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BOARD # 301: REU: Outcomes and Lessons Learned After Organizing a Summer REU Program a Dozen Times over 17 Years

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REU: Outcomes and Lessons Learned After Organizing a Summer REU Program a Dozen Times over 17 Years

Introduction

First offered in the summer of 2006, the NSF-funded Automotive and Energy Research and Industrial Mentorship (AERIM) Research Experience for Undergraduates (REU) program [1] has now gone through four full 3-year funding cycles and has been offered a total of 12 different summers, with 1-2 year breaks in between. The focus of this REU program has long been on automotive and energy research, with strong ties to the automotive industry in Southeastern Michigan. A total of 122 students from 83 different colleges and universities have taken part in the program and have now progressed to different points of their academic and professional paths. One of the greatest successes of this REU has been its ability to attract a diverse group of undergraduate researchers, with groups historically underrepresented in engineering (particularly women) representing over two-thirds of the participants. The program is assessed each year using pre- and post-surveys, as well as focus group discussions in the past 3 years. The assessment and follow-up has also included periodic emails and surveys to gauge the outcomes of the program several years after students have completed the REU. Maintaining contact and tracking the career progressions of students after several years is no easy task, but one that has been made easier with the advent of professional social networking sites, such as LinkedIn. The goal of this paper is to report on some of the demographics and outcomes of this REU, as well as share some of the lessons learned, particularly since the advent of COVID-19.

Program Structure

Over the past 17 years, the primary objective of the AERIM REU program at Oakland University (OU) has been to engage undergraduate students, particularly women and those from other underrepresented groups in engineering, for 10 weeks each summer in rewarding research experiences that **excite and motivate them to embark upon graduate studies and pursue careers in science and engineering in industry, government or academia**. This is achieved by creating a student-centered, supportive, encouraging, and intellectually stimulating environment that allows talented students to explore challenging new areas, connects them with mentors, refines their communication skills, engages them in a community service activity and increases their confidence levels [2,3]. Students work in small teams on a research project under the mentorship of a faculty member, and often, a graduate student and industry mentor. In addition, students participate in a number of professional development activities, including touring industry facilities, attending seminars, participating in an outreach activity to K-12 students [3], meeting with automotive and energy professionals and giving poster and oral presentations on their research.

Recruitment Strategies and Student Demographics

Recruitment for the program followed a multi-pronged approach. Many students found the link to our program through the NSF REU page or through past REU participants and applicants. We also generated a flyer advertising the program - with an embedded QR code linking to the application page - and emailed or mailed it to a number of contacts and institutions, including, but not limited to:

- Department heads of mechanical engineering programs via a list-serv of ME dept. chairs
- Faculty advisors to student chapters of relevant professional organizations such as SAE, SWE, SME NSBE, ASEE Women in Engineering Division (WIED) and WEPAN
- Individual faculty members at various institutions, including HBCUs
- Advising coordinators at neighboring community colleges and universities

- Career services offices who would post the announcement through the job search platform, Handshake
- The Institute for Broadening Participation [4]
- Students specifically identified by faculty members

The program was open to undergraduate science or engineering students with a GPA of 3.0 or above and who were US citizens or permanent residents. In the 2010-2023 period, between 50 and 120 applications were received each year for 8-10 available positions. Each year, 25%-50% of these applications were from women students, and 40%-70% were from underrepresented groups (URG) in engineering (women, African American, Hispanic/Latino, American Indian/Alaska Native). Student selection was based on a combination of factors, including personal statement (on which we placed a large weight), letter of recommendation, GPA, any prior research or practical experience, home institution classification and location. Our REU program announcement clearly stated that prior research or internship experience were not required. This is particularly important for students from under-represented groups or first-generation students, who benefit even more from a research experience [5,6]. When selecting the participants, we aimed for a mix of students who had prior experimental or practical experience and students who had none.

