REU-INFEWS program: Results from Innovations at the Nexus of Food, Energy and Water Security Program

Danielle Pitre, Todd MIsna and Deb MIsna
Mississippi State University

Abstract

From 2017-2021, Mississippi State University's Department of Chemistry has hosted a 10-week summer Research Experience for Undergraduates (REU) program, focused on research related to food, energy, and water security topics. The goals of this program were to train students by providing an intensive research experience, recruit minority and underrepresented students, and provide advising for future career goals. The program hosted a growing cohort of undergraduate students each summer, 113 in total, recruited from a pool of underrepresented students and those with limited research opportunities. The pre- and post-program survey results covering three summers showed consistent self-reported growth among the student cohort in the program's focused skill sets. This manuscript presents three years of the program's success, from initial planning stages and recruitment to final results including a description of the value of each program component.

Introduction

Undergraduate STEM students can be encouraged to remain in STEM fields through research-focused experiences that allow better access to research-involved faculty (Craig, 1999; Frederick, 2012; Ries & Gray, 2018), more modern or needed facilities (Farnsworth et al., 2005; Graham et al., 2013), or a research-focused curriculum (Dillner et al., 2011; Karukstis, 2004; Lindsay & McIntosh, 2000; Wilson et al., 2013; Woodin et al., 2010). A number of summer programs exist to expand these opportunities to students at smaller Primarily Undergraduate Institutions (PUIs), community colleges and liberal arts universities (Craney & DeHaan, 1991). Students in programs at smaller institutions may graduate never having performed research or experimental work outside of the rigidly structured curriculum-coupled laboratory courses. Exposure to external research experiences is particularly beneficial to these students and can support continued student engagement with STEM.

Our program promotes inclusion of underrepresented students in STEM fields to address an increasing national concern. Students of color face barriers in education, especially within STEM education, which lead to much lower proficiency in STEM courses in K-12 which negatively effects their university readiness and performance (Scott & Martin, 2013). Women face more internal and external barriers than men, such as sexism amongst the male-predominant STEM environments, as well as cultural barriers such as pressures to have children (Wilkins-Yel et al., 2021) and expectations of being more family-oriented instead of career/academic oriented. And if those barriers are successfully navigated, there are still the economic barriers previously mentioned in the fact that research opportunities are harder to find for minority students and may be turned down because of financial need and a necessity for the student to work instead (Pierszalowski et al., 2021).

When students are able to access authentic research experiences, it is believed to promote a higher interest in furthering their education (Russell et al., 2007) as well as teaching students a multitude of skills that they may not have had the chance to acquire through traditional laboratory courses (Mohan et al., 2019). Allowing students to integrate their own ideas into their practical chemistry work gives them a feeling of responsibility and control over their learning (Linn, 1995), makes them more likely to enjoy and succeed in science (Ghanem et al., 2018), and allows them to "be involved in the exploration of something new" (Wenzel et al., 2012).

The summer-based Research Experiences for Undergraduates (REU) programs are funded through the National Science Foundation, with over 700 opportunities available throughout the United States. REU programs are an important supplement to the undergraduate student degree experience, and have been shown to promote higher academic success in STEM courses (Fechheimer et al., 2011; Junge et al., 2010), increased retention in STEM degrees (Fakayode et al., 2014), and support higher inclusion of minority students (Nocera & Harrison, 1996; Villarejo et al., 2008) in STEM fields.

A typical REU program supports a ten-week research experience over the summer, and provides students the opportunity to participate in individualized, hands-on research, working under both graduate student and faculty mentors. These programs provide many students with the opportunity to experience research earlier in their academic career (Canaria et al., 2012), as well as giving some students access to training and experiences unavailable at their home institution. By working with knowledgeable researchers, students who might have not had the opportunity to perform hands-on research outside of classroom environments can receive invaluable experience by guided scientific discovery.

Recruiting a diverse cohort of students is the groundwork to REU programs, and there is much importance in choosing both students who are qualified and those who the experience would provide opportunities that they would be unlikely to experience otherwise (McDevitt et al., 2020). As our program focuses on recruiting underrepresented populations, we believe we have succeeded in providing many students with research experiences that were otherwise out of reach.

A main goal of all REU programs is to encourage and motivate students towards pursuing further STEM research work and graduate careers (Spanias & Christen, 2018). By providing our participants with a full summer of both academic and social experiences, as well as giving them access to the wealth of knowledge provided by research advisors and graduate student mentors, our program has followed in the footsteps of those before us in encouraging and promoting graduate school and STEM professional fields as possible career trajectories for our cohort.

Overview of Program

The aim of this Mississippi State University Department of Chemistry REU program (now in its 5th year) was to expose undergraduate students to research experiences regarding interrelated Food, Energy, and Water Security issues (Innovations at the Nexus of Food, Energy and Water Security; REU-INFEWS). We have offered a productive training ground for our country's future leaders in areas of renewable energy, water purification and the science of soil amendment to enhance food security. Targeted students for this program included undergraduates in the majors of chemistry, biochemistry, engineering, and other related STEM fields. We focused on recruiting minority, first generation and women students into our program and our recruiting efforts were aimed at the rich student pool from undergraduate institutions, HBCUs and community college programs located in the Southeastern

United States that typically have limited research opportunities. Our program exposed undergraduate students to a breadth of research on related Food, Energy and Water Security topics and allowed for connections across disciplinary boundaries.

This program hosted 8 students each summer (2017-2019) and 10 students 2020 (funded through 2024) through the NSF-REU program. Additional students were included in the research experiences, summer training workshops and social activities as an expanded research cohort (Figure 1). Some students were paid from external individual professor funded programs, some from independent scholarship programs, and some students were from our host institution and financially supported through the Chemistry department. Additional students also included were doing research for course credit during the summer. This has brought our total cohort of students to approximately 38 per summer (2017: 32, 2018: 39, 2019: 42). An important partner for us has been the Jackson Heart Scholarship Program which financially supports students from Tougaloo College, an HBCU located in Jackson, Mississippi. This program, combined with financial support from our MSU Provost office, has funded 9 students to participate in the summer research experience. Many of our summer students were hosted in the MSU dorms which created a vibrant support community for student socialization. In addition, the inclusion of local MSU students expanded the social connections for out-of-town participants.

The program was housed within the Department of Chemistry at Mississippi State University (MSU) and included professor mentors and research groups from four colleges and seven departments at the university, including Chemistry (College of Arts and Sciences), Biochemistry, Landscape Architecture and Plant and Soil Sciences (College of Agriculture and Life Sciences), Civil Engineering and Biological Engineering (College of Engineering) and Sustainable Bioproducts (College of Forestry). Our ten-week summer program included seminars on career paths and entrepreneurship with a focus toward small business and regulatory concerns in environmental industries. Summer housing, instrumentation and laboratory access have been provided through Mississippi State University.

Program Research Focus

Mississippi State University has a rich history of interdisciplinary research aimed at the utilization of biomass (Chen et al., 2018; Dewage et al., 2018; Karunanayake et al., 2018; Pyrolysis of Wood/Biomass for Bio-Oil: A Critical Review | Energy & Fuels, n.d.; Seepaul et al., 2011; Wijayapala et al., 2014; Yan et al., 2013; Yw et al., 2017) as our warm weather and plentiful water allows for long and productive growing seasons. Our ability to produce high density, high volume biomass within the region is the foundation of this bioproducts program and overlaps with a targeted research focus area of our institution. Many research groups at MSU actively conduct research aimed at converting biomass and microbes into renewable sources of energy (Hu et al., 2012; Kokabian et al., 2018; Wijayapala et al., 2016; Yan et al., 2014). During the production of biofuels we also produce biochar, a 'waste' product which can be used to purify water and amend soil depleted from years of intensive agricultural utilization (Bombuwala Dewage et al., 2018; Essandoh et al., 2015; Karunanayake et al., 2018; Dinesh Mohan et al., 2014; Dinesh Mohan & Pittman, 2006). Mississippi is a state with strong agricultural and forestry industries and the core of this program is the combination of research training for students entering environmental fields with an understanding of regulatory concerns, environmental fate and hazards of contaminants, and engineering approaches to support practical solutions to agriculture, energy and water environmental issues. In addition, our program has a focus toward the start-up and operation of a small business, so that students can understand pathways forward toward launching and sustaining an entrepreneurial effort.

