about to conduct in the form of a boot camp. The team would meet regularly, sometimes daily, to discuss progress and to plan future activities. The program adopted a multi-pronged approach to mentorship and research training, incorporating varied research environments to support students' academic and professional development. In 2019, an additional faculty-student research model was implemented, where students were sent to national laboratories alongside faculty mentors for an immersive three-month research experience. This provided students with direct exposure to cutting-edge research, interdisciplinary collaboration, and real-world STEM applications. However, due to funding redirection, this component was discontinued in subsequent years.

All mentors were selected based on their research expertise, mentoring experience, and willingness to participate in the program. All students received additional support from the campus director at their hosting institutions and were responsible for the students' professional development. Additional support was given through the program associate director who communicated regularly with the student and campus director, and peers who worked alongside the protégé. Collectively these program components aimed to create a supportive and enriching research experience for underrepresented students in STEM. To assess the effectiveness of the summer research program in promoting student retention, academic persistence, and professional development, an evaluation was conducted on student participation, demographic characteristics, and program impact. The analysis focused on participant experiences and mentorship effectiveness from 2019 to 2024.

Methods

Following the selection process, demographic data were collected to understand the backgrounds of participating students. This data collection occurred after selection to ensure that recruitment decisions were based solely on academic standing, prior research experience, and institutional representation rather than demographic characteristics.

To evaluate the program's impact, a mixed-methods approach was employed, combining quantitative survey data with qualitative insights from focus groups. The following section outlines the data collection procedures, including survey administration, focus group methodology, and data analysis techniques.

At the end of their summer research experience, students were asked to participate in an online survey and focus groups to assess their perceptions of the research experience and mentorship. The evaluation team created the survey and focus group questions. Prior to data collection, permission was obtained from the Institutional Review Board.

The surveys were administered electronically via Survey Monkey or QuestionPro during the final two weeks of their programs and prior to the annual conference. However, due to institutional requirements, the platform was later transitioned to QuestionPro. The students were notified and given several reminders to complete the survey. The participants were asked to provide basic demographic information (e.g., gender and ethnicity/race). Additional identifying demographic included student classification (e.g., freshman, sophomore, junior, or senior), expected graduation year, academic major, and field of research. The next section of survey items included students' level of satisfaction with the summer research experiences, their mentor, their research project, and the instruction and preparation they received prior to attending. In addition, the participants were asked to report their perceptions on the impact the summer research experience had on their research, academic, and professional skills. Each item was assessed using Likert-type scale items (1 = strongly disagree to 5 = strongly agree or 1 = not satisfied to 5 = very satisfied). A "not applicable" and a "prefer not to answer" choice was available for every Likert-type question. Finally, open-ended questions were included to assess the students' motivation to apply and their suggestions and ideas for improving the summer research experiences.

Focus groups were conducted with randomly selected participants. Each session was audio taped, transcribed and transcription used in the data analysis. The focus group questions were intended to understand the reasoning behind students' responses in the survey data. For example, students were asked about their expectations of the summer research experience, the most helpful/least helpful guidance and instruction given, factors related to a successful summer research experience, skills gained from the experience, and student's experience and relationship with their mentor. Table 1 outlines the focus group categories and sample questions.

Table 1: Categories and examples of the focus group questions

Pre-Program Activities

Tell us about your pre-program experience (e.g., identification of a faculty mentor, connecting with the Program Director, accessing information you may need to plan your mentored research experience).

1. What was helpful?
2. What information do you wish you had in advance?
3. What suggestions related to pre-program coordination do you have for future programs?

Research Experience

Tell us about your research experiences…

1. What were some of the positive experiences you had when working on your research project?
2. What challenges did you face with your research? What tools, resources, or information did you utilize to manage challenges faced?
3. What recommendations do you have for future mentored research participants?

Research Mentor Experience

Tell us about your mentoring experiences…

- How often did you interact with your research mentor?
- What were some aspects of the mentoring that you most enjoyed? Was there anything that you wished you had received from the mentoring relationship but did not?
- Are there mentoring experiences you hope to have in the future?

Gains from Program Participation
Tell us about any changes you may have experienced as a result of your participation in the program.

- Have you experienced a change in your overall motivation to pursue future research or careers in STEM (e.g., an increase, decrease, or no change)?
- What skillsets do you feel you were able to build or refine during your program participation?
- What skillsets did you wish you could build or refine that you weren't able to during this experience?
- Are there new or additional supports you have identified to help you as you pursue a career in research or a career in STEM?

The evaluation team aggregated the data across the various summer research experiences and descriptive statistics have been generated for the survey items. This allowed the evaluation team to preserve the anonymity of the participants. For the focus group data, the evaluation team's interpretation was based on observation, review of the audio tapes, and analysis of the content contained in the transcripts from all the sessions.

Results

Since 2019, a total of 266 undergraduate students were selected to participate in summer research experiences. Students were eligible to participate in the program if they were enrolled in a STEM discipline and were either U.S. citizens or permanent residents. Students participated in an intensive research activity for eight weeks for a minimum of 30 hours per week. In addition, students were required to create and present a poster for their project at an annual program conference. Table 1 includes the number of students who participated in summer research experiences from 2019 to 2024. The COVID pandemic contributed to low participation in 2020. Additionally, we were unable to access data collected in 2020 (see Table 2 and Table 3).

