REU: A Collaborative and Interdisciplinary Model to Enhance Undergraduate Research Experiences in the Gulf Coast Region

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Abstract
This paper presents an overview of a 10-week summer Research Experiences for Undergraduates (REU) program focused on addressing microplastics pollution in the Gulf Coast region. The team using a mixed-methods approach, assessed the development of research skills and professional identity in a cohort of 10 undergraduate students (N=10). Pre- and post-program surveys, complemented by focus groups, indicate statistically notable gains in research confidence (mean increase +0.33), particularly in interpreting scientific findings (+0.55) and laboratory tool usage (+0.42). Qualitative data reveals that while participants strengthened their identity as researchers (+0.50), immediate intentions to pursue graduate school slightly declined (-0.56), reflecting a more realistic understanding of the research career path rather than disengagement. These findings suggest that place-based, interdisciplinary REU models effectively cultivate technical competencies and professional role understanding.

1. Introduction

With the large-scale production of plastic products and inadequate waste management systems, plastic pollution has become one of the most severe environmental challenges nowadays. Plastic gradually fragments through physical, chemical, and biological processes in the environment, forming microplastics (MPs) smaller than 5 mm in diameter [1]. These particles exhibit high persistence and are widely present in natural and engineered water systems, raising growing concerns about their potential risks to ecosystems and human health [2]. The U.S. Gulf Coast region represents a particularly significant yet relatively understudied area in MPs research. With substantial industrial activity, dense population centers, and numerous wastewater treatment facilities, this region serves as a major pathway for MPs entering aquatic environments. [3]. Studies confirm the widespread presence of MPs in the region's seawater, sediments, and organisms, underscoring the need for systematic detection, monitoring, and control of MPs [4], [5]. Addressing MPs pollution requires not only technological advancements in fields like environmental engineering and materials science but also cultivating talent capable of conducting interdisciplinary research on real-world, complex environmental challenges.

Undergraduate research experiences are widely recognized as a high-impact educational practice that effectively enhances students' research capabilities, scientific self-identity, and commitment to pursuing careers in STEM fields. NSF-funded Research Experiences for Undergraduates (REU) programs play a vital role in broadening access to research opportunities, particularly for students from institutions with limited research resources and underrepresented backgrounds [6]. In response, the University of South Alabama established an NSF REU site titled "Interdisciplinary Research to Address MPs in Gulf Coast Region" [7]. This site integrates microplastic detection, measurement, monitoring, removal, and reuse into a unified research framework. Through structured cohort activities and mentored research training, it supports the development of undergraduate research capabilities and career development. This paper systematically reports the implementation and evaluation results of the 2025 cohort program, aiming to provide evidence for interdisciplinary REU program practices in engineering education.

2. Program Description

2.1 Recruitment and Selection

This REU project conducted nationwide recruitment targeting undergraduate students interested in environmental sustainability, engineering research, and MPs-related topics, which is open to any majors. Recruitment channels included national REU platforms, professional society and university mailing lists and flyers. We recruited a diverse cohort of 10 undergraduate students (N=10) from over 200 applicants nationwide via the NSF Education and Training Application (ETAP) system. Selection prioritized students from institutions with limited research resources, focusing on motivation and alignment with project goals rather than prior experience.

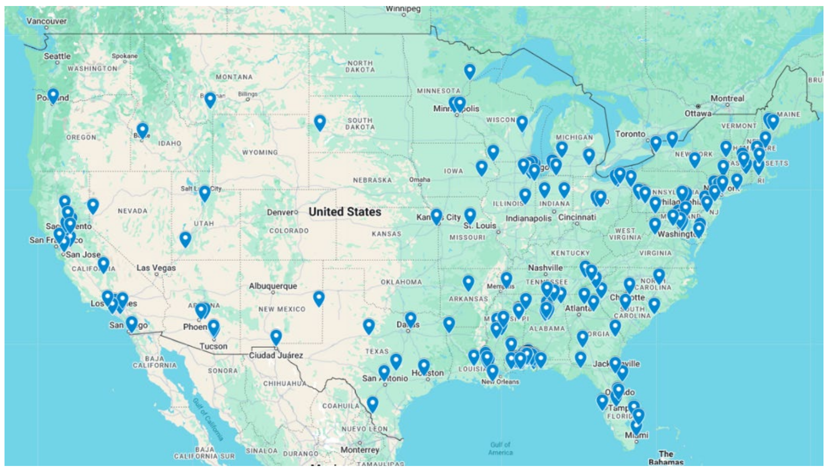

Figure 1. Map of Applicants Distribution in 2025.