Our REU site had three objectives:

1. Train students on state-of-the-art instrumentation and provide intensive research experience within the breadth of Food, Energy and Water Security. Projects emphasize environmental issues, renewable energy concerns, water purification and soil amendment.

2. Our program recruited talented minority, first generation, and female students from institutions with limited research opportunities. We have included students from all over the United States with strong emphasis toward the Southeastern region.

3. Seminars complemented the skills and research training with career advising, training in scientific communication, and identification of career goals and trajectories. Students practiced discussing their projects to outside groups and presented their work at an Undergraduate focused Research Conference at end of the 10-week program.

The overarching goal of this program was to support under-represented groups toward careers in STEM fields, with an emphasis toward graduate school and advanced degrees. We have included additional students supported through external funding sources within each summer cohort so that career advising, and training is expanded to more students. In this paper, we share what we have learned with the recruitment process, student training and experience along with the outcomes of this program. Elements that have made our program successful will be discussed for possible inclusion into other, existing, and future programs with a STEM research training focus.

Figure 1. Participating MSU NSF INFEWS REU students and mentors. Also shown are 29 students participating in MURPs (MIsna Undergraduate Research Program) that also enjoyed a summer research experience. Group photo (research students and mentors) taken at the Shackouls Honors College Undergraduate Research Symposium 2019.

Program Design and Evaluation

Recruitment and Selection of students

Our advertising materials for the REU-INFEWS program was shared via email with science department heads and undergraduate coordinators throughout the Southeastern United States. In addition, recruiting flyers were shared at National American Chemical Society conferences and the Southern Undergraduate Research Conferences to connect with students from Primarily Undergraduate Institutions (PUIs). The PI and Co-PI especially encouraged colleagues at HBCUs in the State of Mississippi and surrounding regions to promote a strong response from HBCU student applicants. As our program received recommendation letters for students, we retained the professor email addresses in a database to be included in subsequent year recruiting efforts. Thus, our number of applicants grew each year.

Our program was awarded initial funding in March of 2016. Our cohort from 2017 was selected from 70 applications, with significant growth in applicants in 2018 and 2019 (130 and 159 applications respectively). Each student applicant for the program was tasked to provide two letters of recommendation from math or science professors, we also required student essays on their previous research experience (if any) and their intended career goals.

The 10-week program as funded by the National Science Foundation provided a stipend of $500 per week, along with dormitory housing and a meal stipend. The dorms at Mississippi State University were initially assigned as single occupancy residence in the cheapest dorm option (2017, 2018). In 2019, administrators at MSU collaboratively agreed to allow REU summer research students to house as double occupancy in the premium dorms for a reduced housing rate. This housing switch worked extremely well for the students in summer 2019 and demonstrably increased student satisfaction as queried through exit interviews. These exit interviews provided an indication that our REU participants preferred having a roommate in the dorms (over having single occupancy) and vastly preferred a private bathroom over a communal hall bathroom. The INFEWS program collaborated extensively with other REU programs housed on campus to offer social connections and opportunities for student engagement. Access to the gym facilities was provided at extreme discount for the summer, along with parking passes and access to all university academic facilities. Participating students took advantage of these perks throughout the summer and helped to promote an enjoyable student experience.

Our initial application deadline was March 15th for a program that started at the end of May. We have adjusted our application deadline earlier (now March 1st) with an initial selection of students beginning in February. We have found that high-achieving students are in demand with all REU programs and are applying to multiple programs. Late communication with the student often means they have already committed elsewhere. We have therefore found that early communication in the selection process (early February) is crucial for recruitment success. Students are tasked to respond to the program invitation within one week if possible so that the next candidate can be selected in event of a rejection.

Our application is available on the Department of Chemistry website with questions on demographic background and math/science courses taken with grades. Three essays are requested: description of previous research experience, career goals, and why student is interested in this summer research program. A holistic approach was taken for applicant consideration and essays weighed heavily in the process with priority given to students expressing interest in research and career goals of research scientist. Two reference letters were part of the application process sent directly to program administrator and we prioritized students that demonstrated strong work ethic and the ability to work as part of a group. In addition, students were asked to rank available projects on their degree of interest. Project ranking often became a determining factor in selection as our program filled.

Priority for student selection were the following criteria: gender, ethnicity, first-generation criteria in addition to GPA, courses taken and letters of recommendation. Our program attracts students from a variety of majors, and we have included students majoring in engineering (chemical, civil, mechanical, biological, and environmental) along with students majoring in chemistry, biochemistry, biology, and environmental sciences. Students have been included after freshman, sophomore or junior years with some students matriculating from community college programs. Since many of our projects focus on the chemical sciences, most students have completed organic chemistry courses before program start although some students with less chemistry background have been included on projects that would be successful with less chemistry knowledge.

Program Research Training Approach

Mentoring Workshop

Our program scheduled a faculty advisor and graduate student mentoring workshop 4 weeks before program start. This mentoring workshop had two primary goals: One was the outline and planning of a 10- week summer undergraduate research project that seemed achievable for the student. The project outline included specific goals and timelines with a recognition that our summer program is keeping students engaged and busy for 40 hours per week. We encouraged project timeline to revolve around data collection for a published manuscript, with identified goals that would result in publication of results. Project plan creation four weeks prior to program start allowed the research groups to consider chemical and supply needs with enough time to order anything that was missing. Each mentor was given up to $500 for student supplies. The second goal of the mentoring meeting was to discuss interpersonal interactions and mentoring of undergraduate students. Discussions focused on communication of expectations, possible conflicts, methods to resolve conflicts and tools were provided to the graduate students to support their time management planning for the summer.

Selected REU student participants were matched with their research group before the program start, and their research project was included in their offer letter. Most of the research skill development was mentored by the faculty advisor and graduate students of that project group, although official training for library resources and SciFinder was included during our first week orientation (further explained under social components of program). Important deadlines for our program included an "elevator pitch" in week 2 that encouraged each undergraduate student to share the overview of their project and their defined goals for the summer research. Each student also presented a poster of their summer research at the end of summer Undergraduate Research Conference hosted by our institutions Honors College and turned in a draft manuscript report of their summer results to their faculty supervisor.

Research Projects

The overarching research theme of this REU program was on Food, Energy, and Water Security and each student was assigned their own individual research project in areas relevant to this focus. The specific research areas included projects addressing issues with energy depletion, freshwater contamination, and food security. Over 20 faculty members and multiple graduate students participated in this program as research mentors. Specific areas of research include:

Professional Development And Socialization Of Students

Upon campus arrival, our students were checked in to their dormitory housing on campus. Our initial program utilized single-occupancy housing in our cheapest dormitory available with shared bathroom facilities on the hallway. In year 3, we were able to afford double-occupancy rooms in our expensive dorms where each student room had a private bath. The dorm rooms had a full-sized refrigerator and microwave in each room, plus communal kitchen facilities on the floor. Our students had access to all university facilities, including a campus gym membership for the summer ($2 for all summer access) and re-

