Strengthening CS Research Capacity of Undergraduate Hispanic Students through the Local REU Model

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Abstract*— This Innovative Practice paper describes the Local Research Experiences for Undergraduates (LREU) program that was established by the Computing Alliance of Hispanic-Serving Institutions (CAHSI) at Hispanic-serving institutions (HSIs) in 2021 to increase the number of students, particularly students from underrepresented populations, who enter graduate programs in computer science. Since its first offering in Spring 2022, the LREU program has involved 182 faculty and 253 students. The LREU program funds undergraduate research experiences at the students' home institutions with an emphasis on first-generation students and those with financial needs. The motivation for the program is to address the low number of domestic students, particularly Hispanics and other minoritized populations, who seek and complete graduate degrees. Research shows that participation in research activities predicts college outcomes such as GPA, retention, and persistence. Even though these studies inform us of the importance of REU programs, many programmatic efforts are summer experiences and, while students may receive support, faculty mentors rarely receive coaching or professional development efforts. What distinguishes the LREU program is the focus on the deliberative development of students' professional and research skills; faculty coaching on the Affinity Research Group model; and the learning community established to share experiences and practices and to learn from each other. Students, who are matched with faculty mentors based on their areas of interest, work with their mentor to co-create a research plan. Students keep a research journal in which they record what they have learned and identify areas for their growth and development as researchers. The LREU provides an opportunity for the LREU participants to cultivate a growth mindset through deliberate practice and reflection from personal, professional, social, and academic perspectives. The paper discusses the multi-institutional perspectives that help CAHSI understand the types of challenges faced in undergraduate research programs, how faculty mentors communicate and make decisions, and how mentors resolve challenges, allowing the research community to better understand students' and faculty experiences. In addition, the paper reports on research and evaluation results that documented mentors' growth in their knowledge of effective research mentoring practices and students' learning gains in research and other skills. The paper also describes the impact of the learning community, e.g., how it supports developing strategies for interaction with and mentoring students from underrepresented populations.

Keywords—Undergraduate Research Experiences, Broadening Participation, Students Professional Development

I. INTRODUCTION

The number of African Americans/Blacks, Hispanics/Latinx, Native Americans/ Alaskan Natives (**AHN**) [1] students who enter and complete doctoral graduate computing studies is disturbingly low despite their growth in numbers nationally and representation in undergraduate (**UG**) studies. In fact, Hispanic UG enrollment increased from 22 percent to 36 percent between 2000 and 2018 [2], composing approximately 19 percent of the total UG population in 2017 [3]. Yet, the number of Hispanics who completed graduate programs in computing fields made up a mere 3 percent in master's and 2 percent in doctoral programs [4]. In addition, although Hispanics are the largest racial/ethnic minority group in U.S. higher education, a mere 12% of Hispanic undergraduates are enrolled in the most selective public 4-year institutions [5]. As a nation, if we want to move the needle in diversifying the computing research workforce, it is time for a paradigm shift. Institutions of higher education cannot continue to operate as they have for decades— in competition with each other and taking pride in exclusive practices and the high numbers of students the institution rejects. Systemic and drastic change will only happen if we work collectively with a shared vision and common agenda for serving and cultivating AHN computing leaders in the institutions where they are most found and feel included. The role of Minority-Serving Institutions (**MSIs**), which enroll by far the largest share of students of color [6], is

critical if we are to authentically diversify STEM disciplines and increase the number of domestic students in graduate programs.

The NSF Eddie Bernice Johnson INCLUDES Computing Alliance of Hispanic-Serving Institutions (**CAHSI**) is responding to the national call to action to accelerate the number of domestic students in graduate computing studies through collective efforts across its alliance. Such efforts include engaging first-year and second-year students in activities that expose them to research, addressing financial needs, establishing a CAHSI Doctoral Student Network, and creating a Local Research Experiences for Undergraduate (LREU) program. This paper describes the Local LREU program and its strategic efforts to create a model that involves undergraduate students in research projects of interest; prepares faculty mentors to build students' identity as researchers and deliberately develop their research, communication, and team skills; and present sessions that describe the graduate-school application process and how to submit a competitive graduate-program fellowship.

