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Early lessons learned from pivoting an REU program to a virtual format

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Early lessons learned from pivoting an REU program to a virtual format

Since the summer of 2006, the NSF-funded Automotive and Energy Research and Industrial Mentorship (AERIM) Research Experience for Undergraduates (REU) program in the department of mechanical engineering at Oakland University (OU) has been offering rich research, professional development, networking and cohort-building experiences to undergraduate students in the science, technology, engineering and math (STEM) fields [1]. With a focus on 10-week long hands-on automotive and energy research projects and a close proximity to many automotive companies, the program has been successful at attracting a diverse group of students. In fact, a total of 104 students from 70 different universities have participated in the program over the past 15 years, with about 70% of the participants coming from groups that have traditionally been underrepresented in engineering (women in particular). Most research projects have been team-based and have typically involved experimental and analytical work with perhaps a handful of numerical simulation-based projects over the years. Prior assessment has shown that students greatly valued and benefited from interacting with faculty mentors, industry professionals, industry tours, and each other [2-4].

REU programs are supposed to be student-centered. Unlike industry internships where the experience of student interns can depend on how much time and effort engineers or supervisors put into assigning them meaningful projects, everything in an REU program is intended to provide the student participants with a positive and enriching experience. REU experiences such as the one at OU provide not only a research experience, but also multiple opportunities for students to grow professionally and academically through seminars, industry or laboratory tours, professional development opportunities, conference presentations, as well as social activities meant to enhance their sense of belonging and increase their sense of self efficacy. The research literature is very clear about the positive impacts of research experiences on undergraduate students, particularly as a way to retain students in STEM, motivate them to pursue STEM degrees and careers, empower them as learners and help them see the relevance and applications of their coursework [5-11]. Prior long-term assessment of our REU program indeed confirms these positive impacts [2]. The AERIM REU program also includes a service learning/community outreach component, which as prior research has shown, has the double benefit of helping the REU participants develop a better understanding of the needs of diverse groups of people, while also providing exciting learning opportunities about STEM for K-12 students [12-14].

As a result of limitations placed on in-person meetings and on-campus activities impacted by the Covid-19 pandemic, like many others, the AERIM REU program was cancelled in the summer of 2020 and then had to pivot to a virtual format in the summer of 2021. Offering the program in a virtual format raised many questions: How could the research projects be conducted with students working remotely? What would happen to the industry/lab tours (which are usually one of the highlights of the summer experience), the outreach activity, as well as meetings with industry professionals? Would students be able to develop connections with the faculty and each other while working virtually? In this short paper we discuss some of the challenges, but also some of the opportunities, that come from offering an REU program virtually.

2021 Student Demographics

Despite the virtual format, the program was successful at attracting a diverse group of students in 2021. In fact, due to the cancellation of many student internships due to Covid-19, we decided to enroll twelve rather than ten undergraduate students in the summer program as a way of maximizing the benefit to students, many of whom had lost internship or research opportunities the previous summer. The twelve students hailed from eight different institutions and encompassed four time zones ranging from Eastern Standard Time to Alaska Standard Time. The 2021 cohort included seven women, three underrepresented minorities, and two students with a reported disability. As seen in Figure 1, over 80% of the participants came from an underrepresented group in engineering (women, African American, Hispanic or Native American), which was even higher than our historical average of 70%. Furthermore, half of the students were first generation in college students, 75% reported having no prior industry internship or research experience and none had ever attended or presented at a research conference. So effectively, for the vast majority of the participants, this was their first exposure to research, applications of engineering, and their first opportunity to work closely with a faculty member and industry professionals.

