REU programs and K-12 outreach: A natural synergy

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Introduction:

Since the summer of 2006, the department of Mechanical Engineering at Oakland University (OU) has been organizing a research experience for undergraduates (REU) program that has been successful at recruiting underrepresented undergraduates in engineering – women in particular. Funded through the National Science Foundation REU program, this summer REU program focuses on automotive and energy-related research projects. The Automotive and Energy Research and Industrial Mentorship (AERIM) REU program at Oakland University aims to engage participants in rewarding automotive research experiences that excite and motivate them to pursue careers in scientific and engineering research, and seeks to address the nationwide problem of the under-representation of women and minorities in the sciences, technology, engineering and math (STEM) [1-2]. To date, 92 students from 64 universities, more than half of whom were female, have taken part in this program.

REU programs are designed around the needs of the undergraduate student participants. The research projects, seminars, laboratory/industry tours, meeting with mentors, networking events and other activities are all set up to maximize the positive impact of a research experience on the students. After all, numerous studies have shown that active participation in hands-on undergraduate research is one of the most effective ways to attract and retain talented undergraduate students, to motivate them towards pursuing careers and advanced degrees in engineering and science, to help them feel more connected to their educational experience and to provide them with a greater sense of empowerment as learners [4-11]. While many student participants have benefitted over the years from their REU experience, the AERIM REU decided to introduce a service learning/community outreach component to its program. One of the distinguishing features of service learning programs is that the goal is to benefit both the students providing the service and the persons receiving it [12, 13]. Service learning programs also help students improve their interpersonal skills and develop a better understanding of the needs of diverse groups of people while also benefiting the recipients of the activity [14]. Hence, one summer, AERIM REU students, led by a former REU program participant, were tasked with developing outreach activities and presentations for K-5 students in an economically disadvantaged charter school in Detroit. The outreach activities were meant to excite the K-5 students about STEM and to provide them with an opportunity to engage in some hands-on activities. These predominantly African American students had very little prior exposure to college students and even less exposure to role models working in STEM.

Program Organization:

The REU undergraduate student researchers were first told about plans for an outreach activity on the very first day of the REU program. The activity was scheduled on a day during the second week of the REU program due to the K-5 academic calendar. Many students initially voiced concerns at the thought of having to come up with some hands-on activities and to give a presentation to young children with so little preparation time. However, a previous REU experience with an outreach program at Worcester Polytechnic Institute recommended that
outreach activities take place earlier in the REU program so as to be “less disruptive to the research activities of the REU students.” [14] Furthermore, it has been our prior experience that most professional development activities and field trips/industry tours are best offered in the first 6-7 weeks of a 10-week REU program as students are most involved and busy with their research projects in the last 2-3 weeks and are reluctant to be distracted from their research activities.

REU students were given complete flexibility to develop their outreach activities with little faculty interference. A prior REU undergraduate researcher who had worked on some outreach activities at Oakland University, Caymen Novak (now a Ph.D. student at the University of Michigan), was recruited to guide them through the process. Caymen met with the students, discussed their interests with them, shared some best practices with them and had them brainstorm about simple, low cost and fun experiments that they could demonstrate to the K-5 students. The goal was to introduce first through fifth graders to different engineering disciplines and to talk to them about what it's like to study engineering and to be an engineer. The tight time schedule required the REU students to work quickly and to learn how to work as a team. It also gave them an opportunity to develop group camaraderie early on in the program. After several discussions and some consultations with the REU program director, the students settled on several hands-on activities, including a saltwater lightbulb, a steam engine, a Lego robot, paper airplane design and testing with students, a spaghetti bridge, a friction slide with different materials and a fluid separation demonstration. The students also developed a list of materials that needed to be procured. Enough supplies were purchased or borrowed from various labs to allow for multiple demonstrations with multiple classes.

Given that the school wished to have the REU students stop by every first through fifth grade class, the REU students split up into two groups, one for the morning and one for the afternoon. Both groups were accompanied by Caymen at the school. The 11 REU students were a relatively diverse group that included four female, one African American and two Hispanic students. They varied from freshmen to seniors. Most had limited oral presentation experience and no prior outreach experience with K-5 students. In each class, the REU students briefly discussed what engineers did and what it was like to be an engineering student and then proceeded to conduct the hands-on activities with the elementary school students under the watchful eyes of their teachers.

**Survey Results:**

Subsequent to the outreach experience, the REU students were surveyed about their experience with the outreach activity. In addition to providing demographic information, they were asked to rate their level of satisfaction or agreement with several statements on a scale of 1 to 5, with 1 being strongly disagree and 5 being strongly agree. Results are summarized in Table 1.