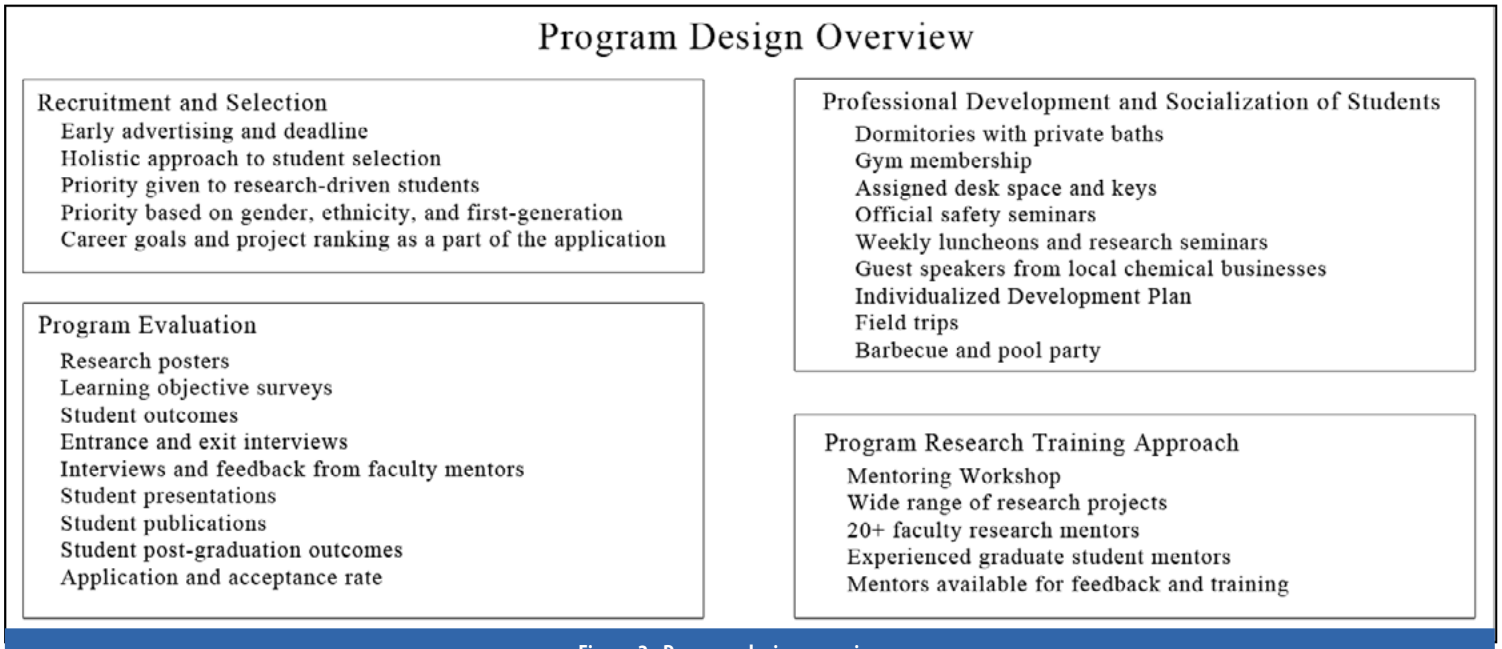

Figure 2. Program design overview

duced rate parking ($40 for summer). Campus food courts and dining halls were available, and students could use their paid meal stipend to access restaurants or groceries. The first week of the program included an initial orientation to the program schedule and available amenities with an orientation packet that included local restaurants, activities and the campus bus schedule. The first morning of program was focused on this orientation overview followed by connecting each student in with their designated research group so they could meet group members, get assigned desk space and keys, and get oriented with research. The remainder of orientation included official seminars on laboratory safety, hazardous waste disposal, library orientation, SciFinder training and introduction to campus services and amenities.

Two weekly seminars were scheduled for the ten weeks of summer. One scheduled every Wednesday at lunch with meal provided, focused on the Responsible Conduct of Research, Career trajectories in STEM fields, information on how to get in to graduate school, an Individualized Development Plan document (2 sessions), how to create a poster for a research conference presentation, and how to write a research manuscript. Our program secondary focus is on small business development and entrepreneurship, so several lunch seminars included guest speakers from local chemical businesses with tours of their facilities.

A second weekly seminar featured faculty speakers. These talks comprised a short overview of research focus (15 minutes), but a larger portion on their career trajectory, why they made major life choices during their career and what they wish they had known. Students were very engaged with these talks and have commented on them extensively in exit interviews. At this stage in their academic training, many students were eager to learn about the range of possible paths forward towards successful careers. The comments reflect that it helps them realize that there isn't just one "right" pathway. Careers can happen from more than one defined pathway, and students have commented that it vastly reduced stress about their future to recognize that a variety of routes can lead to rewarding and productive careers. We discovered that our faculty really buy in to this discussion and enjoy the mentoring interaction as a way of dispensing life advice to the students. The common theme was that faculty shared how they came to their current position. No two faculty stories were alike, and students gained the understanding that there are many paths that can lead to success. This series of presentations served provided an important life lesson for many of the students who began to understand that 'bumps in the road' towards a career were common and that persistence often was rewarded.

The Individualized Development Plan (IDP) was a paper document used with students to identify career goals and specific skills and experiences that would help them toward their defined goal. These documents allowed us to pursue conversations with the students on life priorities as well as the specific experiences the students could pursue to help expand their resume and grow their marketable skills. A specialized discussion with this IDP centered on the components of a strong recommendation letter, what the student identified that they would like said in a letter written about them, and specific approaches the student could do to garner those statements. For example, a student might identify that a strong statement in a rec letter is "strong work ethic". We would go through ideas and examples of how a student could manage their summer experience and their interaction with their research group to garner that statement in a future rec letter. A strong theme for the IDP discussions was that the student had the means to identify specific skills or outcomes that could help them toward their future. We would then explore ways to access those skills or support the defined outcomes. Many students commented in our exit interviews that this process was the point at which "life got real". The targeted discussions helped support students to recognize that they can be active participants in their growth and can both identify and pursue their defined goals.

Participants were given many opportunities to connect with each other, such as field trips and other social events. GroupMe chat groups were created to organize social outings, trips to the gym, and weekend activities. The inclusion of PIs varied from summer to summer; some participant groups were happy to keep their PIs involved in the GroupMe chat while others created splinter groups that included only student participants. In addition to these groups, Photo of the Week contests were hosted, encouraging participants to submit photos each week with various themes (selfie with their research group, best group photo, best nature photo, etc).

Field trips included the Teacher Education EPSCOR workshop hosted at Tulane University and the University of Alabama, and the ERDC government lab in Vicksburg MS (2017, 2018, and 2019, respectively). A second field trip was held each summer based on the participants' interest, and those have included the Huntsville Space Flight Center, the MSU Energy Institute, and a local Water Park. An opening barbecue and pool party welcomed participants each summer, and small evening and weekend social activities such as ice cream and movie nights happened approximately once per week.

Areas of Research/ Project
BioSyngas/ Bio-Oil
Development of multi-functional catalysts for conversion of syngas from biomass to hydrocarbon fuels
Upgrading of biomass fuels with plastic additives
Development of novel methods and catalysts for the production and upgrading of bio-oil
Biochars
Development of biochars for soil amendment and carbon sequestration
Development of biochars for water remediation
The impact of biochar on plant mycorrhizae and impact on plant growth
Exploring the relationship between the chemical mechanism of adsorption and the performance of various biochars
Developing biochar based adsorbents to control sewage and agricultural runoff
Materials and methods for removing excess nutrients from agricultural runoff, thereby reducing eutrophication
Other
Using advanced NMR techniques to monitor the performance of green adsorbents with complex mixtures
Analysis of microplastics in marine animals using optical spectroscopic methods
Utilizing wastewater as a valuable source for water and energy recovery through microbial desalination
Development of bio-degradable polymeric materials

Table 1. Areas of research and their focus

Program Evaluation

Program objectives were evaluated in multiple ways. Written data such as student applications, research posters and learning objectives survey were analyzed and student outcomes were tracked to identify career trajectory post-program. Exit interviews were performed with students each summer to gain feedback about the program, campus experience and student training elements. Interviews and feedback from faculty mentors were analyzed to determine way to strengthen the program. Each following year, the program included new elements in response to prior surveys resulting in an ever-improving summer package. For student participant outcomes, we tracked student presentations and publications related to their research. We also track where students go after graduation from their home institution to determine their path - graduate school or other opportunities pursued. Continued tracking was achieved through LinkedIn connections, Facebook interactions and direct email contact. To evaluate recruitment metrics, we analyzed overall applications and acceptance rate, towards our goal of recruiting women, minority, and first-generation participants and students from institutions with limited research opportunities.

