

## **Board 278: Enriching the REU Experience through Student-Led Outreach Activities**

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# **Enriching the REU experience through student-led outreach activities**

## **Introduction**

The benefits of undergraduate student experiences are well known. Students participating in research experience for undergraduates (REU) programs report increased skills and self-confidence, a greater sense of empowerment as learners and more motivation to pursue science or engineering careers and graduate degrees [1-8]. REU programs generally aim to engage students in exciting and rewarding research and professional development experiences to motivate them to pursue careers or advanced degrees in the sciences, technology, engineering and math (STEM). Unlike most other types of summer internships, REU programs are typically very student-focused. The faculty interactions, projects, activities, seminars, tours, etc. are purposely designed to generate a positive impact on the student participants. This is certainly true of the NSF-funded Automotive and Energy Research and Industrial Mentorship (AERIM) REU program at Oakland University [9], which so far has involved a total of 112 undergraduate students - more than half of them women - from 76 different universities across the United States in 10-week summer research projects since 2006.

After many years of offering a successful REU experience and observing the direct short and long-term benefits on the student researchers [10], the AERIM REU PIs decided to include a K-12 outreach component to their list of REU activities. This decision was driven by the many documented benefits of service-learning programs, which not only are of value to the persons receiving the service, but also the students providing it [11, 12]. They also help students improve their interpersonal and communication skills and develop a better understanding of the needs of people with diverse or different backgrounds [13]. In this paper we report on the organization and results of an initiative to incorporate an outreach activity in the AERIM REU 2022 summer program. Assessment results of the outreach activity will also be shared.

## **Outreach Activity Logistics**

An initial experiment with incorporating an outreach activity to K-5 students in an economically disadvantaged charter school in Detroit was conducted by the PI a few years ago and showed clear benefits to the REU students [14]. In that initial attempt, students were tasked in early June with developing hands-on activities and presentations that could excite first through fifth graders about engineering and STEM. While the activity was highly rated by the REU and elementary school students and teachers, the logistics of working with elementary school teachers close to the end of their school year did not seem to be sustainable. The AERIM REU program typically starts in late May, so REU students only had 1-2 weeks to prepare for their outreach activity, just as they themselves were trying to get started with their REU projects. The very positive feedback from the REU students convinced the PIs of the benefits of trying to incorporate an outreach activity in future summer REU programs, but perhaps with a different partner and timeline. Furthermore, including an outreach activity is also in line with Oakland University's strategic goal and mission

of serving the needs of our neighboring communities through increased community engagement activities.

If the COVID-19 pandemic has taught us one thing, it is the importance of flexibility when plans have to change. First, we had to cancel the AERIM REU program in summer 2020, then had to pivot to a fully virtual format in the summer of 2021 due the COVID-19 pandemic [15]. The AERIM REU program was finally again offered in-person in the summer of 2022, hence allowing for the inclusion of an outreach activity. The initial plan was to partner with a non-profit science center in the city of Detroit. Unfortunately, the science center was experiencing staffing changes, as well as ongoing challenges due to COVID-19, so the AERIM REU PIs had to come up with an alternative.

The School of Engineering and Computer Science (SECS) at Oakland University has a robust and active K-12 outreach program that runs year-round and includes a variety of activities such as field trips to visit engineering labs at OU, hands-on activities, tutoring, summer camps, etc. for elementary through high-school students from a variety of school districts in Southeast Michigan. SECS recently partnered with the Engineering Society of Detroit (ESD) to offer a summer residential STEM program, targeting under-represented minority middle-school girls from the city of Detroit and surrounding areas. The goal of the ESD Girls in Engineering Academy (GEA) is “to improve academic achievement and increase the interest in engineering among girls. ESD’s overarching goal is to decrease the gender gap in engineering professions by helping girls to excel at science, technology, engineering, and mathematics (STEM) and eventually pursue engineering careers” [16]. From July 10 until August 5, 2022, the School of Engineering and Computer Science hosted a four-week on-campus residential camp for 25 rising 9<sup>th</sup>-grade girls from the Detroit area. 83% of the participants were African American and 6% were Hispanic [16]. The on-campus program involved a mix of STEM hands-on activities, computer programming, technical writing and personal development. Every Friday was “Ford Friday,” during which the camp participants interacted with Ford employees and engineers and visited industry facilities. In consultation with the SECS assistant director of outreach, the REU PI’s selected the GEA program for the REU community engagement activity. While the SECS outreach programs connected with almost 3000 K-12 students over the summer, the team felt that the GEA program would have a more significant impact overall as it focuses on providing educational opportunities to underrepresented minority students and could provide a good service learning opportunity for the eight REU students taking part in the 2022 AERIM REU program.