II. Background

A. Overview of CAHSI

CAHSI was founded in 2006 to address the low representation of Hispanics in higher education and the workforce. Funded by both the NSF INCLUDES and Broadening Participation in Computing programs, CAHSI is composed of over 160 public and private sector partners. CAHSI's core purpose is to create a unified voice to consolidate the strengths and resources of HSIs and other groups committed to increasing the number of Hispanics in all computing areas [7].

When CAHSI was named a National INCLUDES Alliance in 2018, it expanded its partnerships to include 27 2-year colleges and 43 4-year colleges and 60 other partners [8], [9]. To be inclusive of 2-year colleges, CAHSI set its vision: By 2030, Hispanics will represent 20% or more of those who earn credentials in computing. Credentials are defined as degrees and certifications that lead to gainful employment and advancement in the field. CAHSI's mission is to grow and sustain a networked community committed to recruiting, retaining, and accelerating the progress of Hispanics in computing. The established Alliance members are in the following regions: Southwest (Arizona, Texas, and New Mexico), West (California), Southeast (Florida and Puerto Rico), and North (Connecticut, Illinois, New Jersey, and New York, Rhode Island, and Virginia). Other partnerships include the most impactful Hispanic organizations in the country and other organizations committed to change (e.g., Excelencia in Education, Great Minds in STEM, CSforAll, and NCWIT). It is these vested partnerships that position CAHSI onto a national platform for its record on increasing the number of Hispanics who are competitive in the workforce and academia.

CAHSI operates using a "Collective Impact Model" that posits a network of committed institutions that are positioned to do more together than any one institution can alone. Collective impact has five components [10]: common agenda, mutually reinforcing activities, continuous communication, common measures, and a backbone. For details on CAHSI's adoption of collective impact refer to Villa et al. [9]. CAHSI supports institutions committed to advancing Hispanic students in computing; provides on-ramps for other alliances, nongovernmental organizations, and partners; and prepares the next generation of CAHSI leaders. By creating distributed on-the-ground support through geographically distributed regional leadership, Alliance institutions deeply engage with partners and each other to learn what works well and what can be improved within their specific contexts. Focused on moving from siloed efforts to collective-impact efforts across campuses, regions, and the nation, CAHSI is an ecosystem that cultivates and empowers Hispanics in computing and recognizes that the health of our nation is tied, in great part, to our ability to build capacity at HSIs to conduct research and advance educational attainment of Hispanics and other underrepresented students.

B. Research Experience for Undergraduates

In the field of higher education and STEM education, the benefit of undergraduate research experiences (**UREs**) has been well-documented. In UREs, students can learn contextual theories, be exposed to and engage with authentic research procedures, and learn how to solve practical problems using real-world examples [11], [12]. As such, UREs positively influence students' motivation, interest in STEM careers, and self-confidence [13], [14], [15], [16], and scientific and communication skills levels in engineering fields [17]. UREs also have positive impact on students' retention and graduation rates in STEM fields [18], [19], [20]. UREs contributed to students' educational and occupational aspirations to pursue graduate studies and career opportunities in the STEM workforce [21], [22]. For instance, Pender and his colleagues [23] collected longitudinal data over 14 years to examine the relationship between participation in summer research internship experiences and graduate school participation, particularly enrollment in STEM Ph.D. programs. They found that summer internship research experiences are significantly and positively related to enrollment in graduate schools in STEM fields, and students who took part in the program more often had a higher likelihood of entering STEM Ph.D. programs than those who did not participate in the research experiences.

In computer science specifically, the benefits of participating in UREs have been proven. Researchers found that UREs are positively related to retention [24], [25], students' self-efficacy and identity as a scientist [26], and college GPA [24]. Given racial disparities in computing, it is crucial to provide students from underrepresented backgrounds with more opportunities to participate in UREs to reduce the disparities and broaden participation in computing [27], as the benefit is more significant for the students [26], [28]. Using a large and representative sample of students tracked over time and a quasi-experimental research design, researchers found that UREs are significantly and positively related to graduate enrollment and graduation in STEM disciplines among underrepresented students [29].