2.2 Program Design and Implementation

This REU site was implemented using a collaborative and interdisciplinary program model designed to integrate MPs research, mentoring, and cohort-based learning within a unified educational framework. The model brings together faculty and graduate mentors from multiple disciplines, including environmental engineering, materials science, sensing technologies, and marine science, to engage undergraduate students in addressing MPs in interconnected natural and engineered water systems. Rather than treating projects as isolated laboratory experiences, the program emphasizes cross-project coordination, shared learning, and systems-level understanding. The program spans ten weeks and follows a full-time, on-campus summer research format. It is designed to immerse students in MPs-related research while providing structured academic and professional support through coordinated research activities, mentoring mechanisms, and cohort engagement. **Table 1** presents the schedule of cohort-based activities implemented across the ten-week REU program, illustrating how research, professional development, and community-building components were integrated throughout the summer. Details of each week's activity can be found at the website [7].

Table 1. 10-Week REU Program Cohort Activities

Phase	Week	Cohort Activity
1	1st week	Welcome, Kick-Off Event
	2nd week	Learning Modules: Literature Review and Writing Skills
2	3rd week	Field Trip to Osprey Initiative LLC and Mobile County Recycling Center
	4th week	Field Trip to Wastewater Treatment Facility, and Aquarium, Dauphin Island
	5th week	Field Trip to KW Plastics, and Troy University
	6th week	Mid-summer Presentation, Glass Studio "Making Your Arts Artifacts"
	7th week	Industrial Webinar: Recycling of plastics packaging: climate, policy, & design
3	8th week	Technical Writing & History Museum of Mobile Visit
	9th week	Research Webinar "Repurpose plastic mulch waste from strawberry farmlands to asphalt pavements", Invited Breakfast to Interact with Industries
	10th week	Celebration, Final Presentation & Research Showcase Symposium

2.3 Program Evaluation

Project evaluation is systematically embedded within the overall design of the REU program to assess the alignment between program objectives and student learning experiences, providing a basis for continuous improvement. The evaluation focuses on three key areas: (1) development of students' research skills; (2) researchers' identity and sense of belonging; (3) the effectiveness of the mentor system and program structure in supporting student learning. The evaluation utilizes multi-source data, including pre- and post-project student surveys, post-project student focus group discussions, and semi-structured interviews with faculty mentors. Data collection timelines are coordinated with the project implementation schedule to comprehensively capture student progress without disrupting research activities. Evaluation outcomes serve not only to summarize program effectiveness but also to inform optimizations for future cohorts.

3. Results and Discussions

This section presents and interprets the evaluation results of the 2025 REU cohort in relation to the program goals. Quantitative findings from pre- and post-program surveys are integrated with qualitative evidence from open-ended survey responses, a student focus group, and faculty mentor interviews. Results are organized around three areas: development of research skills, researcher identity and professional awareness, and the effectiveness of mentoring and program structures. Given the cohort size (N=10), descriptive statistics (means and mean changes) were prioritized over hypothesis testing to identify trends in student growth.

3.1 Researcher Identity and Professional Awareness

One aspect is to understand undergraduate students' research identity and professional awareness through REU programs, as this is often their first-time opportunity to experience such intensive, structured research exposure. **Table 2** summarizes students' pre- and post-program survey responses related to researcher identity, sense of belonging, and career-related perceptions. The table reports mean scores for each item before and after participation in the REU program, along with the corresponding changes over the ten-week period.

Table 2. Pre- to Post-Survey Changes in Identity and Career Aspiration

Identity and Career Aspiration	Pre	Post	Change
I see myself as a researcher.	4.00	4.50	+0.50
I feel a sense of belonging in the research community.	3.82	4.13	+0.31
I am recognized by others (e.g., mentors, peers) as someone who is good	3.73	4.00	+0.27
I enjoy engaging in research practices.	4.27	4.25	-0.02
I feel that I can make a meaningful contribution to the field.	4.36	4.63	+0.26
I intend to apply to graduate school in a STEM discipline.	4.18	3.63	-0.56
I am considering a career in scientific research.	3.82	3.75	-0.07
I believe I have the skills necessary to succeed in graduate school.	4.00	4.13	+0.13
I understand the steps required to apply to graduate programs.	3.18	3.38	+0.19
I am interested in pursuing a career related to environmental science	3.55	3.50	-0.05

