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[Work in Progress] Lessons Learned from a Collaborative NSF REU Program Thematically Centered on STEM Research for Social Change and Its Impact Through Community Engaged Learning

Dr. Leanne Petry, Central State University

Dr. Leanne Petry is a Materials Engineer and Professor in the College of Engineering, Science, Technology, and Agriculture (CESTA) at Central State University (CSU). Her expertise lies in analytical and materials characterization techniques, including microscopy, spectroscopy, chromatography, and electrochemistry. Her research focuses on electrode surface oxidation-reduction reactions for sensor applications, material corrosion mechanisms, and electrochemical degradation. She is a strong advocate for integrating high-impact practices, such as problem-based learning, into lectures, laboratories, and outreach initiatives to enhance student and community engagement in STEM education.

Dr. Kenya Crosson, University of Dayton

Dr. Kenya Crosson serves as Associate Dean for Faculty and Staff Affairs and Research in the School of Engineering at the University of Dayton (UD), and she is an Associate Professor in the Department of Civil and Environmental Engineering and Engineering Mechanics. A UD faculty member since 2007, Kenya teaches undergraduate and graduate courses; manages an environmental engineering research program; and uses her professional skills to advance initiatives and outreach at the university, in her STEM field, and her community. Kenya teaches courses in engineering design, hydraulics, water treatment, and water quality. Her research program focuses on water treatment and water quality, and she collaborates with diverse, interdisciplinary teams to develop, characterize, and evaluate new materials for drinking water and wastewater treatment applications. Dr. Crosson's leadership activities allow her to work collaboratively to advance institutional goals and mission within her department, the School of Engineering, and the university. She facilitated the strategic planning implementation team's revisioning of the School of Engineering's promotion and tenure policies for tenure track faculty, lecturers, and professors of practice; served a three-year term as the UD Learning Teaching Center's Faculty Development Fellow for Diversity and Inclusion, provides workshops on inclusive teaching and anti-racism for the university community; participates in the American Society of Engineering Educators Committee on Diversity, Equity, and Inclusion, and provides workshops and webinars for the Sloan Scholars Mentoring Network's community of graduates of the Sloan Minority PhD Program. Dr. Crosson is a 2018 HERS Leadership Institute alumna and an alumna fellow of the 2021-2022 Executive Leadership in Academic Technology, Engineering and Science (ELATES) Program.

Margaret Pinnell, Air Force Institute of Technology

Dr. Pinnell serves as the Director for Talent Development and Organizational Improvement at the Air Force Institute of Technology. Prior to taking this role, she worked at the University of Dayton for over two decades. While at the University of Dayton she held a number of administrative positions including Associate Dean of Faculty and Staff Development and Interim Dean in the School of Engineering, and the Assistant Provost for Learning and Executive Director of the Learning Teaching Center for the Office of the Provost. Her areas of scholarship include experimental mechanics of materials, teaching and learning, K-12 STEM. Dr. Pinnell is actively engaged in ASEE, WEPAN and DO STEM.

Dr. Melissa Karlin, St. Mary's University

Dr. Melissa Karlin serves as the Director of Office Student Research and Inquiry (OSRI) at St. Mary's University (StMU), and is a Professor of Environmental Science and Sustainability. A StMU faculty member since 2012, Melissa teaches undergraduate courses in GIS, ecology, experimental design, and conservation biology. Her research focuses on wildlife ecology and conservation genetics applications with canids. Dr. Karlin is the lead StMU PI on three National Science Foundation grants and as the Director of OSRI, co-manages an annual 2-day research symposium for StMU students, faculty and staff.

Dr. Ramanitharan Kandiah, Central State University

Professor of Environmental Engineering, Chair, Department of Water Resources, Engineering and Industrial Technology, Central State University, Wilberforce, Ohio. He holds a Ph.D. in Civil Engineering. He is a registered Professional Civil Engineer in Ohio, Certified Professional Hydrologist

Prof. Krishnakumar V. Nedunuri, Central State University

Dr. Nedunuri holds appointment as a Professor at Central State University (CSU) in the International Center for Water Resources Management (ICWRM). He teaches Fluid Mechanics and Hydraulics, Soil and Water Pollution, Water Chemistry, Water Supply, Groundw

Dr. Kaitlin Hill, St. Mary's University

Dr. Hill is an Assistant Professor of in the Mathematics Department at St. Mary's University. She holds a Ph.D. in Applied Mathematics and teaches calculus, probability, statistics, and applied mathematics courses. Her research focuses on applied dynamical systems and mathematical modeling, with application areas in climate dynamics and social systems.

Dr. Corinne Mowrey, University of Dayton

Dr. Corinne Mowrey is an Assistant Professor in the Department of Engineering Management, Systems and Technology at the University of Dayton. She received her BS in Civil Engineering from the Ohio State University, and both her MS in Industrial and Human Factors Engineering and PhD in Engineering from Wright State University.