Given the significant impact of UREs on academic and occupational outcomes, UREs have been developed and implemented in various ways in terms of scale, structure, duration, and support systems for participant students, such as course-based undergraduate research experiences (**CURE**), research apprenticeships with direct guidance of faculty mentor, academic year co-curricular projects, paid/unpaid/for-credit

research experiences, and full-time summer programs. In many cases, UREs resemble scaled-down research experiences in graduate programs, structuring as undergraduate student work and working on an individual project under a faculty mentor's guidance [30].

Given the growth in adoption of CURE [20], researchers examined different types of URE learning modules (e.g., CURE models, traditional apprenticeship-styled models, and integrated and collaborative models). There are mixed findings on the impact of CURE depending on URE models and research sites. First, researchers reported that CURE does not have a significant effect on students' motivation and teamwork [17] and engagement in research inquiry [11] as compared to a research internship [31]. Secondly, comparing two different research programs (undergraduate research programs that offer a limited number of positions and provide financial support; undergraduate research but not implemented in structured programs and mostly voluntary from students) at HSIs, Battaglia et al. [32] found that structured research programs provide higher benefits to develop various skills compared to the unstructured and voluntary research experiences. Third, comparing the impact of a university-sponsored or an NSF-funded REU program in engineering, Follmer et al. [33] reported that students who participated in the NSF-funded REU programs showed higher gains in specific research-based skills than those who participated in the university-sponsored URE programs. Lastly, using systematic reviews and meta-analyses, Ahmad and Al Thani [11] found that CURE models have been effective programs by providing undergraduate students with more research opportunities. CURE models have the potential to keep costs low and effective compared to summer research internship programs [11], [34], [35].

C. CAHSI's Virtual REU Program

CAHSI established the virtual REU (**vREU**) program during the pandemic to ensure students, particularly those with financial need, have an opportunity to engage in research and gain critical skills while advancing their knowledge and financial resources to complete their UG degrees and move to advanced studies [36], [37]. Students received stipends, which alleviated their financial needs. The vREU pilot provided UG research experiences for 51 students and 21 faculty drawn from 14 colleges and universities. Faculty attended weekly sessions on the Affinity Research Group (**ARG**) model, which coached them on how to integrate research, communication, and professional skills intentionally in their research projects [36]. Evaluation found students and faculty feeling positive about the program, particularly the structure, sense of collective action, and sense of support for the majority of faculty and students. The students' self-reported outcomes showed the vREU as a viable option for student growth and research advancement. Students reported the most growth in research skills (89%), technical knowledge (64%) and communication skills, both oral and written (66%). Personal growth, defined as confidence and patience with setbacks, also grew (57%).

III. THE APPROACH: LREU

The LREU program builds upon the vREU model and is facilitated through the CAHSI Backbone with involvement of the regional leads, connectors, and coordinators. The program engages students in extensive research experiences at their home institution, particularly targeting AHN students with financial need and giving preference to first-generation students. The LREU focuses on developing students' domain knowledge in areas aligned with CAHSI research institutions.

Features of the LREU initiative [36], [37] are:

- Students are matched based on their areas of interest with a balance on developing students' domain knowledge in areas aligned with CAHSI research institutions and with the intent of keeping students engaged in an area that excites them.
- Faculty mentors receive professional development that prepares them to adopt/adapt practices from the ARG model that deliberately develops students' research, communication, and team skills.
- Reflection is integrated into the program to support faculty and student growth.
- The culmination of the program includes submission of a research poster.

The LREU initiative [38] establishes a network of faculty at HSIs and student scholars who cultivate a growth mindset through deliberate practice and reflection from personal, professional, social, and academic perspectives. The next sections provide more details of the program.

A. Student and Faculty Requirements

Students and faculty participants in the LREU program each attend an orientation focused on an overview of CAHSI and requirements of the program. It emphasizes that foremost the research projects must be well-defined and have intellectual merit; faculty mentors must focus on students' development of research, communication, and technical skills; and student engagement should elevate their excitement of research. It is imperative that participants understand that the overall goal is to increase the number of domestic students who enter graduate programs, particularly Ph.D. programs.

