Board 31: Research Experiences and Mentoring in Separations

Mr. Thomas McKean, University of Arkansas

Thomas McKean III is a Ph.D. candidate in the Materials Science and Engineering program and the Ralph E. Martin Department of Chemical Engineering at the University of Arkansas working under Dr. Ranil Wickramasinghe. Thomas holds his MS from the University of Arkansas in Microelectronics Photonics and BS in Chemical Engineering from Syracuse University. He has extensive experience mentoring new graduate students and tutoring undergraduate chemistry students. He hopes to continue to help young researchers discover their passion for STEM while finishing his PhD and after.

Jorge Almodovar, University of Arkansas

Jorge Almodovar is an associate professor at the Ralph E. Martin Department of Chemical Engineering at the University of Arkansas. He holds the Ralph E. Martin Professorship in Chemical Engineering. He also serves as the director for the Arkansas LSAMP Bridge-to-the-Doctorate program. He earned his B.S. in Chemical Engineering from Iowa State University and his PhD in Chemical Engineering from Colorado State University (CSU). At CSU he investigated the delivery and stability of growth factors using polysaccharide-based biomaterials. After CSU, he worked as a Post-Doctoral Fellow at the Grenoble Institute of Technology in Grenoble, France investigating the formation of gradients on polyelectrolyte multilayer films, funded by the Whitaker International Program. Prior to joining Arkansas, he was a faculty member at the Chemical Engineering Department at the University of Puerto Rico Mayaguez where he began an active research group. His research interests include extracellular matrix mimetic biomaterials, cell-material interactions, and biomaterials as therapeutics. His research focus is on the engineering of biomimetic materials—inspired by the native cell environment—for fundamental studies, cell manufacturing, tissue engineering, therapeutics, drug delivery and regenerative medicine. His research team also focuses on developing electrospun materials for applications in healthcare and water treatment. He is an author of 35 peer-reviewed research articles, 2 patents, 5 book chapters, and an editor for one textbook.

Dr. Ranil Wickramasinghe P.E., University of Arkansas

Undergraduate Research Experiences and Mentoring in Separations

Ralph E Martin Department of Chemical Engineering, University of Arkansas, Fayetteville, AR 72703

Abstract

A Research Experiences and Mentoring (REM) program funded by the National Science Foundation (NSF) was developed to provide summer research and mentoring opportunities to underrepresented minority (URM) and non-traditional community college students. The goal of the program was to introduce URM and non-traditional students to STEM research opportunities they are not traditionally exposed to through the Membrane Science and Technology (MAST) NSF Industry/University Collaborative Research Center (I/UCRC). The NSF-REM initiative also seeks to provide post-program mentoring not found in typical Research Experience for Undergraduates (REU) programs. The program mirrored a traditional REU 10-week summer experience plus additional professional development mentoring during the following academic year. During the summer, the community college students in the REM program were paired with students from a parallel REU program to work closely together under the same faculty member. Constant collaboration between the students allowed for peer mentoring as the students developed their ability to conduct complex experiments and communicate their results. Post summer program mentoring sessions consisted of speakers from both academia and industry, informal career and research guidance, and a trip to a national conference in Washington D.C. where the students presented their summer research at a poster presentation. Both REM and REU programs along with the faculty advisors contained strong representation of URM groups. All seven REM students were from URM groups, including five women. This diverse community and heavy interaction between the REM and REU programs fostered the self-efficacy of students in both programs. Overall, great improvement in the technical knowledge, ability to conduct and communicate a research project, and desire to pursue a career in STEM was observed in all students over the course of the both the 10-week summer program and post-program mentoring. This was particularly evident among those that presented their work at the national conference, including one student who won second place for best poster. Feedback from mentoring sessions indicated students and their families were more knowledgeable about and open to different types of STEM career paths, particularly research and graduate school. Of the seven students, three have joined new research groups or are continuing to actively pursue research, and three others will transfer to the University of Arkansas following completion of their associate degrees.

Introduction

The Ralph E Martin Department of Chemical Engineering at the University of Arkansas has hosted a National Science Foundation Research Experience for Undergraduates (REU) Site for over 4 years. The REU Site is titled ‘From Bench to Market: Engineering Systems for High Efficiency Separations’. The REU Site has been particularly successful in recruiting students from underrepresented minority (URM) groups in science and engineering. Specifically, from 2017-2021 (four total summers with no program in 2020 due to the pandemic) the participants were 44% female and 53% from underrepresented racial and/or ethnic groups.