While the schedule for the GEA participants was quite full, it generally included time in the afternoons for more open-ended, hands-on activities. The REU students were working in teams of two on a variety of research projects and would be on the same teams for their service learning undertaking. The organization of the outreach activity proceeded as follows:

1. REU students were reminded on the first day of the program that they would participate in an outreach activity later in the summer. This information had been included in the program announcement and website at the time of their application, as well as in their offer letter.
2. In mid-June, a meeting was organized with the SECS assistant director of outreach. In that meeting, she discussed the ESD GEA program with the REU students and tasked them with developing outreach activities and presentations for the camp participants, with a planned date in mid-July.

3. Each REU team was responsible for developing one 1-1.5 hour activity. REU students were given complete flexibility to develop their outreach activities with little faculty influence, but were encouraged to focus on hands-on activities that could relate back to their ongoing REU research projects and that would excite the camp participants about STEM.
4. Teams shared their ideas with their research advisors, the PIs and the SECS assistant director of outreach for feedback. They also developed materials lists for any supplies that they might need for their planned activity, which were then ordered by SECS staff. One team was so resourceful that it reached out to the chair of the department of biological sciences to request access to a biology lab and to a set of microscopes for the day of their presentation! The SECS assistant director of outreach reviewed each proposed project and worked with the REU teams to ensure that they were created with developmentally appropriate practices in mind. Had the target group involved younger or older K-12 students, the activities would have been different.
5. Since the camp participants were minors, all of the REU students had to undergo a background check per university policy. This process was initiated early on to ensure no delays.
6. Each team was assigned a day and time in mid-July for its activity.

### **Hands-on Activities**

One of the great pleasures of giving students full ownership and flexibility in developing their outreach activity is seeing the variety of ideas that they came up with and the enthusiasm that they showed for the task at hand. The 2022 AERIM REU cohort was somewhat smaller than in previous years, eight students rather than ten, in part because we had recruited twelve students rather than ten the previous year when the program was fully virtual and internship opportunities for students were more scarce due to the pandemic. The group included two women, one non-binary and one Hispanic student. One quarter of the students were first generation in college. They varied from freshmen to seniors with majors spanning a variety of disciplines including mechanical engineering, physics, biology and bioengineering. Table 1 summarizes the groups' research projects along with their outreach activity (described in their own words).

As can be noted from Table 1, each group approached the task at hand differently, yet all found a way of relating their activity to the general research area that they had spent the previous weeks working on.

**Table 1:** REU research projects and outreach activities

<b>Group</b>	<b>Research Project</b>	<b>Outreach Activity</b>
Algae	Optimizing algae cultivation for carbon capture and biodiesel production	We shared a presentation about ourselves, why we chose STEM and our project. We taught them how to prepare a sample and use a microscope. We provided samples of the freshwater pond by Vandenberg Hall and our algae. At the end, they drew and colored pictures of their algae.
Battery	Understanding the nucleation of sulfur at electrode-electrolyte interface for lithium-sulfur batteries	Our outreach project was to construct an air battery and measure voltages. The students poured different liquids into cups and used aluminum foil and copper foil as the electrodes of the cell. Different cells were connected in series and a multi-meter was used to measure the voltage of the connected cells. Then an LED was connected to the cells where it was able to be dimly lit.
Vibrations	Energy capture from automotive engine vibrations	We presented our project to the students then lead them in an activity where they created a vibrating doodle bot. Using simple materials like markers, a cup, a small DC motor, and a battery pack, the students created a simple robot that skips around when turned on. Because the legs are markers the students could set the robot on a piece of paper and let the robot draw a picture.
Matlab	Assessment tools for perceived sound quality enhancements	For the outreach activity we talked to the students about sound and our project and then did a Python coding activity. We gave them the code but hid a few of the lines within the definitions so they could try to write it on their own. The code creates a rock paper scissors game between the user and the computer.

### **Assessment Results**

REU students were surveyed about their expectations and experience at the start and end of the summer REU program. Table 2 summarizes their responses to questions pertaining to the service learning/outreach activity pre- and post-REU. The program evaluator developed the brief outreach activity assessment to measure youth perceptions/attitudes toward engineering and more broadly, STEM activities. The project did not use a specific, established instrument, but recognized the work of Lederman [17] in influencing the questions we developed. We wanted to know the level of interest and enjoyment of the youth while involved in the camp activity—even to the extent of wanting to understand if STEM would be a study of pursuit when progressing through school. We wanted to know if engaging with undergraduate students and collaborating on an activity would spark a specific view or attitude of curiosity (interest) and satisfaction (enjoyment).

