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# BOARD # 296: Research Experiences for Undergraduate Students in Computational Sciences and Engineering through an NSF Funded REU Site

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# Research Experiences for Undergraduate Students in Computational Sciences and Engineering through an NSF-Funded REU Site

## REU Program Description

The University of Houston-Downtown (UHD), with support from the National Science Foundation (NSF) under the Computing and Information Science and Engineering (CISE) division, administers a Research Experiences for Undergraduates (REU) site focused on Computational Sciences and Engineering. This program provides research opportunities to eight undergraduate students annually, spanning a three-year period. The positive impact of such undergraduate research on student development and academic growth has been pointed out by several studies[1]-[3].

The Houston-Galveston-Gulf Coast region, a hub for major industries such as petrochemicals, healthcare, and aerospace, offers a unique context for students to engage in research that addresses significant societal challenges, while exploring cutting-edge methodologies in computational sciences and engineering.

The REU program consists of an intensive 8-week summer research experience, during which students collaborate with faculty mentors on projects that tackle key issues in cybersecurity, data analytics, machine learning, bioinformatics, and structural engineering. Following the summer experience, year-long mentoring is provided to ensure continued academic and professional development, as students apply the skills they have acquired. The program encourages participants to disseminate their research findings through presentations and publications, fostering interaction with the broader scientific community.

The key objectives of the REU site are as follows: (1) increase students' interest in pursuing STEM careers; (2) enhance students' confidence in their STEM abilities; (3) cultivate interest in computational sciences and engineering fields; (4) encourage aspirations for graduate studies; (5) promote continuous self-improvement; (6) improve academic performance in STEM disciplines; (7) strengthen career-related skills, such as communication; and (8) motivate students to graduate with STEM degrees.

## REU Research Projects

The summer 2024 research projects encompassed a wide array of topics spanning computer science, cybersecurity, and engineering. These included: Network Analysis of 3D Genome Organization, Privacy-Preserving Sharing of Correlated Data, Attentiveness Detection for Autonomous Vehicle Drivers, Process Automation – Design of Feedback Controllers, Human Engagement Analysis for Virtual Meetings, Design of Floating Barriers, and Effects of Polydispersity on Laminar Flame Speed for Solid/Air Explosions. The unifying theme of these projects was the engagement of a diverse student group in solving complex computational and engineering challenges using methods from cybersecurity, data analytics, machine learning, human-centered computing, bioinformatics, process automation, structural engineering, and data-driven safety management.

Project assignments were made collaboratively with students. As part of the application process, students were asked to prioritize their project preferences. During the program's initial meeting, time was allocated to discuss student interests, faculty expectations, and to finalize project assignments in a collaborative manner.

**Targeted Student Participants**

This program specifically supports women and underrepresented students, with a goal of ensuring that at least fifty percent of participants are drawn from these groups. Recruitment efforts are directed at local community colleges, such as Houston Community College and Texas Southern University, with special outreach to include first-generation college students and military veterans. Participants range from rising sophomores to seniors, encompassing a broad spectrum of academic backgrounds and career interests.

During the first year of the program (Summer 2024), a total of 321 applicants were received, predominantly from universities outside Texas and the Houston area. The initial cohort included an equal distribution of male and female students, as well as participants from both UHD and non-UHD institutions. However, due to the absence of on-campus dormitory facilities, several non-UHD applicants declined their offers, resulting in a final cohort of seven students, two of whom were female and five male.

**Project Evaluation**

The evaluation of the REU site was conducted by the Center for Educational Research and Practice (CERP) [4] for several reasons: (1) the evaluation framework is approved by NSF CISE, (2) the evaluation is provided at no additional cost, maximizing resources for student engagement, and (3) it offers comparative insights with other REU sites, facilitating the identification of areas for program improvement.

The evaluation measures various key areas, including the likelihood of students pursuing graduate studies, acquisition of skills, effectiveness of mentorship, and overall program satisfaction. Student participation in the project evaluation was 100%.

**Likelihood of Enrolling in a Doctoral Program**

A primary objective of the REU program is to increase students' interest in pursuing advanced graduate studies. Data analysis reveals a significant increase in the likelihood of students pursuing doctoral studies in computing following their participation in the program. The likelihood of enrolling in a doctoral program increased from a mean value of 2.71 (pre-REU) to 3.86 (post-REU), suggesting that the program effectively enhanced participants' aspirations for further academic achievement.

**Skills Acquired**

Participants in the UHD REU site demonstrated greater knowledge acquisition in key areas compared to their peers in other REU programs. For instance, students reported significantly greater familiarity with the graduate school application process, averaging a rating of 4.0, compared to 2.6 in the comparison group. Additionally, students showed a stronger

understanding of the research career pathway, with an average rating of 4.57, surpassing the comparison group's average of 3.43. These findings underscore the program's effectiveness in preparing students for future academic and research careers.