Figure 1 shows the distribution of REU participants in terms of college classification at the time of application for each year of the REU program. In recent years, a significant proportion of the student participants have just completed their freshman year. Although our REU grant generally provided funding for eight (in 2006 – 2008) or ten students (2010 – 2023) per year, we sometimes sought and obtained additional funding from OU to support additional students, resulting in 120 total participants. Due to the transition to a fully virtual program in summer 2021 due to Covid19, we elected to fund 12 students due to the dearth of internships for students at the time [7]. The GPA's of the student participants varied between 2.98 and 4.0 with averages between 3.3 and 3.7 depending on the cohort. We purposely selected students with a range of GPAs, and from a variety of institutions, including 4-year colleges, colleges with limited graduate programs, institutions designated by the Carnegie Foundation as being research intensive and extensive universities, as well as three community colleges. More than 80% had no prior research or co-op/internship experience, and this was the first exposure to research and engineering outside of a classroom setting for most students.

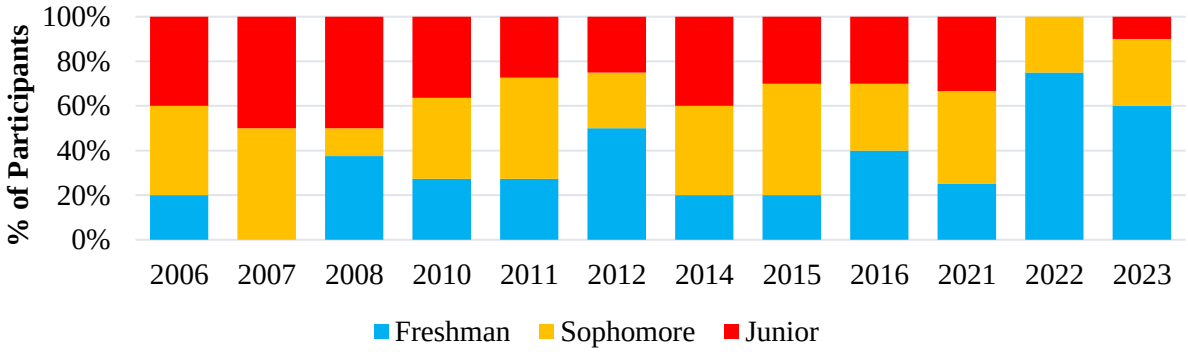

Figure 1: College Classification of REU Participants as a Percentage of Total

Figure 2 shows the gender distribution of the REU participants, where since 2006 **49% have been women**, in addition to one non-binary student participant, with between 40% and 70% of participants identifying as women or non-binary in each cohort. This is significantly higher than the 24.1% of all engineering, and 17.6% of mechanical engineering bachelor's degrees awarded nationally to women students between 2020 and 2022 [8], indicating that we succeeded at reaching one of our key targeted demographics.

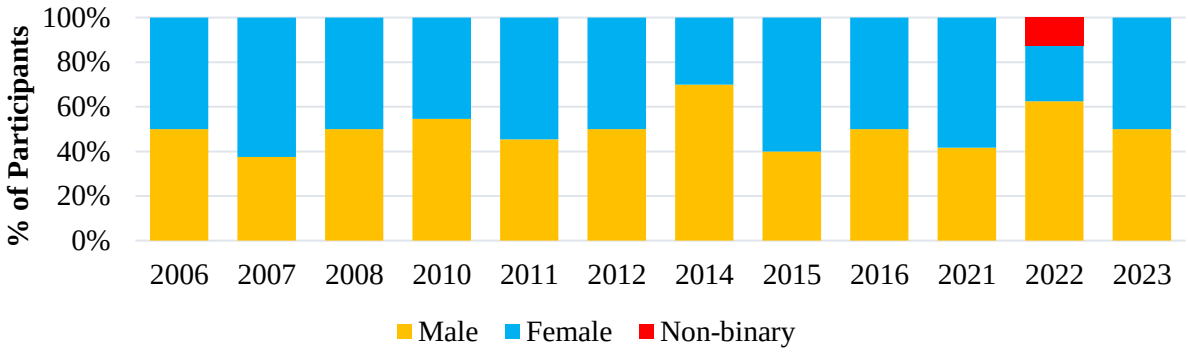

Figure 2: Gender Distribution of REU Participants as a Percentage of Total

The distribution of ethnicity of REU participants is shown in Figure 3. While the distribution varied year to year, over the twelve summers that we offered the program **16.7% identified as Hispanic/Latino, 7.3% African American, and 1.7% American Indian/Alaska Native**. These percentages were still higher than the 13.6% of bachelor's of engineering degrees awarded nationwide in 2021 to Hispanic students, the 4.7% to African American students and the 0.3% awarded to American Indian/Alaska Native students [8]. Noteworthy is the fact that over the life of the program, **70% of all participants were from an under-represented group in engineering** and 37% of the 30 student participants between 2021 and 2023 were first generation college students.