**Table 2:** Survey responses to questions pertaining to outreach activity on a scale of 1 to 5

Question	Min	Max	Mean	Std Deviation
<b>Pre-REU Survey</b> (Priority placed on the following items): 1 = the item is a very low priority and 5 = the item has an extremely high priority				
The opportunity to help learn while participating in a community engagement/service learning experience	2.00	5.00	3.57	0.90
Learning more about the needs of diverse groups of people while participating in a community engagement/service learning experience	3.00	5.00	4.29	0.70
<b>Post REU Survey</b> (Meeting Expectations): 1 = the program completely failed to meet expectations and 5 = the program has fully met expectations				
The opportunity to design and conduct a STEM outreach activity for high school camp students	1.00	5.00	4.25	1.30
<b>Post REU Survey</b> (Level of Satisfaction): 1= low satisfaction and 5 = high satisfaction				
Designing and conducting an outreach activity for high school summer camp	1.00	5.00	4.13	1.36
REU program overall	2.00	5.00	4.38	0.99

As shown in Table 2, students were generally very satisfied with the outreach activity despite giving it a lower priority in the pre-REU survey. To put the data in context, the REU program overall was rated a 4.38/5.0 with a large standard deviation that can be attributed to the impact of one unsatisfied student and a small sample size. When asked to comment on whether an outreach or service learning activity should be a component of future REU programs, students included the following comments.

- *The activity was really cool and fun*
- *The outreach activity was something that should be included in future REU programs because it helped for us to better understand our projects. The program also was a way to help give back to the community and help students see a future career in engineering is possible.*
- *Yes, this was great and should definitely be continued. I think everyone involved had a great experience.*
- *Definitely recommend it for future programs.*
- *It was really fun!*
- *Greatly disliked it. Once again, had I noticed that the outreach activity was required, I would not have applied here.*

While almost all of the responses were very positive and indicated that the outreach activity was fun and should be included in future programs, it can be noted from the last comment that one student was very unhappy with having to take part in such an activity. This dichotomy becomes even more evident in a focus group discussion with the program evaluator. When queried about their experiences with the outreach activities, three key themes arose from the discussion: 1) that the activity gave the REU students a better understanding of their own projects and teaching abilities, even if the experience was not enjoyable for one of them; b) the middle-schoolers had

fun and learned coding; and 3) there is a need to reach out to diverse groups and to the younger generation. In the focus group discussion, one student reflected that “*I think as a whole, for us, to dumb-down our research so they can understand a standard helps us to understand our material. Yes, it gave us a better understanding of our own project and the kids did have fun—that was a good purpose of the activity.*” The dissatisfaction of the one student who disliked the activity is apparent in this exchange with notes from the program evaluator, “*I was not a big fan of the outreach activity. I do not like working with kids and that could have been mentioned more in the application process [others interjected: “it was very clearly mentioned”]. I did not want to work with kids for two hours.*” While this comment raises questions about what to do with students who are not very sociable or who are uncomfortable in settings involving younger students in the future (should we exempt them from the activity or should we continue to require some level of participation by all students given the obvious benefits?), all of the other feedback shows that the REU students saw value in the experience, and more importantly, saw and reflected on the benefits for the middle-school girls. Particularly poignant was this comment made by one of the REU students during the discussion:

*Not only for ourselves, but for the future of the STEM world, having a more diverse community in STEM—women, POC, having LGBTQIA+—it’s really predominantly cis, white, straight males right now and that’s really upsetting. And I think that that creates lots of problems. And so trying to get black women in STEM is very, very big part of it—that we need to reach out to the younger generation, be pushing for this, so I was thrilled to be a part of this opportunity. I think as we get further on with our careers, I think that it’s important to do outreach to younger people who want to pursue STEM, too, because if we do not reach out to them, then STEM just stops—you have to reach the younger generation.*

Feedback from the SECS assistant director of outreach was extremely positive, characterizing all of the REU student-designed and led activities as “remarkable and engaging,” and indicating that the “students of ESD truly enjoyed themselves!” Although the REU outreach activity was only a small component of the 4-week Girls in Engineering Academy summer camp, ESD reported regarding the camp “all the students who participated said we exceeded their expectations in the overall experience.”

In conclusion, incorporating an outreach activity into an REU program was a positive and thought provoking experience for most of the students involved. The time commitment required out of the 10-week REU program was relatively small, yet it provided the REU students with an opportunity to act as role models, mentors, teachers and STEM cheerleaders. It also required them to come up with ways of explaining their research to a lay audience, a skill that is becoming even more important nowadays as scientists need to find better ways to communicate their work to the public at large. While we encountered the small challenge (learned after the fact) of the dissatisfaction of one student with having to take part in an outreach activity, it is our intention to continue to incorporate such an activity in future years.

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