The course is managed through an LREU OneNote Notebook that is open to all participants, the CAHSI Backbone, and regional leads. The notebook outlines the expectations of the student and faculty that include the requirements for attending meetings and completing surveys. General requirements for faculty include:

- setting recurring meeting dates and times with mentee(s),
- developing a research plan with the mentee that includes clear milestones,
- monitoring the mentee's weekly journal entries and provide responses and constructive feedback particularly if the student is not able to progress as expected,
- reviewing and critiquing mentee's poster before they submit their final poster to the Backbone repository and student conference,
- submitting a midterm and final report, and

- creating and/or updating a research profile on the CAHSI Expertise website.

Students' general requirements include:

- attending recurring meeting dates and times with their mentor,
- reviewing and discussing the research plan with their mentor,
- writing weekly journal entries in their journal, and
- submitting a research poster that is reviewed, approved by their mentor and the CAHSI Backbone, and submitted to the Great Minds in STEM Conference, or other conference of their choosing.

To ensure faculty and students have a solid understanding of the planned research, the LREU ensures that the faculty and students agree on a research plan. The research plan captures the following information: student name, semester, year, project title, project description, significance, research goals and objectives (short-term and long-term, if applicable), assigned tasks, deliverables, and milestones. The plan is created before the LREU start date and will guide the mentor and mentee as they set expectations for the work to be done. There should be an understanding that there may be adjustments to the plan as the research progresses and findings warrant changes.

Students must submit weekly entries into their research journal that is also kept in OneNote Notebook. In addition to project title, start date, and end day, students make entries into the research journal in response to the following prompts: work accomplished, problems encountered, what was learned, resources needed, professional development activities attended, if any, and plans for the following week.

B. Faculty Support Structures

A distinguishing feature of the LREU is the faculty professional development effort to support adoption of the ARG model [7], [8], [39], [40], a set of practices built on a cooperative team framework to support the creation and maintenance of dynamic and inclusive research groups. The model focuses on the deliberate development of students' skills needed to succeed in research, academia, and the workforce.

Adoption of ARG is supported by the CAHSI's Holistic Approach to Learning and Knowledge Sharing (CHALKS), a learning model for systematically structuring the adoption of CAHSI's signature practices, such as the ARG model. As shown in Fig.1, the model is designed to develop and promote inclusive practices in educational settings, e.g., classrooms, student organizations, workshops, and research groups. The Canvas Learning Management system is used to deliver CHALKS courses. The CHALKS' ARG course is entitled, *Affinity Research Groups: Creating and Maintaining Effective Research Groups.*

Each session is devoted to a specific ARG practice: Setting Clear Goals and Objectives; Analyzing and Evaluating Abstracts; Asking Probing Questions; Empowering Student Growth through Constructive Critique. Assignments include activities such as incorporating an ARG practice into research team meetings, submitting a plan for an ARG activity, and reflecting on their students' elevator speeches. Faculty must enroll in the ARG CHALKS course unless they have previously participated in an in-person, or virtual ARG professional development workshop previously offered by CAHSI.

The CHALKS sessions bring together elements of cooperative learning, reflection on one's understanding of how to apply what is learned, and deliberate consideration of inclusive practices. To strengthen learning, ARG facilitators post prompts about an effective practice and how mentors applied it. The facilitators and participants respond to what is shared. Example prompts include:

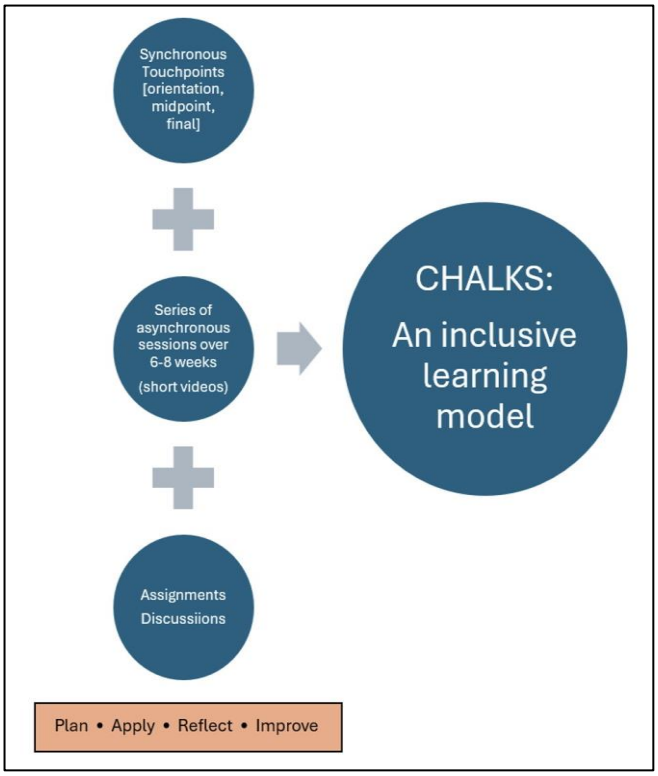

Fig. 1: The CHALKS model for structuring adoption of CAHSI practices.

- Setting Clear Goals and Objectives: What is the value of setting goals and objectives with your mentee(s)? How do you ensure that the goals and objectives set with your mentee(s) are both challenging and achievable? Have you encountered any challenges or obstacles when setting goals and objectives with your mentee(s)? If so, how did you address them?
- Analyzing and Evaluating Abstracts: How well did student(s) recognize what was needed to improve in the assigned abstract, if anything? What would you do differently the next time you conduct this activity? How could CHALKS improve this activity?
- Empowering Student Growth through Constructive Critique: How productive was the critique session with your students? Were the students able to process the feedback given to them on their work and improve?

The CHALKS approach has several virtual touchpoints that all mentors attend synchronously: an orientation in which the Backbone explains the purpose of the LREU, expectations of the mentor and mentee, and the importance of using ARG effective practices; a mid-term meeting to identify any issues that may have arisen and share highlights and reflections from the participants; and a final meeting to thank everyone for their participation, ask them to complete a survey, and discuss final steps for completing the requirements. By merging the benefits of online learning modules and real-time virtual meetings, the 8-week hybrid course is a flexible learning experience. Successful completion of course requirements lead to a Certificate of Achievement. The certificate can enhance faculty portfolios with demonstration of professional development.

Another faculty support structure is the CAHSI Collaborative Learning Community (CCLC) that serves as a forum for faculty to collaboratively discuss challenges in adopting a signature practice, exchange ideas, and explore new activities and tools. The CCLC operates as a community of practice [41] in which a group of individuals, who share an interest, concern, or passion, interact regularly to improve what they do. The intent is to connect people with people, people with experts, and people with resources with the aim of exchanging lessons learned, seeking to extend understanding of a CASHI signature practice, accelerating the speed of decision-making during implementation of the signature practice. CCLC has adopted the following recommendations for an effective community of practice [42]:

- Purpose – Define what the community will do.
- Facilitation/stewardship – Determine who will manage/maintain the vitality of the community.
- Engagement and communication plan – Define a plan to keep the community vibrant and to grow membership.
- Knowledge assets – Determine what constitutes valuable and compelling content.
- Rewards and incentives – Define what rewards and incentives are needed for members.
- Trust – Determine what is needed to establish trust between members.

C. *Student Support Structures*

CAHSI views the opportunity for student fellowships and scholarships as a powerful resource in attracting students into graduate studies toward a doctorate, as early exposure to navigating the graduate application process is critical for creating pathways for Hispanic first-generation college students [38], [43]. As awardees of highly competitive fellowships and scholarships, students have the advantage to be introduced to research early in their academics; and, if they continue into graduate programs, they become valued candidates for faculty positions once they obtain their Ph.D. The Fellow-Net initiative [7] is another CAHSI signature practice that prepares students in submitting competitive applications to graduate fellowships and focuses on a variety of opportunities, e.g., NSF, NASA, DOD, DHS. Fellow-Net also involves faculty in constructive/iterative feedback on fellowship applications. Obtaining a fellowship is critical for many of our students, particularly those who are first-generation, to pursue graduate studies.