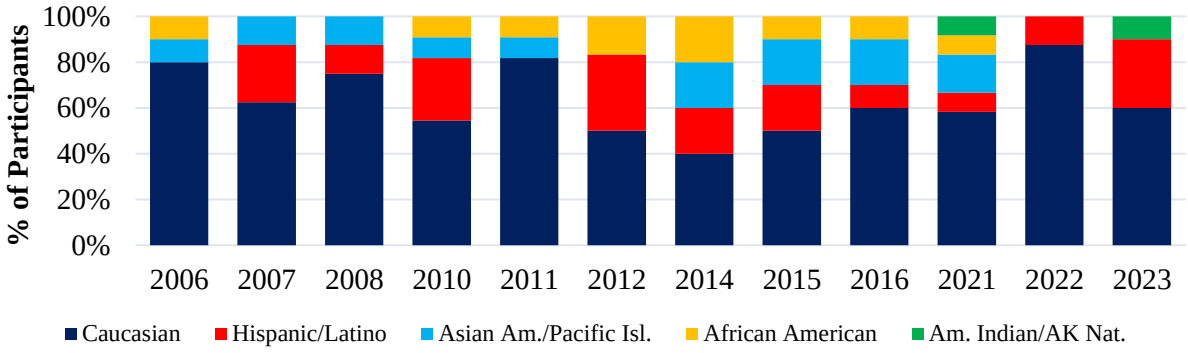

Figure 3: Ethnicity Distribution of REU Participants as a Percentage of Total

Longitudinal Assessment and Program Outcomes

Sixteen different faculty members volunteered between 2006 and 2023 to mentor REU student projects. Additional faculty members assisted with some of the group activities and assessment processes. A full list of projects completed as part of this program can be found on our website [1]. All of the REU students were encouraged to present their research results at professional conferences after completing the REU. Since 2006, the REU research projects have resulted in 63 conference and/or poster presentations, 17 conference proceedings or journal manuscripts, one of which was awarded the 2017 SAE Myers Award for Outstanding Student Paper, and 16 conference papers and poster presentations by faculty about the REU program [9].

A longitudinal email survey of our REU participants spanning 17 years was conducted in August 2024, receiving a nearly 70% response rate. When asked to rate various aspects of the REU program on a 5 point Likert scale that varied between *strongly disagree* and *strongly agree*, 87.2% of the respondents strongly agreed or agreed that they saw more "real world" relevance in their courses after completing the REU, **98.73% that their confidence level had improved as a result of the REU program**, 88.16% that their REU experience had helped them secure an internship, full time job or graduate school admission and

98.73% that they would recommend our REU program to other students. All of the former participants who have graduated work in STEM fields, except for one participant who went on to earn a law degree and is now an associate focused on patent law and intellectual property. They report working in a variety of fields, companies, and industries, including research, academia, national laboratories, automotive, energy, aerospace, and NASA. In the comments section of the survey, many reflected on the impact of their REU experience, describing it as *"a wonderful program that opened many doors to my career"; "incredibly impactful… many opportunities in networking and career development have been especially beneficial to me"; "REU was honestly one of the best parts of my undergrad for so many reasons…growing up shy and unconfident, the position helped me build confidence, interact with peers from other schools and helped me feel much more confident when applying for first jobs in my career…"; "Honestly, I had a wonderful experience in the program and I wouldn't have even been interested in research if I didn't do this program! I'm in the process of writing up my dissertation and defending soon"*.