In 2022, not only did the REU Site host 7 undergraduate students from research institutions around the country, a parallel National Science Foundation Research Experiences and Mentoring (REM) program hosted 7 local students attending Northwest Arkansas Community College (NWACC). The NSF-REM program aims to "enhance the academic and career trajectories of participants who may not otherwise become engaged in a research project," [1]. The program's structure leverages the fact that the students are local to preserve quality mentor-mentee relationships that often fade once students in traditional REU programs return to their home institution. Non-traditional community college students and URM students are much less likely to pursue research opportunities in STEM areas than students at research intensive universities. These students often lack successful peers or representation that demonstrates to them that STEM research is an opportunity that fits their unique circumstances. There is a great need to increase the exposure of community college and URM students to quality research experiences in STEM. In doing so, it will be demonstrated to these students that building the skills to be successful in a STEM career is possible while meeting obligations faced by non-traditional students. The program will also connect URM and non-traditional students with representation and quality academic, industry, and peer mentors within STEM. Further, it was also common among the community college students interested in STEM to have the goal of transferring to the University of Arkansas while lacking meaningful experiences that strengthen their application. The following goals were set for the program to address these needs:

- to provide quality research experiences to URM and non-traditional community college students who otherwise would most likely not participate in such an experience;
- to provide insights into several different STEM career paths through professional mentoring sessions with successful URM STEM professionals belonging to the MAST center and REM program networks;
- to assist with and strengthen their transfer application to the University of Arkansas or similar four-year institution, and ultimately their desire to pursue a career in STEM.

It was hypothesized that by pairing the URM community college students with REU students in the same laboratory, the frequent interactions with their REU counterparts and faculty/graduate mentors would foster a community within the program that will lead to increased self-efficacy in STEM research among the URM and non-traditional students. Additionally, that quality mentoring will expose the URM community college students to people, knowledge and experiences in STEM careers that they would otherwise not receive. Finally, a positive experience in the program would lead to further interest in STEM careers and transfer to a four-year institution, as well as bring more visibility and future participants to the MAST center and the REM efforts at the University of Arkansas.

Methods

Pre-Program Recruitment and Mentor Training

A crucial element toward the success of this program was the ability to recruit and connect with URM community college students that would be quality candidates. A connection to the faculty at NWACC proved to be essential to identify the prospective students. The ideal candidate was someone who engaged with and was successful in an introductory STEM course at NWACC but

was not aware of career paths outside of traditional STEM careers such as nursing. The NWACC professors were able to form initial relationships with the students that was necessary to connect the student with the program and encourage the student to participate. The NWACC faculty both held PhDs and were well-versed in research, allowing them to be extremely effective at identifying and fostering quality candidates. Outside of this connection with the faculty role models, a competitive stipend was also provided to allow the students to meet their obligations and act as a recruiting tool. Interested NWACC students used the same application system for the REM program as students applying to the concurrent REU program. Applicants with no prior research experience were given priority in an effort to reach the students who have little exposure to STEM. REM students were paired with REU students based on research interests and ongoing projects of faculty members selected to be advisors. Specific projects were decided on between the students and their advisor. It was suggested that the students work on different aspects of the project but not required.

Since mentoring is such a critical component of the structure of the program, mentor training provided by the national NSF-REM program leaders was included prior to the arrival of the students and repeated after the conclusion of the 10-week summer research experience. Sessions focused on addressing issues faced by URM groups and non-traditional students that hinder them from developing a sense of comfort within the lab and as a part of STEM in general. The NSF-REM initiative is designed to "train the trainers", and the training directly from the national leaders was only provided to the faculty and graduate student coordinators. The program coordinators were then tasked with using these principles to connect with the students and give them tools to maximize their relationship with their mentor. In the future, a more formal worksheet or workshop based on these principles may be designed for the students and their faculty/graduate student mentors.