Graduate students at HSIs play an essential role as institutional actors who can improve the experiences of students through increased interaction with undergraduate students as roles models, teaching assistants, research assistants, and lab instructors. These interactions include both academic and personal support, as Hispanic graduate students likely have a deeper understanding of their cultural and linguistic backgrounds [44], [45]. Hispanic graduate students also benefit from these multiple roles because they provide opportunities to improve their teaching, coaching, and mentoring skills. Faculty are encouraged to provide opportunities for their mentees to interact with graduate students at their home institutions. It is critical that faculty mentors include opportunities for AHN graduate students to interact with undergraduate AHN students, such as the LREU mentees. To support students, CAHSI established the CAHSI Doctoral Student Network, which hosts workshops focused on the graduate application process, applications to the fellowships, and providing academic, professional, and personal support structures.

IV. FINDINGS

A. *Participation Numbers*

Fig. 2 shows the participation of students in the LREU across four different regions. The West region involved 11 HSIs from California; the Southwest region involved 12 HSIs from Texas and New Mexico; the Southeast region involved 6 HSIs from Florida and Puerto Rico; and the North involved 6 HSIs from New Jersey, Illinois, and Virginia. The projected total in green is the expected number of students who participate in the LREU over a three-year period, and orange is the projected after a two-year period. Note that the program started in Spring 2022. The demographics of the participants are shown in Fig.3. It is important to note that Mixed race largely represents students who identified as Hispanics and another race. If we were to look at the number of participants from underrepresented groups, then their participation would be approximately 85%.

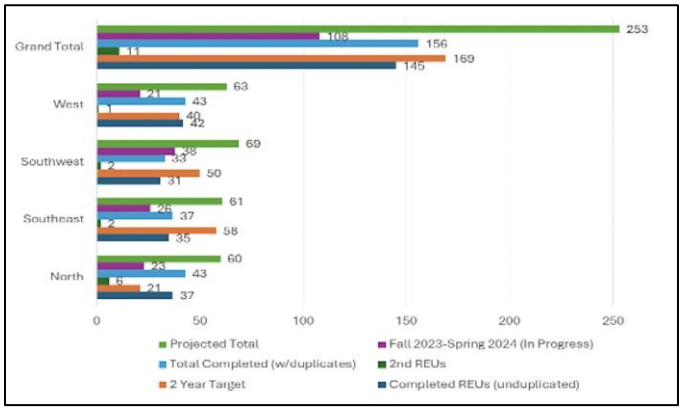

Fig. 2: CAHSI Local REU Student Participants Spring 2022 - Spring 2024

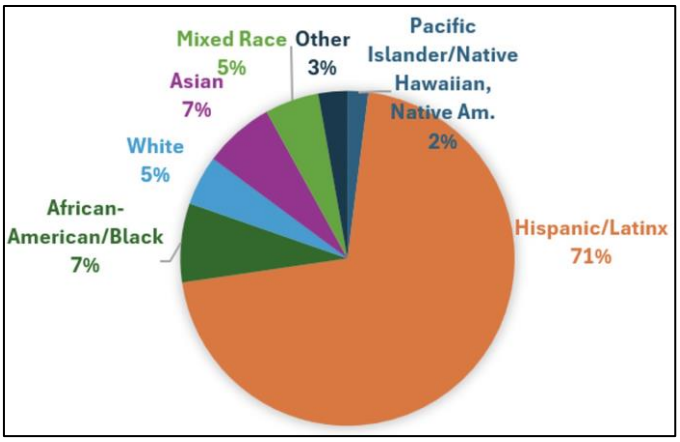

Fig. 3: Race/Ethnicity of LREU Participants Spring 2022 - Spring 2024

B. *Survey Results – Mentors*

The external evaluators collected survey data from student researchers in the LREU program and their faculty mentors. A pre-post survey was administered to students, focusing on their research, professional, and career outcomes, as well as their intentions to pursue graduate school. The mentor survey was administered at the end of the experience and focused on outcomes related to faculty mentoring skills and knowledge, and their observations of students' learning and development from the LREU experience. Data from the 2023-24 academic year are still being analyzed. This paper presents data from the 2022-23 academic year.