One of the metrics that we use to assess the impact and outcomes of this REU program is the percentage of participants who later enroll in graduate school and pursue careers in STEM fields. This is in line with NSF goals. Not all students from the 2021-2023 cohorts have graduated yet, so our analysis here focuses on the 2006-2016 cohorts. This extends prior reporting that we had made on the earlier cohorts [10]. As shown in Figure 4, in their responses to the pre-REU surveys, between 10% and 44.4% of the 2006-2016 participants stated future plans to attend graduate school; the remainder indicated that they were either undecided or planned on working post-graduation. Not surprisingly, these percentages increased in the post-REU survey which was administered on the last day of the program since the importance of graduate school was emphasized throughout the program. However, the impact on graduate school plans persisted in the longer term. Of the 90 students who participated in the REU between 2006 and 2016, between 62.5% and 90% applied to a graduate program (depending on the cohort) and over 77% have either matriculated in or completed one or more graduate programs. Paying down student debt and the desire to gain some work experience were the main reasons stated by students who have decided not to enroll in graduate school immediately upon graduation.

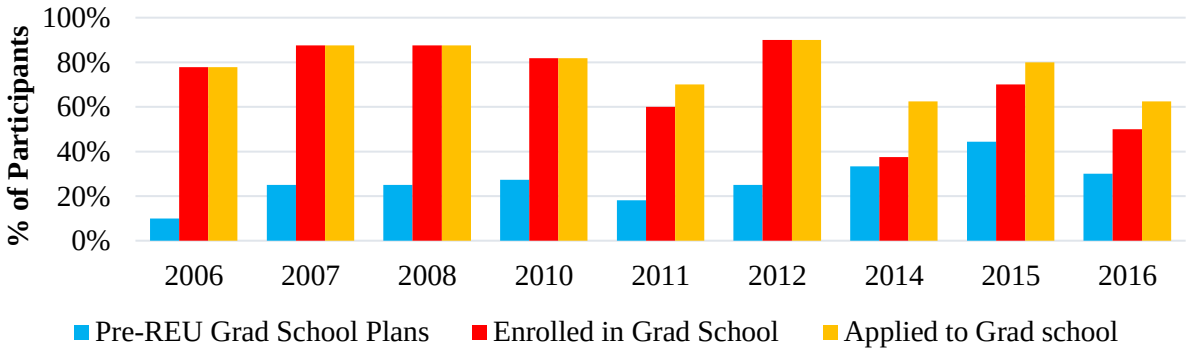

Figure 4: Comparison of Pre-REU Survey Results and Actual Post-Graduation Graduate School Attainment (2006-2008, 2010-2012 and 2014-2016 cohorts)

Conclusions and Some Lessons Learned

One of the biggest challenges with long-term assessment of an REU program is the fact that most of the participants are not part of the REU-site institution and may no longer use their school e-mail address once they graduate. Maintaining regular contact with past participants is critical for longitudinal studies. Collecting personal, non-school email addresses at the beginning and end of the program is important to ensure that students are reachable post-graduation. With the growing trend of less responsiveness to email, the PI's have been encouraging students to create LinkedIn accounts and to update their resumes (with the

help of a Career Services staff member) while they are participating in our REU program. Faculty then connect with them via LinkedIn or other social media, allowing for periodic contact and updates on their career progress. Text messaging is also used periodically to contact some of the more recent participants. These strategies have been so successful that, as of August 2024, we have only lost contact with three former participants since the program's inception in 2006.

The advent of Covid-19 and the need to switch to a fully virtual format in the summer of 2021 brought about some useful lessons as well. The availability of virtual meeting and chat messaging options such as Zoom or Discord now make it easier to schedule and conduct virtual meetings with REU students prior to the start of the program, allowing for discussions of logistics, project topics and other important background information before students even set foot on campus. Such tools also allow for more frequent communications between students and their faculty mentors, and have also allowed us to expand our pool of seminar speakers since they do not need to be physically located in our local vicinity.

The successes that our students have had through STEM employment or through successful graduate degree completion after completing the REU program point to the successful achievement of our stated goals. While these outcomes cannot solely be attributed to the REU program, student feedback and communications indicate that their REU experience played a significant role in their career trajectories.

Acknowledgments

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