Students' self-perceptions moved in a positive direction overall (from 3.89 to 3.99). The clearest gains were in seeing themselves as researchers (+0.50), sense of belonging (+0.31), feeling recognized by others (+0.27), belief they can contribute (+0.26), and knowing the steps to apply to graduate school (+0.19). Enjoyment of research was stable with a trivial dip. Several items slightly decreased, particularly intention to apply to graduate school (−0.56) and considering a research career (−0.07). In short, the program strengthened identity and belonging and clarified the graduate pathway, while some students recalibrated their immediate plans for graduate school or pursuing research. Concurrently, students' intentions to pursue graduate studies or research careers showed a slight decline. Qualitative data suggests this shift more likely reflects a more rational assessment of future paths after gaining deeper insights into the realities of research work, rather than a negative attitude toward research itself.

3.2 Development of Research Skills

Drawing on experiential learning theory [8], which posits that reflection deepens cognitive understanding, this study also examines how students' self-assessment of their research skills influences the development of their professional confidence. **Table 3** presents students' pre- and post-program survey responses measuring confidence across multiple research skill areas. Mean scores are reported for each item, along with the corresponding changes.

Table 3. Pre- to Post-Survey Changes in Participants' Confidence

Confidence in Research Skills	Pre	Post	Change
Identify a research question or problem	3.64	3.88	+0.24
Conduct a literature review using scientific databases	3.27	3.63	+0.35
Formulate a testable hypothesis	3.64	4.00	+0.36
Design an experiment or study	3.46	3.50	+0.05
Collect and analyze data	3.73	4.00	+0.27
Use laboratory tools and techniques relevant to environmental science	3.46	3.88	+0.42
Interpret scientific findings and draw conclusions	3.46	4.00	+0.55
Communicate your research in writing (e.g., papers, posters)	3.46	3.88	+0.42
Present your research verbally to others	3.09	3.38	+0.28
Work independently on a research task	3.46	3.75	+0.30

As shown in **Table 3**, students' overall confidence in research skills increased from 3.46 to 3.79 (+0.33). The largest gains were observed in interpreting scientific findings and drawing conclusions (+0.55), using laboratory tools and techniques (+0.42), was directly reflected in focus group discussions. Participants moved beyond basic familiarity to technical proficiency, describing how they learned to operate laboratory instruments such as fluorescence spectrophotometers and independently perform dilution calculations, communicating research in writing (+0.42). These areas closely align with the program's emphasis on hands-on laboratory work, data interpretation, and iterative writing and presentation.

Moderate improvements were also observed in literature review, hypothesis formulation, data collection and analysis, oral presentation, and independent work. In contrast, confidence in experimental design increased only slightly (+0.05), indicating more limited growth in this area. Feedback from both students and mentors suggests that this constraint was closely tied to the short duration of the program and the fact that projects were embedded within existing faculty research. This pattern highlights experimental design as an important target for enhanced scaffolding in future cohorts.

3.3 Mentoring, Cohort Experience, and Program Structures

Qualitative data from open-ended survey questions, the student focus group, and faculty mentor interviews provide detailed insight into how mentoring and cohort structures shaped students' experiences in the REU program.

3.3.1 Student Perspectives on Mentoring and Learning

Before the program, students described researchers as evidence-based problem solvers who collect and analyze data, draw defensible conclusions, and communicate findings, often highlighting traits such as curiosity, persistence, and collaboration. They also expressed strong expectations for mentoring, particularly in hands-on laboratory and field training, data analysis, and deeper domain knowledge in environmental engineering, materials science, and MPs, along with communication and career guidance.

After the program, students consistently reported tangible growth in both technical and professional skills. Many described learning to operate laboratory instruments such as fluorescence spectrophotometers, perform dilution calculations, and manage larger datasets in Excel. Students also emphasized improved data analysis and interpretation, stronger scientific writing, and greater confidence in explaining their work to non-experts. Several participants noted that they developed a clearer understanding of the research process itself, including how to move from literature review to hypothesis formulation, experimental methods, and data analysis. Field trips and interdisciplinary collaborations were frequently cited as making the research feel more authentic and meaningful.