Program Outcomes

Recruitment Metrics

We enrolled 24 REU students during the first 3 summers of operation. The first year, 2017, one selected student decided she had made a mistake in enrolling within the program after the first week and she asked to leave. We were able to roll her funding over into year 2 and support 9 students in 2018. Of the 24 total students supported within the REU, 16 were women, 4 were Black or African American, and 11 were First Generation. Eighteen students were from primarily undergraduate institutions (PUIs) or institutions with limited research capabilities. Three students were from Historically Black Colleges and Universities (HBCUs). Undergraduate institutions represented included Mississippi College, Huntingdon College, Tougaloo College, Jacksonville State University, Stetson University, Spring Arbor University, Tuskegee University, Georgia Southern University, Alcorn State University, Edinboro University and Thomas Nelson Community College. The majority of students were Chemistry majors (11 of the 24) with Chemical Engineering, Biomedical Engineering, Civil engineering, Biochemistry and Biology also represented.

For the REU program, 87.5% of our participants fulfilled our recruiting focus of women, Black or African American or First-Generation students. Additional undergraduate researchers were supported through external funding grants supplied by our research mentor faculty. An additional 9 students from Tougaloo College, an HBCU located in Jackson, MS were supported through private scholarship and funds supplied from the MSU Provost office and were treated as full program participants even though their funding came from a different source. The expansion of our cohort to include additional externally funded students allowed us to support a strong and diverse cohort. As well, local Mississippi State University students were supported through the Department of Chemistry, the MSU Shackouls Honors College and external programs to support local student research participation. A full breakdown of students is shown in Table 2.

Research Outcomes

Twenty-four REU participants successfully completed the program and presented their research work at the final Shackouls Honors College Undergraduate Research Symposium. We had 2 students win awards with these presentations and 3 students presented their work at external conferences including the American Chemical Society National Meetings (Hill et al., 2018; Powell et al., 2018) and the Annual Biomedical Research Conference for Minority Students (Walker & Street, 2017), 1 student won an award at a National ACS meeting. Another student won a travel award from the REU student committee to present their work in Washington, DC. An additional 89 students from our externally funded programs presented their work and 1 won an award at the Southeastern Undergraduate Research Conference. 5 students presented their work at external conferences, and a further 2 students had plans to present their work at the National ACS meeting in Philadelphia in 2020 but these plans were cancelled due to covid-19.

Six manuscripts (Crisler et al., 2020; Feng et al., 2019; Ghimire et al., 2021; Hill, Boulet, et al., 2019; Hill, Hunt, et al., 2019; Navarathna, Bombuwala Dewage, et al., 2020) have been published from the REU program participants. We continue to strongly encourage our research mentors to publish their work and more manuscripts are in preparation. An additional 19 publications (Alchouron et al., 2021; Arana & Gude, 2018; Burk et al., 2020; Cope, Sheridan, et al., 2020; Cope, Valle, et al., 2020; Das et al., 2020; Herath et al., 2021; Krantz et al., 2019, 2020; Li et al., 2019; Liyanage et al., 2020; Mikek et al., 2017, 2018; Navarathna, Dewage, et al., 2020; Obi et al., 2020; Samaraweera et al., 2021; Shirley et al., 2020; Wolgemuth et al., 2021; Yadav et al., 2017) have occurred with the externally supported students.

Dr. Deb Mlsna was an invited speaker at the 2019 South-Eastern Regional Meeting of the American Chemical Society (Mlsna, 2019), the 2020 International Frontiers in Chemical Technology Conference (Mlsna, 2020), and the 2018 National ACS Meeting (Mlsna & Mlsna, 2018). Dr. Todd Mlsna was an invited speaker at the 2020 International Frontiers in Chemical Technology Conference (Mlsna, 2020), and the 2018 National ACS Meeting (Mlsna & Mlsna, 2018).

The pre-and post-surveys shared with students targeted our learning objectives for the summer experience and tracked student attitudes toward their own scientific confidence on 9 questions. Students were asked to rank themselves on a 5-point Likert scale as "unknown" (level 1) up through "advanced" (level 5). Students consistently showed improvement in their skill sets after the ten-week program with the strongest learning gains observed with designing a hypothesis and writing a manuscript. Full results are shown in Figure 2.al., 2019; Liyanage et al., 2020; Mikek et al., 2017, 2018; Navarathna, Dewage, et al., 2020; Obi et al., 2020; Samaraweera et al., 2021; Shirley et al., 2020; Wolgemuth et al., 2021; Yadav et al., 2017)cardiac system development and nervous system function. Previous studies have demonstrated that the regulatory domain (RD have occurred with the externally supported students.

Dr. Deb Mlsna was an invited speaker at the 2019 SouthEastern Regional Meeting of the American Chemical Society (Mlsna, 2019), the 2020 International Frontiers in Chemical Technology Conference (Mlsna, 2020), and the 2018 National ACS Meeting (Mlsna & Mlsna, 2018). Dr. Todd Mlsna was an invited speaker at the 2020 International Frontiers in Chemical Technology Conference (Mlsna, 2020), and the 2018 National ACS Meeting (Mlsna & Mlsna, 2018).

Student Outcomes

Six of our REU students have entered graduate school programs, with an additional 7 matriculated into the workforce or professional school programs (medical, dental, pharmacy school). Seven students are still completing their undergraduate degree. Approximately the same number of external students have also moved on to graduate school programs, and we continue to monitor the students to determine where they move toward after graduation.

The pre-and post-surveys shared with students targeted our learning objectives for the summer experience and tracked student attitudes toward their own scientific confidence on 9 questions. Students were asked to rank themselves on a 5-point Likert scale as "unknown" (level 1) up through "advanced" (level 5). Students consistently showed improvement in their skill sets after the ten-week program with the strongest learning gains observed with designing a hypothesis and writing a manuscript. Full results are shown in Figure 2.

		NSF: REU-INFEWS Funded			Externally funded Students			MSU Students/ half time		
		2017	2018	2019	2017	2018	2019	2017	2018	2019
Gender	Male	3	3	2	3	5	6	4	7	9
	Female	4	6	6	3	2	7	2	5	10
Ethnicity										
	White	5	6	4	3	4	6	5	10	16
	Hispanic/Latino	1	1	1	1					1
	Asian American			2			1		1	1
	African American	1	2	1	2	4	6	1	1	1
	Other									
Other Factors										
	First Generation College Students	4	2	6		4	6	2	2	1
	Students from Historically Black Colleges	1	1	1	2	3	5			
Total Cohort 2017*	19	7			6			6		
Total Cohort 2018*	28		9			7			12	
Total Cohort 2019*	40			8			13			19

Table 2. Participants- Funded Students in Research Cohort

*additional students were doing research for course credit

With this evaluation, we hoped to address the question as to whether our participants were leaving our program feeling more capable at performing scientific tasks such as writing manuscripts and presenting their research. The evaluation surveys were designed to help students convey their confidence for these tasks with a simple number system and topics that specifically targeted areas of the program that we focused on. The data we received from these evaluations supports the conclusion that our program has indeed helped students feel more confident with these tasks.

Discussion

The learning objectives of oral communication and relating their project into the larger picture were supported through a collaborative relationship developed with an NSF EPSCOR-funded program, Creative Science through Inquiry (CSI). CSI was a teacher education workshop designed to support middle and high school science teachers to expand their skills in laboratory experiences. The REU participants visited this workshop each summer to interact with the teachers and support them to perform a biochar adsorbance experiment created by the PI and Co-PI to explain the programmatic research.