Figures 1 and 2 illustrate the knowledge gained by participants regarding the graduate school application process and the experience of being a graduate student, respectively.

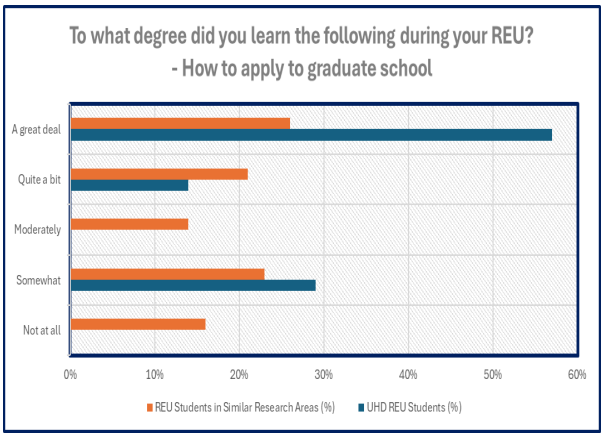


**Fig. 1:** Knowledge gained during the REU How to apply to graduate school

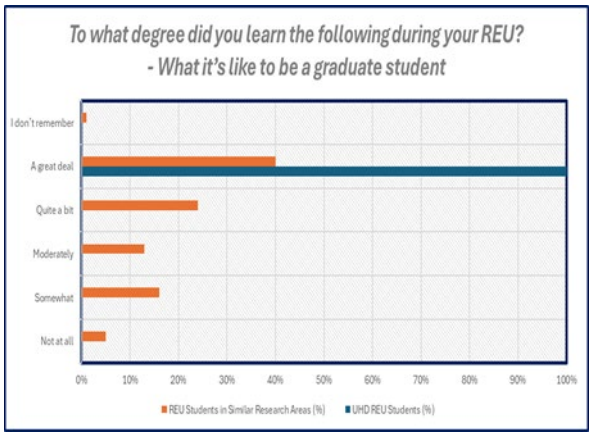


**Fig. 2:** Knowledge gained during the REU What it is like to be a graduate student

Although our university offers only master's level programs and does not have PhD offerings, we invited faculty and graduate students from local R-1 universities to discuss graduate school, the expectations for graduate studies, and strategies for success as a graduate student. The project evaluation showed that participants gained valuable insights into graduate studies and demonstrated a heightened interest in pursuing graduate studies.

In addition to gaining insights into graduate school, participants attended several workshops organized by UHD's Career and Development Center. During these sessions, students learned how to write an effective resume and prepare for job interviews. The effectiveness of these workshops is reflected in the data presented in Figure 3.

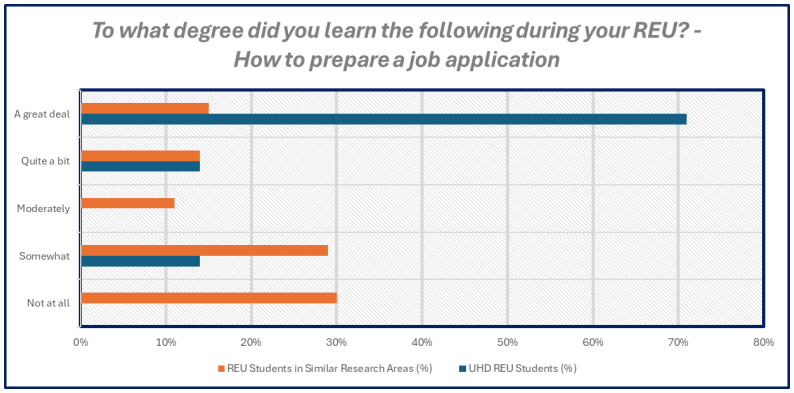


**Fig. 3:** Knowledge gained during the REU – How to prepare for a job application

**Program Mentorship**

Given that UHD offers only master's level programs and does not have PhD offerings, students benefited significantly from direct mentorship with faculty members. These daily interactions fostered strong mentoring relationships that extended beyond the summer program, providing ongoing support and guidance. Figures 4 and 5 demonstrate high participant ratings regarding the effectiveness of faculty mentorship, highlighting positive assessments of mentor accessibility, professional integrity, content expertise, and supportive guidance.