Summer Research Program Structure

In addition to lab-specific orientation and training, the program managers held weekly research meetings to check in with the students during the 10-week summer research experience where the students were expected to be in labs full time. This time was designed to assess the students' weekly progress, provide a forum to practice presenting technical ideas, give feedback, answer questions, and communicate any upcoming events or deadlines. A major component of these meetings was a session for students to develop and present a "quad" slide summarizing their progress to date. Figure 1 provides sample quad slides created by the students. The graduate student coordinators presented the structure of the quad slide and provided a template for the students at the first meeting. The following research meetings offered students a forum to present their quad slide and receive feedback from their colleagues and the program managers. Half of the students presented each week, and as such the students were required to provide biweekly updates to their slides. The students practiced their final presentations during this time beginning three weeks before the final presentations.

The most significant organized event of the summer research experience involved the students and program managers travelling to chemical production companies in Longview, TX. This practical experience was particularly important to the goal of increasing the interest and awareness in STEM careers among the REM students. Program managers rented vehicles and drove the students to the sites. University of Arkansas alumni were heavily involved in selecting the companies to be

Figure 1 Example of Quad slides produced by students during the program

visited. Plant tours of Eastman Chemical Company [2] and Invista Plastics [3] were organized. The students were given presentations from company leaders discussing the products produced and the processes to produce them. Plant and laboratory tours were then provided by pertinent personnel. The companies were selected to provide views of two very different company styles, one much larger and more commodity based (Eastman) and one much more focused on research and product development (Invista). A reception was held following the tours to give the students additional networking opportunities with the alumni professionals.

The summer experience finished with the students reporting their results in both a final report and oral presentation. Reports varied in length between approximately 5 to 20 pages depending on the types of data collected. Final presentations were practiced and improved over the final three weeks

of the program. A presentation session open to the department and relatives was held on the final day of the program. The final task for the students was to complete a survey and give feedback on the program to the program managers and the overall REU/REM experience at the University of Arkansas. Questions pertaining to technical and non-technical improvements, knowledge of STEM careers and professional development, mentoring relationships, and overall confidence to pursue research and STEM were included. Students scored themselves to provide quantitative data as well as free response questions that provided additional context.

REM-Specific Post-Program Mentoring

At this point the REU program concluded, but a key component of the REM program was to maintain contact with the students and provide ongoing mentorship for at least the next academic year. At the beginning of the program's final week, a meeting was held with the REM students and the program managers to discuss the feedback from the REM students and plan future mentoring activities in the form of monthly meetings. Different types of professional development activities were proposed to the students such as job seeking skills (i.e., resume building and interviewing), transfer and graduate school information, presenters from industry, local industry visits, etc. The students and program managers both felt the industry presentations would be of most value. The students were interested in learning about more career paths in relevant industries and having the chance to ask the speakers about their journey to their position. Program managers desired to continue to connect the students with more URM mentors while facilitating the discussion to guide the presenter to include content relevant to mentoring. Speakers included representatives and alumni from the University of Arkansas in the University of Arkansas transfer department and companies within the MAST center network. Formal mentoring concluded with guidance for presenting a poster at the 2023 Emerging Researchers National (ERN) conference. A subsection of the ERN conference was designated specifically for REM, allowing the students to form an REM community and present within the community. For most of the students it was their first experience at a large national conference, and by combining the REM meeting with the ERN conference the students were able to experience a variety of conference settings in a single trip. A formal practice session was organized as a mentoring event the month prior to the conference. Funding for this conference was included in the REM grant.

Results

Representation and Peer Mentoring

The primary objectives of the REM program were to provide quality research experiences that increase the self-efficacy of URM and non-traditional college students to perform STEM research, to provide exposure to career opportunities and mentors from URM STEM professionals, and to aid NWACC students attempting to transfer to the University of Arkansas or similar research institution. Both the REU and REM programs contained a majority of students from URMs. Four of the seven REU students were underrepresented minorities (all women, one Hispanic). All REM students were underrepresented minorities, including five women, two Hispanic, and one African American. Faculty advisors were also from underrepresented minorities. Of the eight faculty advisors, three were women and two were Hispanic. One of the graduate student program managers was female as well. The diverse faculty and graduate provided strong connections with mentors from URM backgrounds similar to those of the REM students. Representation for URM

groups is critical to developing self-efficacy and community in careers with typically little representation. The backgrounds of the students were all represented among the mentors and efforts were made to pair students and mentors with similar backgrounds. The program coordinators monitored the relationship between student and advisor at weekly research meetings, particularly early on to maximize the short period of just ten weeks. Overall, the program constructed an extremely diverse community that emphasized inclusion and successfully brought together many different students and faculty from different backgrounds.