REU participants at this workshop were tasked to explain their summer research project in a 3-minute presentation for the secondary school educators. This early start presentation, given in the 2nd week of the program, yielded enormous value for our participants as it supported them to become familiarized with their topic and research focus very early in the summer program. The presentation consisted of two PowerPoint slides, the first giving detailed background and the importance of their summer research and the second detailing their project specifics including summer goals and a list of tasks. Scheduling an early student presentation was vital because it got the participants up to speed quickly with their project and fostered independence for the student in recognizing their own summer goals.

In addition, the interactions between the undergraduate REU participants and the teachers were brilliant to observe and was a remarkable team building experience. The undergraduates were able to step into a teaching role while

the teachers got to see how much student growth occurs at the undergraduate level. Both teachers and students strongly endorsed this workshop experience for multiple years, and we believe that the completion of the CSI workshop helped both the teachers and students feel proud of their progress. As well, the learning objective of improving writing skills was supported through the student research poster at summers end and the submission of a manuscript draft on their project a program requirement. The reports were formatted to provide experience with writing a research publication, so all details such as introduction, methods, results, and discussion were required. These provided both invaluable scientific writing experience for the undergraduate participants, and a rough draft for their research mentors to expand on for future publication.

	Graduate School	Professional School/ Employment	Still completing BS degree	No outcome/ lost track.
REU Students	6	7	7	4
External Funded Students	6	6	9	5
MSU Students	5	8	16	8

Table 3. Self-reported student outcomes

Conclusion

The learning objectives of oral communication and relating their project into the larger picture were supported through a collaborative relationship developed with an NSF EPSCOR-funded program, Creative Science through Inquiry (CSI). CSI was a teacher education workshop designed to support middle and high school science teachers to expand their skills in laboratory experiences. The REU participants visited this workshop each summer to interact with the teachers and support them to perform a biochar adsorbance experiment created by the PI and Co-PI to explain the programmatic research.

REU participants at this workshop were tasked to explain their summer research project in a 3-minute presentation for the secondary school educators. This early start presentation, given in the 2nd week of the program, yielded enormous value for our participants as it supported them to become familiarized with their topic and research focus very early in the summer program. The presentation consisted of two PowerPoint slides, the first giving detailed background and the importance of their summer research and the second detailing their project specifics including summer goals and a list of tasks. Scheduling an early student presentation was vital because it got the participants up to speed quickly with their project and fostered independence for the student in recognizing their own summer goals.

In addition, the interactions between the undergraduate REU participants and the teachers were brilliant to observe and was a remarkable team building experience. The undergraduates were able to step into a teaching role while the teachers got to see how much student growth occurs at the undergraduate level. Both teachers and students strongly endorsed this workshop experience for multiple years, and we believe that the completion of the CSI workshop helped both the teachers and students feel proud of their progress. As well, the learning objective of improving writing skills was supported through the student research poster at summers end and the submission of a manuscript draft on their project a program requirement. The reports were formatted to provide experience with writing a research publication, so all details such as introduction, methods, results, and discussion were required. These provided both invaluable scientific writing experience for the undergraduate participants, and a rough draft for their research mentors to expand on for future publication.

The authors feel that we have had a very successful launch to the chemistry NSF-REU program at Mississippi State University. We have introduced many underrepresented students to the benefits of STEM careers and helped to foster a further interest in pursuing these careers. All told, 113 students spent 10 weeks emersed in research while networking with potential colleagues in their cohort that may support their work for further decades. Along the way, they learned how to prepare and give presentations, write research papers, maximize their resumes for graduate school, navigate research laboratories, discuss scientific principles with those in their field, and had countless other opportunities for progressing further into their chosen fields.

The program elements were supported through the three-year implementation of this REU-INFEWS pro-

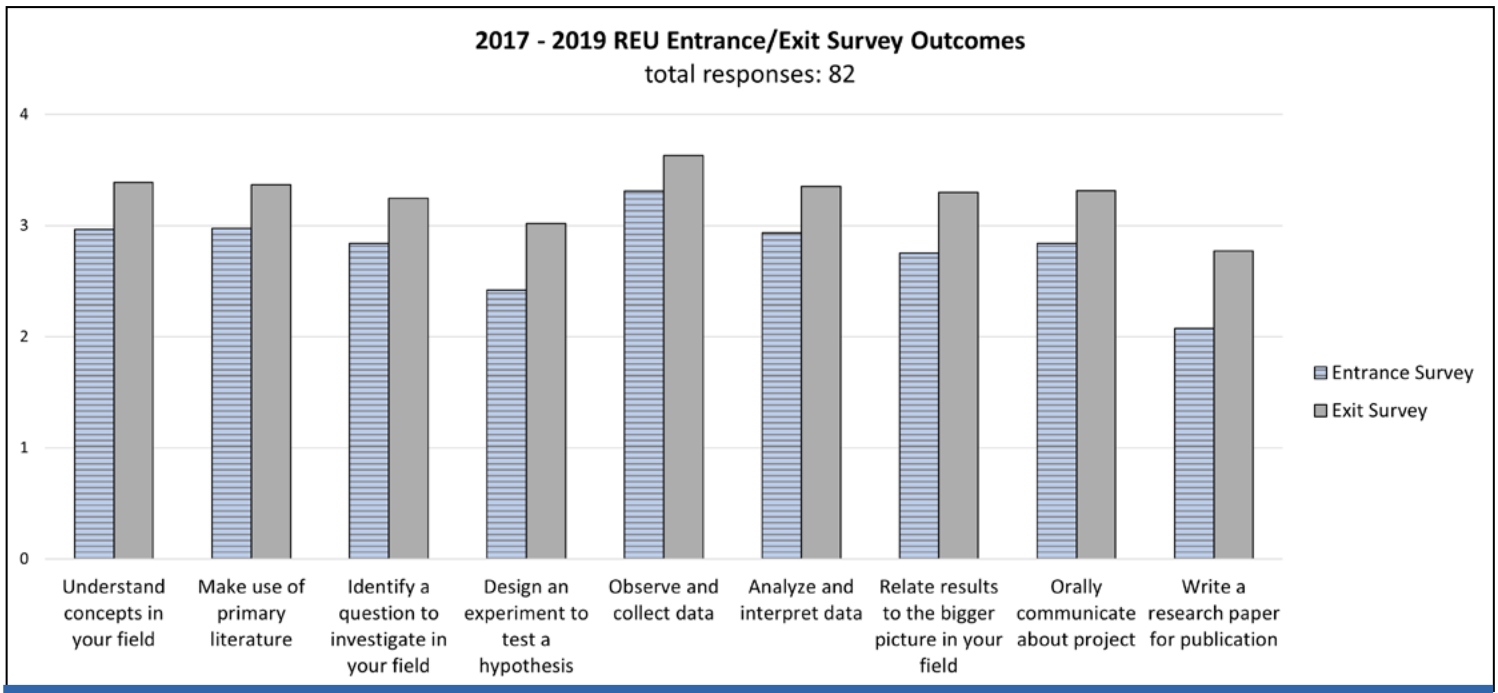

Figure 3. Learning Outcomes survey results.

gram. The program continues at Mississippi State University through renewal funding and continues to expand in breadth and scope to support undergraduate students engaged in research. Successes with this program are the continued inclusion of additional participants supported through external funding programs and private scholarship. One of the most effective recruiting components was to include the faculty writing recommendation letters on the next year's recruiting list. The faculty that are engaged to support an undergraduate student with an REU application are excellent recruiters for the next layer of participants. This REU program has run successfully, has become a model program for our university, and continues to support the mission of engaging undergraduate students in authentic research experiences.