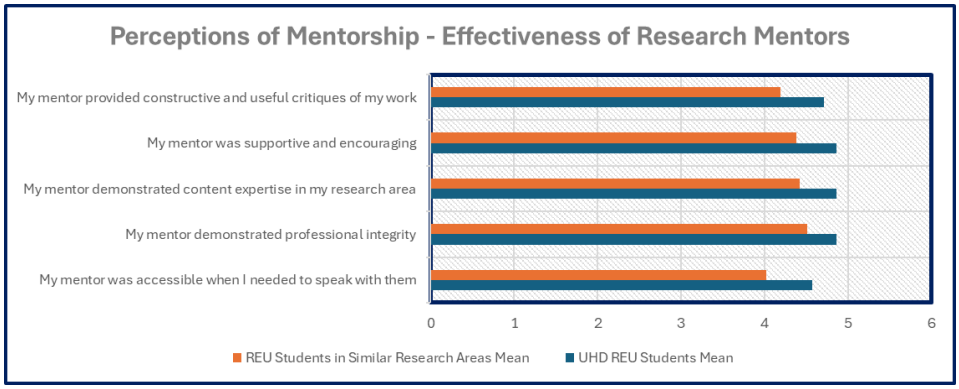


Fig. 4: Perceptions of Mentorship – Effectiveness of Research Mentors

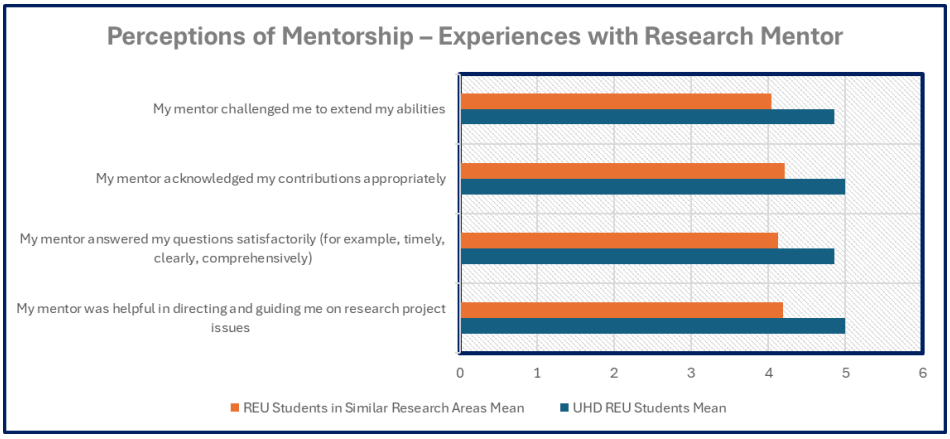


Fig. 5: Perceptions of Mentorship – Experiences with Research Mentors

**Program Satisfaction**

Participant satisfaction was notably high, with students expressing contentment with both the overall REU experience and the resources provided for their research, reflected in average ratings of 4.71 and 4.57, respectively. Students not only gained technical expertise but also acquired a deeper understanding of academic and professional pathways within STEM fields. The program's mentorship and research components contributed significantly to its success, effectively preparing students for graduate school and careers in STEM. Positive feedback from participants regarding their knowledge, skills, and overall satisfaction indicates that the program successfully met its objectives.

To foster a cohesive program environment and ensure that all participants felt welcome and valued, various activities were organized throughout the day to encourage student interaction. Shared activities, such as light breakfasts, progress reports, and daily planning, enhanced engagement among participants. Figure 6 illustrates student perceptions regarding the quality of interactions within the research group.

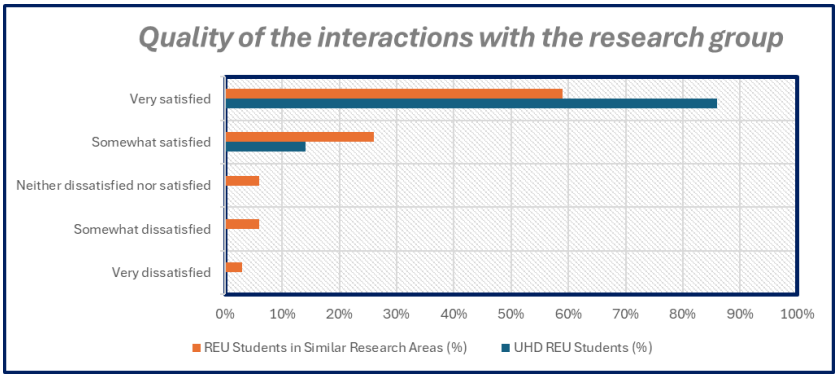


**Fig. 6:** Perceptions of quality of the interactions with the research group

## Conclusion

The first cohort of participants in the REU site at the University of Houston-Downtown demonstrated significant progress toward achieving the program's goals. Through structured research experiences, faculty mentorship, and community engagement, the program provided meaningful opportunities for students from underrepresented backgrounds to excel in computational sciences and engineering. The success of the program in improving academic performance, and interest in advanced studies and STEM careers highlights its potential to contribute to the broader goal of strengthening national competitiveness in science and technology.

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