Peer mentoring was emphasized by pairing the REM students with an REU student from a traditional four-year university. All labs but two housed both an REU and REM student, even if they were not working together directly on the same project. In all cases but one the pair did work on the same project. Of the seven REU students, five were from R1 research universities. The REU students were able to provide insights into attending four-year university where research is more prevalent and studying STEM at such a university. Additionally, since the REM students were local and had vehicles, they were able to assist the REU students with the transition to living at the University of Arkansas for the summer. The quantity and quality of interactions between the students and the program managers clearly established a sense of community among both the REU and REM students. Student feedback from the final meeting with the REM students indicated that the partnership and associated peer mentoring helped their confidence and progress in lab as hoped. The students in pairs spoke to the benefits of having a partner, namely that having the person to discuss the project with helped their understanding tremendously. One REM student commented that having a partner, “made my experience easier and helped me communicate with peers that I wouldn't have otherwise.” This sentiment was shared among REU students working with an REM partner, and neither felt the difference in background created any discontent or tension between the two students. No negative feedback was received from any students working in pairs regarding working with a partner or their partner personally. It should be noted that the more senior REU students did end up working on their own, in part due to a difference of abilities and ability to contribute to project design. These students were still very willing to aid the other REU and REM students and felt that having a familiar colleague in lab was helpful to acclimating to the environment even if they weren’t working together directly.

Technical and Non-Technical Results of Summer Research Experience

Weekly meetings provided a forum to practice communicating research, receive feedback from peers and the program managers, and stay organized and on track provided that was very well received by the students. The students commented in the final feedback session that, “the weekly meetings were extremely helpful in organizing and understanding our project's progress. While a bit stressful at times it gave us a visual goal of what we were aiming for and what we've completed. It was also interesting to understand other people's projects and see their development.” The first meetings were crucial for the program managers to identify the progress the students had made integrating into the labs. Discussing the importance of an efficient start instilled a sense of urgency in the students from the beginning. Notably, there were two groups of students who had only had one meeting with their advisor over the first week and had not spent any time in laboratories. Knowing this helped the program managers assist the student and their advisor to coordinate

training and an efficient as possible start to the project. The first meeting was also key to provide formal instruction into the criteria by which the quad slide would be informally evaluated (i.e., is the appropriate information present in each location of the slide and is anything incomplete or missing that is necessary for a clear, mid-level explanation of their project's objectives, methods, and results). Feedback from the students specifically mentioned this session as helpful to understanding the framing of their projects and interpreting scientific literature by establishing connections between the format of the quad slide and the format of a STEM journal article. One commented, "The weekly meetings were helpful, especially in the beginning. I found the talks regarding poster presentations, how to write a cohesive paper with a good story, and presentation tips to be really helpful when we neared the end of the program. The REM program gave me a huge confidence boost in comprehending research papers, journals, and articles in a way that I can now explain new ideas and concepts to people who are not familiar with the topic after I have read about it."

The alternating presentation schedule between the REU and REM students gave the students the chance to observe many other presentations between subsequent updates. This format resulted in dramatic improvements in clarity of both oral delivery and slide design when reporting the complex components of their projects. Improvements were observed both week to week for the group as a whole and in each iteration of the individual presentations. One REM student even commented that the final presentation of her research was her first time giving any STEM presentation, and the presentation received excellent feedback from the program managers. This same improvement was observed for the final presentation over the practice sessions in the final three research meetings. The final week of presentations clearly incorporated feedback that was given to the presentations of the previous week. It is also likely the peer mentoring provided by working with a partner enhanced the quality of these presentations. The substantial improvement observed by the program managers and resoundingly positive feedback from the students provided evidence that these meetings greatly increased the self-efficacy of the REM students in particular.