References

Alchouron, J., Navarathna, C., Rodrigo, P. M., Snyder, A., Chludil, H. D., Vega, A. S., Bosi, G., Perez, F., Mohan, D., Pittman Jr., C. U., & Mlsna, T. E. (2021). Household arsenic contaminated water treatment employing iron oxide/bamboo biochar composite: An approach to technology transfer. *Journal of Colloid and Interface Science, 587*, 767–779. https://doi.org/10/gh4n6v

Arana, T. J., & Gude, V. G. (2018). A microbial desalination process with microalgae biocathode using sodium bicarbonate as an inorganic carbon source. *International Biodeterioration & Biodegradation, 130,* 91–97. https://doi.org/10/gdrnzn

Bombuwala Dewage, N., Liyanage, A. S., Pittman, C. U., Mohan, D., & Mlsna, T. (2018). Fast nitrate and fluoride adsorption and magnetic separation from water on α-Fe2O3 and Fe3O4 dispersed on Douglas fir biochar. *Bioresource Technology, 263*, 258–265. https://doi.org/10/gdskgk

Burk, G. A., Herath, A., Crisler, G. B., Bridges, D., Patel, S., Pittman, C. U., & Mlsna, T. (2020). Cadmium and Copper Removal From Aqueous Solutions Using Chitosan-Coated Gasifier Biochar. *Frontiers in Environmental Science, 8*, 541203. https://doi.org/10/gh4n3d

Canaria, J. A., Schoffstall, A. M., Weiss, D. J., Henry, R. M., & Braun-Sand, S. B. (2012). A Model for an Introductory Undergraduate Research Experience. *Journal of Chemical Education, 89*(11), 1371–1377. https://doi.org/10/f4cds4

Chen, W., Lin, T., Dai, Y., An, Y., Yu, F., Zhong, L., Li, S., & Sun, Y. (2018). Recent advances in the investigation of nanoeffects of Fischer-Tropsch catalysts. *Catalysis Today, 311*, 8–22. https://doi.org/10/gdm3b8

Cope, J. D., Sheridan, P. E., Galloway, C. J., Awoyemi, R. F., Stokes, S. L., & Emerson, J. P. (2020). Synthesis and Characterization of a Tetradentate, N-Heterocyclic Carbene Copper(II) Complex and Its Use as a Chan–Evans–Lam Coupling Catalyst. *Organometallics, 39*(24), 4457–4464. https://doi.org/10/gh4n6z

Cope, J. D., Valle, H. U., Hall, R. S., Riley, K. M., Goel, E., Biswas, S., Hendrich, M. P., Wipf, D. O., Stokes, S. L., & Emerson, J. P. (2020). Tuning the Copper(II)/Copper(I) Redox Potential for More Robust Copper-Catalyzed C–N Bond Forming Reactions. *European Journal of Inorganic Chemistry, 2020*(14), 1278–1285. https://doi.org/10/gh4n6t

Craig, N. C. (1999). The Joys and Trials of Doing Research with Undergraduates. *Journal of Chemical Education, 76*(5), 595. https://doi.org/10/d26snz

Craney, C. L., & DeHaan, F. P. (1991). A collaborative summer research program for community college students. *Journal of Chemical Education, 68*(11), 904. https://doi.org/10/bjtqtj

Crisler, G. B., Perera, V., Hernandez, C. G., Orr, A., Davis, R., Moore, J., Smith, J., Varco, J., Schauwecker, T., Brown, A., Mlsna, T., & Mlsna, D. (2020). Phosphate in Soils: An Undergraduate Exploration of Soil Texture, Chemistry, and Amendment. *Journal of Chemical Education, 97*(4), 1077–1082. https://doi.org/10/gh4n3m

Das, S., Nugegoda, D., Qu, F., Boudreaux, C. M., Burrow, P. E., Figgins, M. T., Lamb, R. W., Webster, C. E., Delcamp, J. H., & Papish, E. T. (2020). Structure Function Relationships in Ruthenium Carbon Dioxide Reduction Catalysts with CNC Pincers Containing Donor Groups. *European Journal of Inorganic Chemistry, 2020*(28), 2709–2717. https://doi.org/10/gh4n6h

Dewage, N. B., Fowler, R. E., Pittman, C. U., Mohan, D., & Mlsna, T. (2018). Lead (Pb2+) sorptive removal using chitosan-modified biochar: Batch and fixed-bed studies. *RSC Advances, 8*(45), 25368–25377. https://doi.org/10/gh5f2m

Dillner, D. K., Ferrante, R. F., Fitzgerald, J. P., & Schroeder, M. J. (2011). Integrated Laboratories: Laying the Foundation for Undergraduate Research Experiences. *Journal of Chemical Education, 88*(12), 1623–1629. https://doi.org/10/cjzss2

Essandoh, M., Kunwar, B., Pittman, C. U., Mohan, D., & Mlsna, T. (2015). Sorptive removal of salicylic acid and ibuprofen from aqueous solutions using pine wood fast pyrolysis biochar. *Chemical Engineering Journal, 265*, 219–227. https://doi.org/10/f64gb7

Fakayode, S. O., Yakubu, M., Adeyeye, O. M., Pollard, D. A., & Mohammed, A. K. (2014). Promoting Undergraduate STEM Education at a Historically Black College and University through Research Experience. *Journal of Chemical Education, 91*(5), 662–665. https://doi.org/10/ghbrdg

Farnsworth, F. V., Sienerth, K. D., & Karukstis, K. K. (2005). Professional Infrastructure for Supporting the Undergraduate Research Enterprise on Campus. *Journal of Chemical Education, 82*(6), 825. https://doi.org/10/bt4h9q

Fechheimer, M., Webber, K., & Kleiber, P. B. (2011). How Well Do Undergraduate Research Programs Promote Engagement and Success of Students? *CBE Life Sciences Education, 10*(2), 156–163. https://doi.org/10/bg5bvx

Feng, D., Barton, G., & Scott, C. N. (2019). Synthesis of 2,5-Dibutyl-3,6-dimethyl-1H,2H,4H,5H-pyrrolo[3,4-c]pyrrole-1,4-dione: A Diketopyrrolopyrrole Scaffold for the Formation of Alkenyldiketopyrrolopyrrole Compounds. *Organic Letters, 21*(7), 1973–1978. https://doi.org/10/gh4n5b

Frederick, K. A. (2012). CUR and NCUR Join Forces on Undergraduate Research. *Journal of Chemical Education, 89*(2), 183–184. https://doi.org/10/bmfxcv

Ghanem, E., Long, S. R., Rodenbusch, S. E., Shear, R. I., Beckham, J. T., Procko, K., DePue, L., Stevenson, K. J., Robertus, J. D., Martin, S., Holliday, B., Jones, R. A., Anslyn, E. V., & Simmons, S. L. (2018). Teaching through Research: Alignment of Core Chemistry Competencies and Skills within a Multidisciplinary Research Framework. *Journal of Chemical Education, 95*(2), 248–258. https://doi.org/10/gc5mn3

Ghimire, U., Heili, M. K., & Gude, V. G. (2021). Electrochemical desalination coupled with energy recovery and storage. *Desalination, 503*, 114929. https://doi.org/10/gh4n49

Graham, M. J., Frederick, J., Byars-Winston, A., Hunter, A.-B., & Handelsman, J. (2013). Increasing Persistence of College Students in STEM. *Science, 341*(6153), 1455–1456. https://doi.org/10/gfkrbs

Herath, A., Layne, C. A., Perez, F., Hassan, E. B., Pittman, C. U., & Mlsna, T. E. (2021). KOH-activated high surface area Douglas Fir biochar for adsorbing aqueous Cr(VI), Pb(II) and Cd(II). *Chemosphere, 269*, 128409. https://doi.org/10/gh4n5d

Hill, R. A., Boulet, K. J., Perera, R., Davidson, M. B., & Fitzkee, N. C. (2019). Investigating How Protein Mixtures Interact with Gold Nanoparticles. *Biophysical Journal, 116*(3), 48a–49a. https://doi.org/10/gh5f25

Hill, R. A., Byers, A. H., Hunt, J., Sanders, E., Mlsna, T. E., & Fitzkee, N. C. (2018, March). *An NMR Based Metabolomics Approach to Understanding Biochar's Effects on Escherichia coli.* The 255th American Chemical Society National Meeting & Exposition, The 255th American Chemical Society National Meeting & Exposition, New Orleans, LA.