LREU mentors were asked about their participation in the CCLC professional development course. About ¾ of LREU mentors reported that they regularly attended learning community meetings, while 97% of mentors had attended at least one session. In the CCLC course, mentors discussed challenges and learned from each other while being introduced to resources and materials related to research mentoring. Nearly all mentors (95%) found value in the meetings, especially gaining resources and learning about best practices. Nearly all LREU mentors (85%) used CCLC resources, materials, workshops, or trainings in their research group.

From the course, some mentors, particularly those from R1 universities, expanded their conceptions of what undergraduates could accomplish in research and the value of working with undergraduates. When asked in an open-ended question how being an LREU mentor changed their conception of working with undergraduate researchers, the most common response was that they had learned how to approach mentoring undergraduate students and how their needs may vary from graduate students. Another common theme was that LREU mentors expanded their conceptions of the capabilities of undergraduates as they realized that undergraduates could make substantial contributions to research projects. Some mentors realized that all undergraduates could contribute to the research group, as demonstrated in this comment, "I thought that only graduating seniors were capable of doing sophisticated research, but this is not the case." Another mentor wrote, "Undergraduates are capable of designing interesting and impactful studies and going through the steps to run those studies. It was great to see such independence from the students.

LREU mentors also gained knowledge and skill in mentoring practices. Nearly all mentors displayed significant growth from the baseline to spring 2023 in their knowledge of effective research mentoring practices for underrepresented students ($t=2.436$, $df=57$, $p=.018$) with a moderate effect size ($d=0.424$). Mentors also displayed significant growth in their knowledge of how use the Affinity Research Group model in their research group ($t=6.365$, $df=57$, $p=.0001$), with a moderate effect size ($d=0.644$). The percentage of mentors who were knowledgeable or had extensive knowledge of effective practices to mentor diverse undergraduate researchers rose from 39% in the baseline to 86% in spring 2023. Almost all LREU mentors (93%) used evidence-based mentoring practices in their research group that have been shown to benefit students from underrepresented groups.

C. *Survey Results – Student Participatns*

In the first week of their participation in the local REU, students were directed to a pre-survey, and following the local REU, students were directed to a post LREU survey. Given rolling start dates and many REUs leading late into the summer, those eligible for analysis in the 2023 school year are presented in this draft, while authors intend to update the data when 2024 spring data is available (early June 2024). The pre and post matches were limited to the following factors:

- participants who consented to the pre and to the post,
- participants who completed at least one scale on both surveys.
- participants who used the same email address in both pre and post, and
- participants who completed the post survey by Jul 31, 2023.

There were 33 students who met all criteria.

Overall, post survey scores show strong agreement with statements related to student self-report of skills. Post scale means were between 5 (agree a little) and 7 (strongly agree), indicate the students had high regard for their research, problem solving, and LREU skills, as well as their peer and mentor support and graduate school preparation. Matched pair t-tests can provide specific information regarding the efficacy of an intervention, where participants describe their own perspectives on specific attitudinal constructs before participating in the intervention and after participating in the intervention. The use of scale mean scores (averaged scores across multiple items) bolsters claims, particularly when the constructed scales have face validity in measuring what one hopes the intervention will affect.

The following scales were tested for statistically significant change over the course of the Local REU:

- "Research skills," which targets high level research tasks like writing and conceptual understanding of literature,
- "Problem solving skills," which emphasizes deliberate practice, reflection, and communication of process,

- "Peer support," focusing on students' sense of emotional and academic camaraderie in the department,
- "Faculty support," regarding all faculty local REU students encounter in their major,
- "ARG/LREU development," targeting specific tasks related to the LREU experience, and
- "Graduate school support," related to information about and identification with a graduate student trajectory.

Table I shows the statistical comparisons indicating students achieved great gains in problem solving skills, LREU development, and graduate school support—all of these gains have effect sizes in the "high" category, nearing or surpassing one standard deviation of difference from pre to post. This indicates high practical, real-world significance of the findings.