Dr. Kellie Schneider, The Foodbank, Inc. (Dayton, OH)

Dr. Kellie Schneider is the Chief Knowledge Officer at The Foodbank, Inc. where she is responsible for gathering, evaluating, integrating, and distributing data and information in support of The Foodbank's mission – "eliminating hunger and its root causes". Prior to joining the leadership team at The Foodbank, Kellie served as an Associate Professor in the Department of Engineering Management, Systems, and Technology at the University of Dayton as well as an Instructor in the Freshman Engineering Program at the University of Arkansas.

Elizabeth Generas, Wright State University

Elizabeth Generas is an external evaluator for education and social justice projects. She completed a graduate certificate in Program Evaluation from Wright State University, where she is also a doctoral candidate in the Doctor of Organization Studies program.

[Work in Progress] Lessons Learned from a Collaborative NSF REU Program Thematically Centered on STEM Research for Social Change and Its Impact Through Community Engaged Learning

Abstract

This paper examines the inaugural cohort of a National Science Foundation Research Experience for Undergraduates (NSF REU) program designed to foster interdisciplinary STEM research for social change, specifically aligned with the United Nations' Sustainable Development Goals (UN SDGs). Collaborative efforts among three universities enabled participants—science and engineering undergraduates in their first to third years—to engage in research projects that aimed to promote social equity and community transformation. Through this program, participants not only strengthened their technical expertise in engineering, chemistry, and physics, but also deepened their ethical awareness of the social, cultural and environmental implications of their research. The paper highlights the lessons learned in managing and facilitating the program, with a focus on leveraging regional resources to create meaningful experiential learning opportunities. It discusses how participants were encouraged to explore their identity formation and its impact on STEM career development while fostering a sense of belonging and self-efficacy in their fields. Using a mixed methods evaluation and assessment approach, findings suggest several implications: (a) an increase in participants' awareness and skills within STEM fields, potentially enhancing interest in these areas; (b) a greater understanding of social change partnerships and their integration into higher education research; and (c) transformed practices that could prepare more students for STEM careers. Emphasizing educational research in engineering and community engagement, this paper discusses the critical importance of promoting access, respect, and opportunity for all in fostering successful community partnerships and addressing environmental issues such as biodegradation, solid waste management, and pollution prevention. Activities focused on complex social issues surrounding food insecurity and availability of healthy food in urban communities as well as successful citizen reentry from prison into communities will also be discussed.

Introduction

In 2020, Bret Eynon and Jonathan Iuzzini published an ATD Teaching and Learning Toolkit with Achieving the Dream [1] that presents a body of work that was developed from the New Learning Compact Framework in 2019 by Every Learner Everywhere [2] with the intent of fostering a culture of teaching and learning excellence designed to enhance student success. Within this Toolkit, evidence-based pedagogies are presented guided by research in validated high impact practices (HIPs) for teaching and learning in higher education as designated by George Kuh and the Association of American Colleges and Universities (AAC&U) in 2008 [3].

One of the many HIPs identified is undergraduate-based research, where students, particularly those majoring in science, technology, engineering and mathematics (STEM), participate in structured inquiry, critical data analysis, and discipline-specific approaches to understanding. Other HIPs highlighted include community based learning, referred to here as community engaged learning (CEL), in which students experience “real-life” situations outside of the

classroom. These experiences require situational problem-solving skills and promote global learning and exposure to diverse perspectives, encouraging creativity, discovery, and innovation through collaborative partnerships among diverse groups.

To enhance and build upon these HIPs, three universities within the United States, Central State University (CSU), the University of Dayton (UD) and St. Mary's University (StMU) received a three-year collaborative grant from the National Science Foundation. This grant supports a Research Experiences for Undergraduates Site titled *"Collaborative Research: REU Site: STEM Research for Social Change."* The main objective of this grant is to provide first through third year undergraduates in STEM fields with research opportunities that promote social equity and community transformation. The program emphasizes ethical and reflective engagement with the socio-cultural and environmental aspects of scientific research. Through immersive undergraduate research experiences, the program aims to foster personal growth and cultural awareness among students as they co-create socially impactful solutions in partnership with communities.

Program Description

The collaborative STEM Research for Social Change REU program welcomed its inaugural cohort of eight undergraduates in the summer of 2024. Over a three-year period, including the summers of 2025 and 2026, the program will engage a total of 28 undergraduates in a 10-week transformative research experience. The experience is thematically focused on social change research that positively impacts society and aligns with the United Nations' Sustainable Development Goals. The STEM Research for Social Change program has four distinct components: (1) Research; (2) Mentoring; (3) Social Capital; and (4) Student Development. A primary objective of this program is to enhance student participants' knowledge and understanding of science and engineering research that meaningfully transforms communities by promoting social change and fairness in society. An additional objective of this program is to use mentors (both faculty and community partners) to enhance scientific and professional skills that will better prepare undergraduate students for graduate school and entering the workforce. A similar and complementary objective of this program is to develop their personal and professional networks for STEM research careers. And lastly, the final objective of this program is for mentors to enhance undergraduates' sense of belonging, identity formation, and competence related to science and engineering research.