Hill, R. A., Hunt, J., Sanders, E., Tran, M., Burk, G. A., Mlsna, T. E., & Fitzkee, N. C. (2019). Effect of Biochar on Microbial Growth: A Metabolomics and Bacteriological Investigation in E. coli. *Environmental Science & Technology, 53*(5), 2635–2646. https://doi.org/10/gfvmpt

Hu, J., Yu, F., & Lu, Y. (2012). Application of Fischer–Tropsch Synthesis in Biomass to Liquid Conversion. *Catalysts, 2*(2), 303–326. https://doi.org/10/gdm292

Junge, B., Quiñones, C., Kakietek, J., Teodorescu, D., & Marsteller, P. (2010). Promoting undergraduate interest, preparedness, and professional pursuit in the sciences: An outcomes evaluation of the SURE program at Emory University. *CBE Life Sciences Education, 9*(2), 119–132. https://doi.org/10/dcnvnx

Karukstis, K. K. (2004). Reinvigorating the Undergraduate Experience with a Research-Supportive Curriculum. *Journal of Chemical Education, 81*(7), 938. https://doi.org/10/bbppz5

Karunanayake, A. G., Todd, O. A., Crowley, M., Ricchetti, L., Pittman, C. U., Anderson, R., Mohan, D., & Mlsna, T. (2018). Lead and cadmium remediation using magnetized and nonmagnetized biochar from Douglas fir. *Chemical Engineering Journal, 331*, 480–491. https://doi.org/10/gdzzxz

Kokabian, B., Ghimire, U., & Gude, V. G. (2018). Water deionization with renewable energy production in microalgae—Microbial desalination process. *Renewable Energy, 122*(C), 354–361. https://doi.org/10/ggdth7

Krantz, K. E., Weisflog, S. L., Frey, N. C., Yang, W., Dickie, D. A., Webster, C. E., & Gilliard, R. J. (2020). Planar, Stair-Stepped, and Twisted: Modulating Structure and Photophysics in Pyrene- and Benzene-Fused N-Heterocyclic Boranes. *Chemistry – A European Journal, 26*(44), 10072–10082. https://doi.org/10/gh4n6f

Krantz, K. E., Weisflog, S. L., Yang, W., Dickie, D. A., Frey, N. C., Webster, C. E., & Gilliard, R. J. (2019). Extremely twisted and bent pyrene-fused N-heterocyclic germylenes. *Chemical Communications, 55*(99), 14954–14957. https://doi.org/10/gh4n6g

Li, Z.-Y., Lakmal, H. H. C., Qian, X., Zhu, Z., Donnadieu, B., McClain, S. J., Xu, X., & Cui, X. (2019). Ruthenium-Catalyzed Enantioselective C–H Functionalization: A Practical Access to Optically Active Indoline Derivatives. *Journal of the American Chemical Society, 141*(40), 15730–15736. https://doi.org/10/gh4n5p

Lindsay, H. A., & McIntosh, M. C. (2000). Early Exposure of Undergraduates to the Chemistry Research Environment: A New Model for Research Universities. *Journal of Chemical Education, 77*(9), 1174. https://doi.org/10/bs32gw

Linn, M. C. (1995). Designing computer learning environments for engineering and computer science: The scaffolded knowledge integration framework. *Journal of Science Education and Technology, 4*(2), 103–126. https://doi.org/10/bmjkz7

Liyanage, A. S., Canaday, S., Pittman, C. U., & Mlsna, T. (2020). Rapid remediation of pharmaceuticals from wastewater using magnetic Fe3O4/Douglas fir biochar adsorbents. *Chemosphere, 258*, 127336. https://doi.org/10/gh4n5c

Mikek, C. G., Machha, V. R., White, J. C., Martin, L. R., West, S. J., Butrin, A., Shumaker, C., Gwin, J. C., Alatrash, N., MacDonnell, F. M., & Lewis, E. A. (2017). The Thermodynamic Effects of Ligand Structure on the Molecular Recognition of Mono- and Biruthenium Polypyridyl Complexes with G-Quadruplex DNA. *European Journal of Inorganic Chemistry, 2017*(33), 3953–3960. https://doi.org/10/gh4n5r

Mikek, C. G., West, S. J., Gwin, J. C., Dayal, N., Sintim, H. O., & Lewis, E. A. (2018). Berenil Binds Tightly to Parallel and Mixed Parallel/Antiparallel G-Quadruplex Motifs with Varied Thermodynamic Signatures. *ACS Omega, 3*(9), 11582–11591. https://doi.org/10/gh4n5s

Mlsna, D. (2019). *Undergraduate Research Experiences: The Power of Quality Mentorship and Programming, Mentoring and support for the REU-INFEWS- Food, Energy, Water Security Program at Mississippi State University.* SouthEastern Regional Meeting of the American Chemical Society, SouthEastern Regional Meeting of the American Chemical Society.

Mlsna, D. (2020). International Conference on Frontiers in Chemical Technology, International Conference on Frontiers in Chemical Technology, Sri Lanka.

Mlsna, D., & Mlsna, T. (2018). *Research experience for undergraduates: Food, energy and water security at Mississippi State University*. The 255th American Chemical Society National Meeting & Exposition, The 255th American Chemical Society National Meeting & Exposition, New Orleans, LA.

Mohan, D., Katoch, S., Jayasuriya, S., Turaga, P., & Spanias, A. (2019). An REU Experience in Machine Learning and Computational Cameras. *2019 IEEE Frontiers in Education Conference (FIE)*, 1–5. https://doi.org/10/ghh578

Mohan, D., & Pittman, C. U. (2006). Activated carbons and low cost adsorbents for remediation of tri- and hexavalent chromium from water. *Journal of Hazardous Materials, 137*(2), 762–811. https://doi.org/10/b5mk2q

Mohan, D., Sarswat, A., Ok, Y. S., & Pittman, C. U. (2014). Organic and inorganic contaminants removal from water with biochar, a renewable, low cost and sustainable adsorbent – A critical review. *Bioresource Technology, 160,* 191–202. https://doi.org/10/f52hdm

Navarathna, C. M., Bombuwala Dewage, N., Keeton, C., Pennisson, J., Henderson, R., Lashley, B., Zhang, X., Hassan, E. B., Perez, F., Mohan, D., Pittman, C. U., & Mlsna, T. (2020). Biochar Adsorbents with Enhanced Hydrophobicity for Oil Spill Removal. *ACS Applied Materials & Interfaces, 12*(8), 9248–9260. https://doi.org/10/ghc74h

Navarathna, C. M., Dewage, N. B., Karunanayake, A. G., Farmer, E. L., Perez, F., Hassan, E. B., Mlsna, T. E., & Pittman, C. U. (2020). Rhodamine B Adsorptive Removal and Photocatalytic Degradation on MIL-53-Fe MOF/Magnetic Magnetite/Biochar Composites. *Journal of Inorganic and Organometallic Polymers and Materials, 30*(1), 214–229. https://doi.org/10/gh4n5f

Nocera, D. G., & Harrison, J. F. (1996). Enhanced Performance in Chemistry by Minorities at the University Level: A Comprehensive Program. *Journal of Chemical Education, 73*(12), 1131. https://doi.org/10/fhbfq2

Obi, A. D., Walley, J. E., Frey, N. C., Wong, Y. O., Dickie, D. A., Webster, C. E., & Gilliard, R. J. (2020). Tris(carbene) Stabilization of Monomeric Magnesium Cations: A Neutral, Nontethered Ligand Approach. *Organometallics, 39*(23), 4329–4339. https://doi.org/10/gh4n6c

Powell, M., Pitre, D., & Mlsna, T. E. (2018, March). Fluoride Removal with Magnesium/Aluminum Modified Biochar. *The 255th American Chemical Society National Meeting & Exposition*. The 255th American Chemical Society National Meeting & Exposition, The 255th American Chemical Society National Meeting & Exposition, New Orleans, LA.