Table 2: Participant Demographic Characteristics

	2019	2020	2021	2022	2023	2024
Total Participants	53	8	39	51	57	58
Female	45%	*	72%	61%	56%	55%
Hispanic	50%	*	49%	67%	70%	58%
White	21%	*	46%	41%	65%	66%
Black/African American	10%	*	10%	3%	14%	2%
Asian	11%	*	18%	9%	11%	16%
Native American	0	*	0	9%	0	2%
Multiracial	8%	*	5%	9%	8%	5%

*The evaluation team were unable to access data collected in 2020.

The participants, predominately from Hispanic (48%-68%) and female (61%) reflected a consistent representation across the institutions (see Table 2). A large proportion of students majored in life sciences and engineering. Overall satisfaction with the program was notably high, with 91%-94% of participants expressing contentment with their experience. Similarly, 79%-98% of students reported receiving high-quality mentorship (see Table 3). Participants highlighted significant skill development in areas such as research (94%), organization (94%), and communication (88%), with many gaining proficiencies in creating research posters and delivering oral presentations. Despite these successes, challenges such as insufficient pre-program preparation, unclear mentor expectations, and limited time for project completion affected 30%-40% of participants. Nonetheless, all the students prepared a scientific poster to present at the annual program conference. Financial difficulties and logistical hurdles in the programs were recurring issues, though students valued the cultural and community-building opportunities provided by these programs.

Table 3: Overall Participant Satisfaction with the Program and Mentor						
	2019	2020	2021	2022	2023	2024
Overall Satisfaction	94%	*	89%	92%	85%	81%
Satisfaction with Mentorship	96%	*	97%	82%	91%	79%

While most participants expressed satisfaction with the summer research experience and mentorship, the evaluation team conducted focus groups to gather suggestions for improvement. Several key themes emerged, particularly regarding communication, organization, and mentorship dynamics.

One of the most frequent suggestions was to increase communication between program coordinators, faculty mentors, and students before the start of the research experience. Participants emphasized that early communication would help clarify project expectations, roles, and responsibilities, ensuring a smoother transition into the summer program. As one student shared: "I wish I was given more information before the start of the research experience so that I could prepare."

Additionally, students reported challenges in meeting with their mentors consistently, which impacted on their research progress and sense of belonging in the program. One participant described feeling isolated due to the lack of mentor engagement: "I wasn't able to see or meet with my mentor, and it made it really hard to continue my research. It felt lonely."

To address these concerns, students recommended structured mentorship support, such as regularly scheduled meetings between mentors and students to ensure consistent guidance and interaction. Another key recommendation was for the program to facilitate initial conversations between students and mentors to establish expectations and reduce discomfort in navigating mentorship relationships. One student explained: "I wish that the program would have started convos with my mentor because I felt awkward asking for certain things. But if someone higher up could’ve done it, it would have been easier for me."

Finally, participants suggested enhancing organization and structure within the research experience. Specific recommendations included the implementation of a firm schedule, a list of required tasks, and scheduled weekly meetings with program coordinators and faculty mentors to track progress and provide support. These structural changes, they believed, would create a more engaging and effective research environment for future cohorts.

Discussion

Underrepresented groups in STEM face persistent disparities in degree attainment and graduate study advancement [4]. Research highlights key program components that support their success. This study evaluated undergraduate student perceptions of mentorship and research experiences from a summer research program.

The program evaluation revealed both notable successes and areas for improvement. High participant satisfaction reflected the program's strong mentorship and impactful research opportunities. Students consistently reported increased confidence, enhanced research abilities, and improved communication skills, emphasizing the program's critical role in preparing them for future STEM careers. Furthermore, the program demonstrated a strong commitment to diversity by engaging students across a broad demographic spectrum, with success in supporting Hispanic and female participants.

Despite these strengths, challenges emerged that require attention. Participants expressed a need for clearer pre-program communication and guidelines to streamline coordination and set accurate expectations for both students and mentors. Additionally, time constraints within the program often hindered the completion of research projects, suggesting the need for extended durations or more realistic project scopes. Financial stressors, including delayed stipend payments and insufficient amounts, also negatively impacted the student experience.

To strengthen this program and similar initiatives, we recommend the following actions:

1. **Extend Research Opportunities at Home Institutions**
   Implement a yearlong research experience at each student's home institution. This approach reduces the time to degree, enhances local accountability, and simplifies coordination. Students would avoid relocation, alleviating financial burdens associated with housing and travel [9].
2. **Provide Clearer Mentor Guidance**
   Offer comprehensive training and support for faculty mentors to foster a more intellectually and socially supportive environment. Additionally, establish metrics to evaluate mentor effectiveness, ensuring alignment with program goals and student needs [10].
3. **Enhance Professional Development**
   Integrate flexible and institution-specific professional development opportunities, such as leveraging university libraries and encouraging participation in institutional undergraduate research conferences. These activities will deepen students' connections to their universities and equip them to navigate available resources effectively [11].

4. **Preserve Institutional Knowledge**
   To ensure continuity, appoint co-directors or other leadership structures to maintain program stability and smooth transitions during staff turnover [9].
5. **Track and Support Alumni Progress**
   Establish mechanisms for long-term tracking of students after program completion. Collect personal information (with consent) to monitor their academic and professional journeys and provide support as needed. This data will also inform program effectiveness and alumni impact [12].
6. **Evaluate Program Effectiveness Continuously**
   Incorporate robust evaluation measures, including systematic tracking of faculty mentor effectiveness and student outcomes. Regular feedback from participants and mentors will ensure ongoing program refinement [5].

These recommendations aim to build on previous research and the current program's successes, address identified challenges and create a more sustainable and impactful experience for students from underrepresented groups in STEM. By implementing these strategies, future programs can better prepare students for advanced STEM pathways while promoting equity and inclusion in the field.

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