Participants and Participant Activities

For the 2024 STEM Research for Social Change cohort, the REU participants engaged with faculty mentors and their community partners in one of five research projects as shown in Table 1. Participants represented a diverse group of individuals, coming from a range of backgrounds, ethnicities and institutions. Prior to the 10-week REU experience, the programming included a virtual kick-off session prior to campus on-boarding, move-in, and residence hall occupancy at the University of Dayton (UD). In 2025 and 2026, Central State University and St. Mary's University will host participants, respectively. Once on site, student participants engaged in a full day orientation session with program principal investigators (PIs) and co-principal investigators (Co-PIs). The orientation opened with an ice breaker activity, marking the first in-person meeting between the cohort and the PIs and Co-PIs. Although this was their initial face-

to-face (F2F) interaction, the group had previously connected through several virtual sessions as noted in Table 2 before arriving. The orientation also included several briefings which pertained not only to responsible conduct of research, laboratory safety and Title IX compliance but also to asset-based research engagement with community partners and developing a sense of belonging. Following a community building lunch session attended by the research mentors, participants joined their respective mentors for laboratory tours, discussions about research projects, and collaborative goal setting to establish research expectations and preferred communication styles. Table 2 outlines the professional development (PD) programming integrated into the REU participants 10-week experience.

Table 1 - STEM Research for Social Change 2024 Participant Research Projects

Research Project	Partner Organization	Participant Number	Participant Major(s) and Academic Rank
Waste Collection Route Optimization to reduce Greenhouse Gas Footprint	Montgomery County Environmental Services | Solid Waste District	1	Sophomore; Computer Science
Porous Carbon Sorbent Regeneration for Dye Absorption Optimization	AIMM Labs, Inc.	2	Freshman; Engineering and Sophomore; Engineering
Bioenergetic Evaluation and Modeling of Microbial Biodegradation	SERDP	2	Junior; Computer Science and Sophomore; Engineering
Citizen Reentry Utilizing a Foodbank Approach	The Foodbank of Dayton	2	Junior; Engineering and Sophomore; Undecided STEM
Sensor Development for Aquaponics	Local Farmers	1	Freshman; Computer Science

Table 2 - STEM Research for Social Change 2024 Participant Professional Development

REU PD Title	Workshop Topics	Category	Format
Know Before You Go	Meet and Great; Program and Housing Expectations, Timeline and Project Teams; Stipend and Meals; Travel and Move-in; University Facilities and Essential Items Needed	Logistics	Virtual
Opening Orientation	Research Ethics and Responsible Conduct of Research; Lab Safety and Anti-Harassment; Asset-Based Research and Sense of Belonging	Professional Skills	F2F
Demystifying Research	Library Resources and Literature Reviews	Professional Skills	F2F
Prestigious Graduate Fellowships	Graduate School Application Processes	Professional and Networking Skills	F2F
Aquifer, Rainfall and Geology Research	Collaborative REU and RET Research Bootcamp	Professional and Networking Skills	F2F
Air Show	Air Show STEM Day; Hands-on Community Engaged Active Learning	Networking Skills	F2F
STEM Summer Research Writing Workshop (Part I)	Crafting Accomplishment; Focused Resumes; Highlighting Research Experience	Professional Skills	F2F
STEM Summer Research Writing Workshop (Part II)	Telling Your Professional Story	Professional and Networking Skills	F2F
Oral Poster and Presentation Practice	Dry Run Delivery and Feedback on Developed Artifacts from PIs, Co-PIs and Community Partners	Professional Skills	F2F
Navigating Networking Events and Elevator Pitches	Key Characteristics of an Elevator Pitch; Examples and Scenarios; Practice to Make a Good Impression; Polite Exit Strategies	Professional and Networking Skills	F2F
STEM Research for Social Change REU Symposium	Collaborative REU and RET Research Symposium Day	Professional and Networking Skills	F2F

Methodology

Using a mixed methods approach [4] and the Joint Committee on Standards for Educational Evaluation to develop the assessment plan [5], both qualitative and quantitative data were gathered and analyzed to document and evaluate the successes and challenges experienced by the year one cohort. Instruments used for evaluation included site observations, mentor and participant surveys, as well as participant interviews. Observations during the end-of-program symposium provided insights into the level of rigor and learning achieved by participants throughout the program. Mentors were surveyed to assess participant progress, and the TIDES survey was adapted to include relevant questions, transitioning from a pre | post format to a comprehensive evaluation of the full experience. TIDES, or Teaching to Increase Diversity and Equity in STEM, is a program initiated by the University of Dayton with funding from the AAC&U to implement an Inquiry-Based Computer Science Curriculum for STEM Student Success with the intent to transform computer-science related curriculum and enhance underrepresented student interest, retention, and competency in STEM fields. As for the individual participant interviews, they offered a deeper exploration of the summer's outcomes and helped identify potential challenges. Interview transcripts underwent coding using Guba and Lincoln's constant comparative analysis [6]. These codes resulted from emerging themes from the individual participant transcripts and related to programmatic objectives.