Student feedback regarding the trip to Longview was also quite positive. The Eastman plant tour mainly focused on the scale of the plant. The tour consisted of driving around the plant being introduced to different petrochemical unit operations and processes. The time at Invista was spent discussing the business of technology development, many of the well-known consumer products Invista contributed to, and observing laboratory equipment much more closely than was possible at Eastman. The balance between the two catered well to the group. It was a near even split between the students that found the scale and environment of Eastman more appealing and those who preferred the laboratory environment of Invista. The students mentioned that even though the trip took place at the beginning of the program it was still refreshing to have the chance to leave the laboratory, and they felt renewed motivation to resume their research when they returned. It was also commented that more companies related to their specific backgrounds, such as pharmaceuticals and other applications falling closer to bio or mechanical engineering, may have been more relevant to this particular group's personal interests. Regardless, final meeting feedback showed the exposure to the professional industry environment was a strong positive influence on the desire of the REM students to enter STEM fields.

Figure 2 contains a collection of results obtained by the REU and REM students. Of the nine projects, four focused on technologies for water purification, three focused on techniques for protein separations, one investigated cell viability on specialized surface coatings, and one developed engineering education principles regarding the use of hydrogen. Each of these projects involved state-of-the-art techniques in the associated field of research, and while this was originally daunting to some of the students they ultimately embraced the technical components of their projects. One of the students mentioned this specifically, "I was very nervous about interacting with any developing research as I saw it completely out of my reach, but as time passed