TABLE I: STATISTICAL COMPARISONS

Scale means, Local REU Students	**1 = strongly disagree, 7 = strongly agree**		**Paired t-test results (n = 33 matched pairs)**	
	Pre-survey scores	**Post-survey scores**	**P-value (alpha value is 0.05)**	**Is the result significant?**
Research skills scale (5 items)	5.38	5.5	0.238	No, Effect size = 0.15
	(e.g., I can prepare a scientific poster for presentation to a technical audience, I can understand journal articles in my field.)			
Problem solving scale (8 items)	5.95	6.25	0.000	Yes, Effect size = 0.49
	(e.g., I reflect on my thinking before designing a solution, I communicate a problem and solution in multiple ways.)			
Peer support scale (6 items)	5.29	5.43	0.211	No, Effect size = 0.13
	(e.g., Other students take my comments or suggestions seriously in class, I like studying with other students in a group.)			
Faculty support scale (7 items)	6.04	6.18	0.103	No, Effect size = 0.19
	(e.g., My professors believe I have the capability to succeed in computing, I am comfortable meeting with my professors for academic help.)			
LREU development scale (10 items)	4.62	5.83	0.000	Yes, higher; effect size = 1.42
	(e.g., I know how to write a high-quality personal statement, I know the parts of a research paper in my area of interest.)			
Graduate School Preparation Scale (8 items)	4.68	5.43	0.000	Yes, higher; effect size = 0.85
	(e.g., I have at least one peer I can talk to about graduate school, I understand funding options for graduate school.)			

V. LIMITATIONS

A vital component of the model is the faculty mentors' deliberate inclusion of ARG practices in their LREU. To address the time committed to professional development, the team established the on-line CHALKS course with virtual touchpoints. A limitation is that a CHALKS ARG course requires periodic engagement from ARG experts to respond to questions and challenges that faculty face as they may be working with undergraduate students for the first time and/or adopting ARG practices. A solution is to increase the number of those with ARG expertise, i.e., seasoned faculty mentors who volunteer to respond to posts at least twice a month.

Although the LREU program aims to modify faculty mindsets around what it means to have an inclusive research group, it requires dedicated time for faculty to immerse themselves in deep reflection, which can be time intensive. Although evaluation findings indicate some faculty experiencing mindset shifts, the extent to which these shifts influence departmental climate will take time as there are other factors that need to be considered. In addition to the certificate of completion upon successful completion of the CHALKS ARG course, the LREU team will seek other mechanisms to incentivize faculty to invest time and effort, including working with administrators on rewards and recognition of faculty who take part in such programs.

VI. SUMMARY

The LREU model was conceptualized to address the sparse number of domestic students, particularly Hispanics and other minoritized populations, who seek and complete graduate degrees. While studies have shown the importance of REU sites as described in the Background Section, traditional REU efforts are residential summer experiences wherein participating students move to another institution. Many Hispanic students, especially those who are first-generation college going and those who have caregiving responsibilities, are less likely to apply for REUs.

The development of characteristic research, technical, and professional skills (e.g., networking, communication, and teamwork) are crucial for computing students. The CAHSI LREU program provides students with the opportunities to develop and practice such skills through poster presentations and elevator talks with feedback and constructive critique. Further, the distinguishing aspects of the LREU model is that its focuses on the deliberative development of skills needed to succeed in research; faculty coaching on the proven Affinity Research Group practices; and the learning community established for faculty to share experiences and practices, as well as to learn from each other. Students are supported in the LREU environment through a match process that aligns their interests with a mentor, a research plan that outlines their research project and its significance, and a research journal in which they record what they have learned and identify areas for their growth and development as researchers. Reflection is integral to both faculty and student growth.

Because CAHSI is a network of almost 80 HSIs operating with a collective impact framework, there is an opportunity among the LREU participants to cultivate a growth mindset through deliberate practice and reflection from personal, professional, social, and academic perspectives. Through the CCLC and discussion groups, faculty across the CAHSI network of almost 80 HSIs, faculty are building a network of researchers. This along with the requirement to prepare and submit a research poster to the Great Minds in STEM conference provides opportunities to collaborate and build connections for students to move into graduate programs.

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