Results to Date and Participant Impact

Findings suggest several implications: (a) an increase in participants' awareness and skills within STEM fields, potentially enhancing interest in these areas; (b) a greater understanding of social change partnerships and their integration into higher education research; and (c) transformed practices that could prepare more students for STEM careers. As this REU emphasized educational research in engineering and community engagement, qualitative and quantitative results do suggest participants attained new knowledge regarding STEM research based on participation in discipline specific research that provided meaningful societal impact by contending with environmental issues such as biodegradation, solid waste management, and pollution prevention (Table 1). Treatment of these topics in the research projects enabled participants to see the alignment of their significance with the SDG goals. Similarly, fostering successful community partnerships and research activities focused on complex social issues surrounding food insecurity and providing access to healthy food in urban communities as well as successful citizen reentry from prison into communities called several participants "to action" for "social change."

Additionally, this REU emphasized the critical importance of workforce development by promoting meaningful participation and expanding representation in STEM fields. Through its recruitment process, the program broadened access for individuals traditionally underrepresented in STEM. Of the eight participants, in cohort 1, 75% of them identified as female and 62.5% identified as non-white. Additionally, 25% of the students reported attending a Hispanic-Serving Institution (HSI). Moreover, 50% of the participants were sophomore status, with 25% reporting freshman classification and the remaining 25% reporting junior classification. In terms of providing a transformative research experience, in year one, half of the cohort reported having not previously participated in academic research (i.e., four of eight), and that this REU opportunity was a new experience for them allowing them to develop new lab skills, particularly

when it came to working with specific laboratory techniques. Of the remaining four, only one of those participants had significant research experience at three semesters in total. The other three participants reported only one semester of research lab experience.

The professional development sessions were received well by REU participants, in particular the resume building and locating and applying for graduate school and fellowships. They did recommend shortening some of the sessions and incorporating more applied strategies. Overall, the cohort reported more self-confidence and an enhanced sense of belonging and self-efficacy related to engineering and scientific research. In general, 75% of the undergraduates reported greater confidence in overcoming problems, understanding scientific literature, and performing in and having a STEM career. Notably, 25% of participants expressed concerns about competition in STEM, describing it as a barrier that challenged their own sense of self regarding their personal STEM abilities.

Ongoing and Future Work

In year two, strategic changes are being implemented to enhance the recruitment and application process. Short descriptions of potential summer research projects will now include details on their relevance to specific majors, allowing applicants to rank their top choices based on personal interest for better alignment with their academic backgrounds and interests. This approach builds on insights from year one, where participants recognized the importance of diverse disciplines and skill sets in advancing team research efforts.

To further advance this initiative, the program will offer ongoing learning opportunities for undergraduates to engage in research for social change aligned with the United Nations' Sustainable Development Goals. Community partnerships will remain a key component, ensuring that research remains grounded in real-world relevance. Each project is intentionally designed to reflect the SDGs and principles of social justice, fostering meaningful student engagement and reinforcing community-centered values through impactful research experiences. Additionally, the team of PIs and Co-PIs will implement follow-up programming for the second and third cohorts during the summers of 2025 and 2026, respectively, with an emphasis on strengthening structured mentor-mentee interactions.

As participants in cohort two will be hosted by Central State University, faculty mentors from the host institution will lead the research projects, with additional contributions from faculty at the other two institutions. Some projects will continue from year one, while others will introduce new efforts designed to enhance collaboration and innovation across institutions.

Several collaborative projects, including biodegradation, aquaponics, citizen re-entry, and water and waste resource management, will continue in year two. Additional faculty mentors and community partners will be added to accommodate the increased number of participants (10 instead of eight). New collaborations will also leverage ongoing research efforts in semiconductors, horticulture, and forensic science, fostering increased synergy among the three participating universities.

Residence hall accommodations will be secured in advance, with protocols established for emotional support animals (ESAs) and other potential needs from lessons learned in year one.

Mentors, PIs and Co-PIs will connect with mentees virtually before travel to discuss research projects, SDG alignment, community partners, communication and feedback preferences, and logistical details, including coordination with relevant offices at Central State University.

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