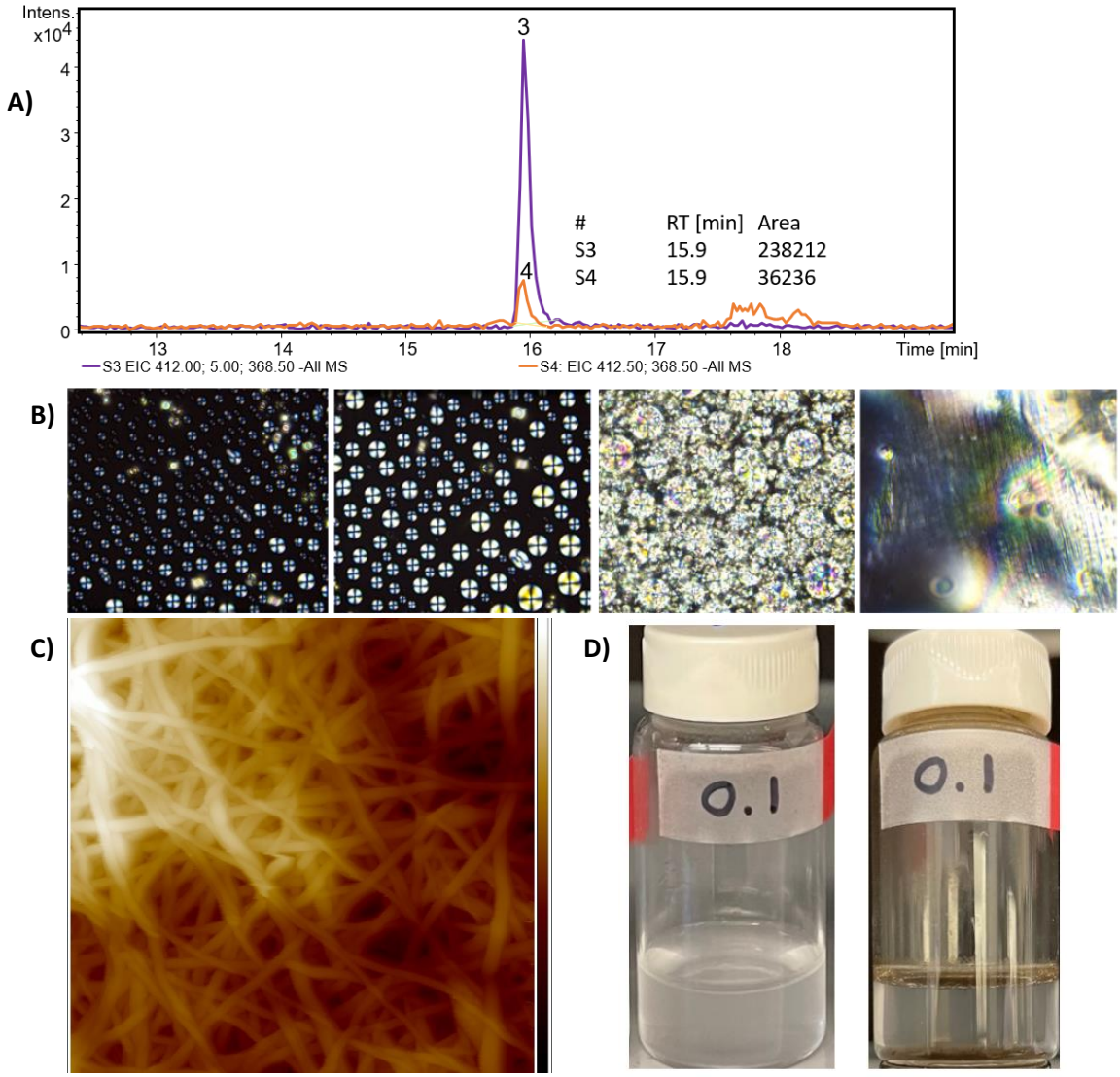

Figure 2. Collection of results obtained by both the REU and REM students. A) shows a liquid chromatography mass spectroscopy output reading the removal of perfluorooctanoic acid from drinking water. B) shows the transition of liquid crystal materials to the nematic phase under cooling. C) shows an atomic force microscopy of an electrospun nanofiber membrane. D) shows the removal of oil contaminants using modified magnetic nanoparticles.

understanding of my project became a lot stronger. Not to mention I was able to then communicate with a larger range of research information from my peers. I can definitely say I have a much firmer grasp of research and the ability to process unknown information in a correct manner." The projects largely represented the research interests of the faculty in the Ralph E. Martin Department of Chemical Engineering at the University of Arkansas and the MAST center. The program did not consider potential projects and the connection to chemical engineering in its design but did find the interdisciplinary and broad nature of chemical engineering research a strong fit for the goals of the program. Many of the students grew to be more interested in biotechnology, agriculture, etc., and commented that their exposure to chemical engineering research and industry helped them better visualize a career in their field of interest. This is still a positive outcome for the program based on the student's desire to pursue a career in STEM.

Post-Program Survey

The final component of the summer experience for both the REU and REM students was a survey assessing self-efficacy as a researcher and STEM professional, ability to communicate the technical and non-technical aspects of research, the quality of mentoring relationships formed during the program, and knowledge of different career paths in STEM. A collection of these results is presented in Table 1. Possibly the most notable finding from the results of this survey was the similarities in answers between the REU and REM students. Of the questions relevant to the goals of the program, only one question relating to a desire to work as an industrial engineer was statistically significantly different between the REU and REM students, with the REM students much more interested in working as an industrial engineer. Otherwise, the similarity in answers demonstrates the REM students were not hindered by their non-traditional status. This was further supported by the results of the self-efficacy questions. On average, the REM students consistently rated themselves highly in questions describing general problem solving and data analysis of ~4.5/5. The students were very confident in their presentation and explanation skills as both received perfect scores of 5/5. High scores continued to be obtained from questions assessing the quality of mentoring relationships and knowledge of STEM career paths. All questions relating to relationships with research mentors received an average score of 4.75/5 for the REM students. A perfect 6/6 was obtained from questions addressing the quality of mentoring relationships formed with advisors in terms of intellectual stimulation, accessibility, providing of resources, and minimizing anxieties relating to research. Lastly, the REM students rated themselves 4.75/5 to attend a master's program and 3.5/5 to attend a PhD program. This could reflect the practical and applied mindset of non-traditional students. Overall, the program had a positive effect on their desire to pursue a career in STEM, as they rated themselves 4/5 as more likely to both work in a science lab or as an industrial engineer than before participating in the program. Table 1 presents a collection of responses from both the REM and REU students.

*Table 1 Student Responses to Selected Survey Questions. * Indicates the Question is /6 instead of /5*