3.3.2 Mentoring Relationships and Cohorts Support

Students characterized faculty and graduate mentors as accessible and consistent sources of guidance. Mentors were praised for breaking down complex procedures, coaching students on laboratory techniques and poster development, and preparing them to answer questions about their research. Regular check-ins and an open, supportive climate made it easier for students to seek help when needed. Peer collaboration within the cohort also played an important role, with many students describing how problems were worked out collaboratively at the bench before or alongside mentor consultations. Faculty mentors confirmed these patterns. They observed growth across the full research pipeline, including laboratory methods, data handling, analysis and interpretation, and communication through writing, posters, and question-and-answer sessions. Mentors also noted increasing student independence and ownership over time, with students becoming more capable of explaining why specific methods were chosen and defending their research decisions.

3.3.3 Program Challenges and Areas for Improvement

Both students and mentors identified similar challenges. Time and scheduling constraints were the most common, particularly as data collection intensified and presentation deadlines approached. Occasional equipment or access limitations also slowed planned work. Students requested clearer early-stage planning, including meetings with advisors to establish week-by-week research goals, as well as more seminars, cross-department activities, and additional time for poster and presentation preparation. Mentors similarly recommended short-horizon planning with explicit weekly goals, expanded orientation and methods training, and structured checkpoints for poster development and public communication. Overall, the qualitative results indicate that the REU's layered mentoring, peer partnerships, and interdisciplinary cohort structure supported strong growth in research skills, confidence, and researcher identity. At the same time, the findings highlight the importance of early planning, targeted support for experimental design, and improved logistics to further strengthen future program implementation.

4. Conclusions

This paper evaluated the outcomes of a ten-week, NSF-funded REU site focused on interdisciplinary MPs research. Mixed-methods data (N=10) revealed that hands-on laboratory and field experiences drove significant gains in research confidence, specifically in data interpretation and tool usage, and strengthened researcher identity. Concurrently, a slight decline in immediate graduate school intentions reflected a shift toward informed, realistic career assessment rather than disengagement. While mentoring and cohort support were critical to student independence, feedback regarding time constraints highlights the need for improved scaffolding in experimental design for future cohorts. Ultimately, this work demonstrates how place-based, interdisciplinary models effectively prepare undergraduates for addressing complex environmental challenges.

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References

[1] H. Shi *et al.*, "Small plastic fragments: A bridge between large plastic debris and micro- & nano-plastics," *TrAC Trends in Analytical Chemistry*, vol. 168, p. 117308, Nov. 2023.

[2] Y. Liu, M. Tourbin, S. Lachaize, and P. Guiraud, "Nanoparticles in wastewaters: Hazards, fate and remediation," *Powder Technol*, vol. 255, pp. 149–156, Mar. 2014.

[3] J. K. Grace, E. Duran, M. A. Ottinger, M. S. Woodrey, and T. J. Maness, "Microplastics in the Gulf of Mexico: A Bird's Eye View," *Sustainability 2022, Vol. 14, Page 7849*, vol. 14, no. 13, p. 7849, Jun. 2022.

[4] S. Monira, R. Roychand, F. I. Hai, M. Bhuiyan, B. R. Dhar, and B. K. Pramanik, "Nano and microplastics occurrence in wastewater treatment plants: A comprehensive understanding of microplastics fragmentation and their removal," *Chemosphere*, vol. 334, p. 139011, Sep. 2023.

[5] V. G. Le *et al.*, "A comprehensive review of micro- and nano-plastics in the atmosphere: Occurrence, fate, toxicity, and strategies for risk reduction," *Science of The Total Environment*, vol. 904, p. 166649, Dec. 2023.

[6] D. Lopatto, "Undergraduate research experiences support science career decisions and active learning," *CBE Life Sci Educ*, vol. 6, no. 4, pp. 297–306, Dec. 2007.

[7] University of South Alabama, "NSF REU Site at University of South Alabama: Interdisciplinary Research to Address Microplastics in Gulf Coast Region," Available https://sites.google.com/southalabama.edu/nsfreu/home. [Accessed Feb. 6, 2026]

[8] S. Wu, M. Kang, J. Cleary, L. LaCross, and P. Neupane, "Case study of integrating standards, codes, and specifications into engineering curricula: various pathways to professional readiness," ASEE Annual Conference & Exposition Conference Proceeding, Montreal, Canada, 2025.