As shown in Table 1, despite their previously stated misgivings during the first week of the program, the average ratings for all questions were 4.5 and above on a 5-point scale. Students felt that they were given enough time to prepare for the activity, that the limited amount of guidance that was provided to them was sufficient and that they liked being given the freedom to come up with their own presentations and activities. More importantly, they felt that the children were engaged during the activities (something that was corroborated by Caymen and by the
teachers) and that they felt that both they and the children had benefited from the REU activity. This early in the program, several of the REU students were still somewhat shy and generally uncomfortable speaking in public, yet the experience of sharing their own passion for engineering with younger children who looked up to them and, dare we say, saw them as mentors, was rewarding. All of the REU students reported that such activities should continue to be part of the REU program in the future.

Table 1: Survey Responses on a scale of 1 to 5 (1 being strongly disagree and 5 being strongly agree

<table>
<thead>
<tr>
<th>Survey Question</th>
<th>Avg. Rating</th>
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<tbody>
<tr>
<td>We were given enough preparation time to develop our presentation and activities in the days prior to our visit to the school.</td>
<td>4.7</td>
</tr>
<tr>
<td>We were given enough instructions on what to do to prepare for the event.</td>
<td>4.7</td>
</tr>
<tr>
<td>I liked being given the freedom to come up with our own presentation and activities.</td>
<td>4.7</td>
</tr>
<tr>
<td>The children seemed to be engaged during our presentation and activities.</td>
<td>4.8</td>
</tr>
<tr>
<td>Our engineering demonstrations and activities were appropriate for the age-level of the audience and the time allowed.</td>
<td>4.6</td>
</tr>
<tr>
<td>The children benefited from our outreach activity.</td>
<td>4.5</td>
</tr>
<tr>
<td>I feel that I benefited from this outreach activity.</td>
<td>4.6</td>
</tr>
<tr>
<td>I enjoyed taking part in this activity.</td>
<td>4.8</td>
</tr>
<tr>
<td>An outreach or service learning activity should be a component of future REU programs.</td>
<td>4.5</td>
</tr>
</tbody>
</table>

More telling however were comments that the REU students provided in the open comment section of the survey. Some are summarized below:

- *It feels great to communicate science to a younger generation. The looks in their faces during the experiments or when you ask a question is invaluable.*
- *I didn't want to do the activity initially, I thought the kids were going to give us a hard time. But, I ended up having fun, especially when giving the demonstrations. Now I know that elementary school kids aren't so bad.*
- *Worked on my presentation and communication skills in front of a large group. Did not have a lot of experience presenting to children before this event. It was a learned [sic] event for me as well. I also realized how interested some children are at a young age about science.*
- *The development of communication and presentation skills is really important. Presenting during the outreach activity was a good practice.*
• It was really nice to get out and do something for the community, and it was fun to see how excited the kids were about engineering.

• A lot of students, especially in the fifth grade class, had so many questions that we did not have time to answer them all. I was wondering maybe we should have had a shorter presentation and longer Q & A section. I'm not sure if the students would have enjoyed and learned more with a longer Q & A section.

• I think if we were given some more time, we could have had the kids do an activity relating to engineering, which could be beneficial. (Note: this comment referred to the amount of time at the school)

• A similar activity, but with local high schoolers, would be a good opportunity to use more interesting/complex experiments.

These and other comments show that the REU students not only enjoyed the experience, but walked away from the outreach activity seeing benefits to both the K-5 students, as well as to themselves. Furthermore, it shows that some of the REU students started to reflect about the effectiveness of their “teaching” and of ways to further improve the benefit to other students in the future.

Given that the outreach activity took place close to the end of the school year, efforts to get the already time-strapped elementary school teachers to complete a survey were unsuccessful. However, email feedback from the teachers indicated that they were very happy with the activities as they saw their students engaged and excited about engineering and hands-on activities. Efforts will be made in the future to obtain additional assessment data to gage the impact on the K-5 students.

All and all, this was a positive experience for all involved. It did not take too much time away from the REU students’ research activities, yet provided them with an opportunity to reach out to younger students. It provided the REU students with an opportunity to work on their communication skills. By requiring the REU students to share their experiences and enthusiasm for engineering, it reminded them of the reasons why they chose to pursue engineering or STEM degrees in the first place. Given the positive outcomes of this experiment, it is our intention to organize such activities in future REU program offerings.

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