How much did the program improve ability or desire to...	REM	REU	Significant Difference?
Analyzing data for patterns.	4.4	3.83	none
Figuring out the next step in a research project	4.4	3.83	none
Problem-solving in general	4.6	4	none
Understanding how data are collected	4.8	4.33	none
Making oral presentations	5	4.5	none
Explaining my project to people outside my field.	5	4.33	none
Writing scientific reports or papers	4.4	4.33	none
My working relationship with my research mentor	4.75	4.33	none
The amount of time I spent with my research mentor	4.75	3.67	none
The advice my research mentor provided about careers or graduate school	4.75	4.17	none
The research experience overall	5	4.67	none
Interactions with my REU advisor(s) was both intellectually stimulating and interpersonally rewarding.*	6	5.67	none
My REU advisor(s) was easily accessible to answer questions about my project or discuss research ideas*	6	5.67	none
My REU advisors modeled the process of scientific inquiry in a manner that improved my understanding*	6	5.83	none
My REU advisors helped me to minimize anxieties I had concerning the research process*	6	5.83	none
enroll in a Ph.D. program in science, mathematics or engineering	3.5	3.5	none
enroll in a master program in science, mathematics or engineering	4.75	3.33	none
work in a science lab	4	3.33	none
work as an industrial engineer	4	2	*P < .05

REM-Specific Post-Program Mentoring

Post-program mentoring was the major difference between a typical REU program and the format of this program that attempted to specifically target URM community college students. This structure sought to take advantage of the fact that the students were local to maintain relationships and provide both formal and informal mentoring after the conclusion of the program. A typical challenge mentoring relationships face involves the mentor and mentee growing more distant as both move on to different endeavors. This was the case in this program, as only two of the seven were regularly engaged with the entirety of the mentoring activities hosted. Three others expressed regret they were extremely busy with work and other outside engagements that prevented regular attendance, but the final two only engaged with one or two sessions once the program completed. It was hoped that relationships built over the 10-week period would support attendance to the mentoring sessions, and this was observed to some extent but not as strongly as was hoped. The students did find the sessions useful and engaging, saying “the mentoring sessions were helpful in connecting with people in industry and academia and seeing the different paths students can take after their schooling”. One student has applied to numerous international programs offered by the University of Arkansas that she was made aware of during the information session with the transfer department. URM presenters from STEM groups shared a variety of experiences and career decisions that defined their journey to becoming a STEM professional from a background that typically does not pursue STEM. The informal gatherings these sessions produced also provided additional quality mentoring opportunities for the students. Another group of NWACC students

was included in these sessions as a part of a separate program providing similar research experiences during the academic year. This continued to emphasize community and mentoring by giving the incoming students a contact with similar students who had just built experience in research. Further, the students were able to discuss continued professional and research development with the graduate student coordinators. Two of these students had continued to work on research during the academic year and were able to receive guidance on project design.

The culmination of post-program mentoring involved the students presenting their research at a national conference. The NSF-REM initiative hosted a professional development and poster presentation session as a part of the ERN conference designed to bring together URM STEM researchers from different programs, backgrounds, and universities. Funding was included for all seven students to travel to the conference but only four took advantage of the opportunity. Of the three who did not attend, two cited work and other obligations as reasons to miss and the third did not stay connected after the program at all. The final mentoring session before the conference was given as a forum for the students to practice their poster presentations. The students did note that guidance received during this session was extremely helpful as this was the first poster they created. At the conference, the students were given the chance to receive expert presentation training, ask questions to a panel of professionals, observe different poster presenters, and listen to keynote speakers targeted toward growing URM interest in STEM. These presentations were much more valuable to the students than those at a highly technical conference. Finally, the students presented their own work at a poster session specific to REM students, forming a national cohort of students involved in REM programs. One of the students in this program won second place for best overall poster. Overall, the students who remained engaged long enough to take advantage of the opportunity to attend the ERN conference all felt they benefited greatly, and it was clear their self-efficacy when presenting had continued to increase. Students who attended the conference stated “The conference was amazing for networking and really understanding what working in STEM is like. I personally love conferences because of all the different people you get to meet and the different events/workshops that are hosted. You never know what you might get out of a good conference and for me, I feel really motivated and excited about research and pursuing my education after attending a conference.” and “I thoroughly enjoyed the conference as it gave me an excuse to chat about my research and learn in-depth about other people's work. It was inspirational to see such diversity in STEM and made me aspire to aim higher in my career. It was my first conference of that magnitude and I had never experienced such privileges before which most definitely made me want to pursue more conferences.” The emphasis on exposing URM students to STEM at this conference continued to grow their desire to pursue a career in STEM.