Pyrolysis of Wood/Biomass for Bio-oil: A Critical Review | Energy & Fuels. (n.d.). Retrieved February 24, 2021, from https://pubs.acs.org/doi/10.1021/ef0502397

Ries, K., & Gray, S. D. (2018). Fostering Undergraduate Research with a Nontraditional Student Population. *Journal of Chemical Education, 95*(9), 1443–1447. https://doi.org/10/gfcrx8

Russell, S. H., Hancock, M. P., & McCullough, J. (2007). Benefits of Undergraduate Research Experiences. *Science, 316*(5824), 548–549. https://doi.org/10/bqk833

Samaraweera, H., Sharp, A., Edwards, J., Pittman, C. U., Zhang, X., Hassan, E. B., Thirumalai, R. V. K. G., Warren, S., Reid, C., & Mlsna, T. (2021). Lignite, thermally-modified and Ca/Mg-modified lignite for phosphate remediation. *Science of The Total Environment, 773*, 145631. https://doi.org/10/gh4n6n

Seepaul, R., Macoon, B., Reddy, K. R., & Baldwin, B. (2011). Switchgrass (Panicum virgatum L.) Intraspecific Variation and Thermotolerance Classification Using in Vitro Seed Germination Assay. *American Journal of Plant Sciences, 02*(02), Article GO8602540. https://doi.org/10/dqbxdc

Shirley, H., Figgins, M. T., Boudreaux, C. M., Liyanage, N. P., Lamb, R. W., Webster, C. E., Papish, E. T., & Delcamp, J. H. (2020). Impact of the Dissolved Anion on the Electrocatalytic Reduction of CO2 to CO with Ruthenium CNC Pincer Complexes. *ChemCatChem, 12*(19), 4879–4885. https://doi.org/10/gh4n6j

Villarejo, M., Barlow, A. E. L., Kogan, D., Veazey, B. D., & Sweeney, J. K. (2008). Encouraging Minority Undergraduates to Choose Science Careers: Career Paths Survey Results. *CBE—Life Sciences Education, 7*(4), 394–409. https://doi.org/10/b3xqhx

Walker, J., & Street, J. (2017). *Pyrolysis of Southern Yellow Pine with High Concentrations of co-Fed HDPE Plastic.* Annual Biomedical Research Conference for Minority Students, Annual Biomedical Research Conference for Minority Students, Phoenix, AZ.

Wenzel, T. J., Larive, C. K., & Frederick, K. A. (2012). Role of Undergraduate Research in an Excellent and Rigorous Undergraduate Chemistry Curriculum. *Journal of Chemical Education, 89*(1), 7–9. https://doi.org/10/ddgpkt

Wijayapala, R., Karunanayake, A. G., Proctor, D., Yu, F., Pittman, C. U., & Mlsna, T. E. (2016). Hydrodeoxygenation (HDO) of Bio-oil Model Compounds with Synthesis Gas Using a Water–Gas Shift Catalyst with a Mo/Co/K Catalyst. In W.-Y. Chen, T. Suzuki, & M. Lackner (Eds.), *Hand*book of Climate Change Mitigation and Adaptation (pp. 1–34). Springer. https://doi.org/10.1007/978-1-4614-6431-0_79-1

Wijayapala, R., Yu, F., Pittman, C., & Mlsna, T. (2014). K-promoted Mo/Co- and Mo/Ni-catalyzed Fischer–Tropsch synthesis of aromatic hydrocarbons with and without a Cu water gas shift catalyst. *Applied Catalysis A: General, 480*, 93–99. https://doi.org/10/f58sp4

Wilson, A., Howitt, S., Roberts, P., Åkerlind, G., & Wilson, K. (2013). Connecting expectations and experiences of students in a research-immersive degree. *Studies in Higher Education, 38*(10), 1562–1576. https://doi.org/10/fzdrhp

Wolgemuth, D. K., Elmore, S. D., Cope, J. D., Sheridan, P. E., Stokes, S. L., & Emerson, J. P. (2021). Manganese-catalyzed aziridination of olefins with chloramine-T in water and buffered aqueous solutions. *Catalysis Communications, 150*, 106275. https://doi.org/10/gh4n62

Woodin, T., Carter, V. C., & Fletcher, L. (2010). Vision and Change in Biology Undergraduate Education, A Call for Action—Initial Responses. *CBE Life Sciences Education, 9*(2), 71–73. https://doi.org/10/d9bxfz

Yadav, D. K., Tata, S. R., Hunt, J., Cook, E. C., Creamer, T. P., & Fitzkee, N. C. (2017). 1 H, 15 N, and 13 C chemical shift assignments of the regulatory domain of human calcineurin. *Biomolecular NMR Assignments, 11*(2), 215–219 https://doi.org/10/gh4n3b

Yan, Q., Lu, Y., Wan, C., Han, J., Rodriguez, J., Yin, J., & Yu, F. (2014). Synthesis of Aromatic-Rich Gasoline-Range Hydrocarbons from Biomass-Derived Syngas over a Pd-Promoted Fe/HZSM-5 Catalyst. *Energy & Fuels, 28*, 2027–2034. https://doi.org/10/tdm

Yan, Q., Yu, F., Liu, J., Street, J., Gao, J., Cai, Z., & Zhang, J. (2013). Catalytic conversion wood syngas to synthetic aviation turbine fuels over a multifunctional catalyst. *Bioresource Technology, 127*, 281–290. https://doi.org/10/f4jnnd

Yw, L., Qg, Y., J, H., Bb, C., J, S., & F, Y. (2017). Fischer-Tropsch synthesis of olefin-rich liquid hydrocarbons from biomass-derived syngas over carbon-encapsulated iron carbide/iron nanoparticles catalyst. *Fuel, 193*, 369–384. https://doi.org/10/gh5f2k

Danielle Pitre is a Ph.D. student in Chemistry at Mississippi State University. She received her B.S. in Chemistry from Mississippi University for Women. Her research interests include both analytical and educational chemistry.

Todd E. Mlsna is a Professor in the Mississippi State University Chemistry Department where he teaches Analytical and Environmental Chemistry. His bachelor's degree is from Albion College (Albion, Michigan) and his Ph.D. from the University of Texas (Austin, Texas). His graduate work focused on synthetic organic fluorine chemistry, as did his postdoctoral work at Clemson University. From 1994 to 1998 he worked at the Naval Research Laboratory (NRL), Washington, D.C., on the development of absorbent polymer-film- based chemical sensors. In February 2003, Dr. Mlsna founded Seacoast Science, a private chemical sensor company, and served as president for 6 years before becoming chairman of the board. He joined the chemistry faculty at Mississippi State University in 2009. His current research is focused on water remediation and soil amendment using byproducts from the biofuel generation industry.

Deb Mlsna is an Associate Professor of Chemistry at Mississippi State University with a research focus in Chemical Education. Her B.S. degree is from Davidson College and her Ph.D. is from the University of Texas at Austin. She taught chemistry at a variety of institutions before joining the faculty at Mississippi State University as a lab coordinator and instructor; in 2013 she transitioned into a tenure-track position with a research focus of Chemical Education. Her research lab focuses on programs and curricula designed to support student engagement in STEM and enhance basic understanding of chemical principles. She is co-PI of the REU-INFEWS Program and is responsible for student training and engagement with the summer research program. Dr. Mlsna has been awarded numerous teaching awards for her contributions in the classroom, including the Grisham Master Teacher Award of Mississippi State University.