Considerations for Future Iterations and Similar Programs

This theme of engagement leading to quality experiences encapsulated the results of the first year of the program well. Keeping the students engaged following the summer research proved to be more challenging than expected. Those who did fully engage gave consistent feedback that the program has exposed them to a variety of new research and transfer opportunities as well as much more knowledge pertaining to careers in STEM. Future iterations of the program are not expected to include any major changes. Improvements largely will involve efforts to increase engagement with post-program mentoring, maximize mentoring relationships formed during the program, and

implementing more consistent measures of tracking the students and quantifying the program's outcomes. Collaboration with other REM programs at national meetings has led to further initiative to form a network connecting participants and administration between programs. More formal events, such as regional REM meetings, will provide more chances for quality post-program engagement with the students and offer them more opportunities for professional growth. Connecting with the administrators of other REM programs can improve procedures, measures to give students quality interactions with their advisors are of particular interest. Another tool to be implemented is a module-based mentor training platform created by the NSF-REM initiative. This site allows the program coordinators to build a mentor training course containing modules specific to the issues faced by the program's target demographic. This course will be constructed to last approximately 30 to 60 minutes and will be provided to the faculty and graduate student mentors prior to the start of the program. Finally, further collaboration will be sought to improve methods of acquiring quantitative data and tracking the students after the program. An in-person exit interview may be conducted in addition to the survey, and various professional social networks will be utilized for tracking such as LinkedIn and Slack.

Summary

An REM program was designed to address the need to increase the access of URM and non-traditional students to meaningful STEM research opportunities. The structure of the program to pair the REM community college students with the REU students from other research institutions created a community environment that provided successful representation in STEM research for a demographic that does not typically have them. The program's first goal was to provide a quality research experience for these students to demonstrate STEM research is feasible given their non-traditional or URM status. The impressive progress made by both the REM and REU students speaks to the development of the REM students over the course of the program. It was clear from the final result of the projects, the improvements made between weekly meetings, and the feedback received from the survey and exit meeting that the self-efficacy of the REM students increased greatly through both the 10-week summer experience and the post-program mentoring. The secondary aim of the design of this program was to provide exposure to representation and different career paths in STEM and guide the students to transfer to the University of Arkansas. Students spoke to the value of the mentoring activities such as the industry visit, URM presenters, and ERN conference and how that positively influenced them to continue to pursue STEM careers. To the best knowledge of the authors, three of the seven students have successfully transferred to a STEM major at the University of Arkansas and the rest still intend to transfer or pursue other research opportunities. Future iterations of this program hope to build a national network and community of REM programs and provide more training for mentors to work with non-traditional URM students. Based on the success of this program, the program managers recommend other institutions explore REM opportunities for URM and non-traditional students that develop this traditionally underserved group of students into confident STEM professionals.

Acknowledgements

We would like to acknowledge the participants: REM students Silver Babb, Kaili Ralston, An Tran, Jesus Sanchez, Brandon Prado, Diana Hernandez, and Dee Mason. The REU students Noa Raimond, Brianna Bair, Alanis Olmo Jimenez, Eliana Wray, TJ Hockett, Aaron Prado, and

Matthew Chertok. The faculty advisors Dr. Ranil Wickramasinghe, Dr. Jorge Almodovar, Dr. Natacha Souto, Dr. Xianghong Qian, Dr. Audie Key Thompson, Dr. Bob Beitle, Dr. Karthik Nayani, and Dr. Keisha Walters.

We would also like to acknowledge the national REM program administrative support provided by the MAST Center Coordinator Heather Pollard, assistance with the post program survey provided by Dr. Jacquelyn Dee Mosely, and Aubrey Schultz for her work as a graduate student coordinator.

Lastly, we extend major acknowledgements to Dr. LaShall Bates and Dr. Gary Bates for their recruiting and support that made this program possible.

Funding was provided by the National Science Foundation 2150436 (REU Site) and 1822101, 2207153 (REM program).

References

[1] "Research Experience and Mentoring," in *National Science Foundation official website*, National Science Foundation, Alexandria, VA, USA: 22314. https://archive.ph/20130413184846/https://www.dtrasubmission.net/help/quadchart.asp

[2] "Eastman The Result of Insight" in *Eastman Chemical Company Homepage*, Eastman Chemical Company, Kingsport, TN, USA: 2022. https://www.eastman.com/Pages/Home.aspx

[3] "Invista: Home" in *Invista Homepage*, Invista Plastics, Longview, TX, USA: 2022. https://www.invista.com/