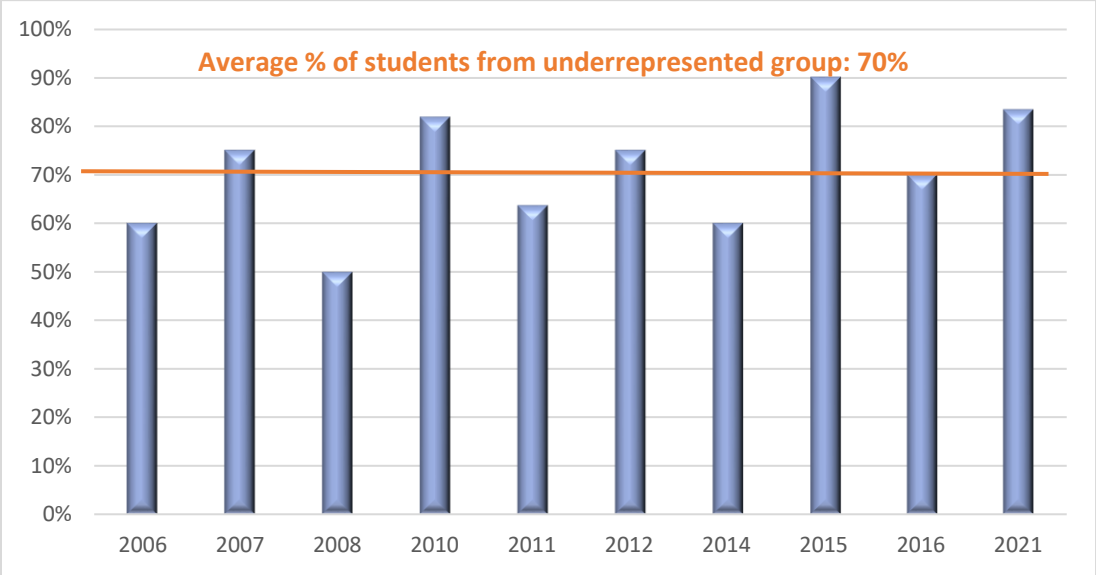

Figure 1: Percent of REU participants from underrepresented groups in engineering (women, Hispanic, African American, Native American)

Some Program Logistics

While the PIs were happy with the student make up, running and organizing the program in a virtual format was very challenging on many levels, including some basic program logistics. First, was the issue of how to pay students who would never set foot on campus. This was a new experience for our institution and we presume for other institutions as well. Communications were necessary with the Human Resources and Payroll departments to figure out the proper procedures that needed to be followed to ensure timely stipend payments to the undergraduate participants. PIs planning such programs in the future should work through such details ahead of

time to ensure no payment delays. This is particularly important for first generation or lower income students who may be depending on timely payments to cover living expenses. Our grant had also budgeted funds for on-campus housing at OU, as well as a meal allowance for all student participants. Since the students were working remotely, we converted those payments to direct payments to the students to help cover some of their housing and living expenses. Additional logistical issues included creating OU computer accounts and providing VPN access ahead of time for each student participant so they could access computing and library resources at OU, much like they would have done had they been participating in person. Different universities may have different policies regarding providing such remote access to individuals not on campus, so it's important to work out those logistics ahead of time with the appropriate units on campus.

Also somewhat challenging was the scheduling of group meetings, seminars, presentations, etc. via Zoom. With some participants located on the West Coast and in Alaska (3 and 4 hours behind Michigan, which operates on the Eastern Standard time zone), scheduling some of the meetings at our usual 9:00AM or even 10:00AM time slot did not seem to be equitable. Whenever possible, we scheduled group meetings after 11:00AM EST and encouraged faculty advisors to be mindful of time differences when meeting with their individual research groups. A few exceptions to this rule were the end-of-program virtual conference, which was run jointly with other REU programs at OU and a handful of industry presentations, which were scheduled somewhat earlier in the day. Students generally took these challenges in stride with one student stating: "*Working with someone in a different time-zone was something that took a little getting used to, however, we were both very dedicated to our project and made ourselves available as much as possible*." In fact, while the time-zone differences were not always optimal, one could view them as an opportunity for students and faculty to practice working the way many engineers and researchers work nowadays in an increasingly connected world, with teams often spread out across several countries and multiple time-zones.

One benefit that we discovered with the switch to a virtual format was the availability of webinars and live-streamed technical presentations organized by various professional societies in which students could participate. Given the automotive focus of this REU program, the PIs identified several virtual events organized by SAE Detroit, including a virtual tour of the Insurance Institute for Highway Safety's (IIHS) Vehicle Research Center test track in Virginia. Furthermore, while Zoom does not replicate the experience of meeting face-to-face and chatting with an industry expert, we were still able to organize several Zoom meetings for the student participants with professionals from the automotive industry, including several former REU students. The use of Zoom was more convenient for many of these busy professionals who did not have to drive to campus and hence had more scheduling flexibility. It also allowed us to invite speakers from out of state who might not have otherwise been able to meet with the students. While the level of student engagement and casual conversation with the industry speakers was not the same in a virtual setting as it typically is in-person, the mere act of exposing students to a variety of role models and career paths is still critical, particularly when dealing with first generation college students. This is reflected in the following quote from one of the participants at the end of the program: "*Throughout this experience, I feel like I have gained a lot of insight in terms of what to expect from an industry job. As someone who is a first generation college student, I really don't have many opportunities to interact with professional engineers*

outside of job interviews or college organized events. The opportunity to speak with a wide range of industry veterans in a more relaxed and laid-back setting has really eliminated the 'fog and mirrors' I sometimes felt while imagining myself moving forward with my career. Of course I wish we could have met in person but I'm glad to have gotten the opportunity at all."

Sadly, the service learning/community outreach component of the program had to be dropped in summer 2021. The activity, which was supposed to take place in conjunction with the Michigan Science Center in Detroit, could not be organized in a virtual manner. Hopefully we will be able to re-incorporate it into the program once we are back in-person in future summers. Similarly, lab and industry tours (for example, a Chrysler assembly plant or of an automotive wind tunnel facility) could not take place virtually for many reasons. Such tours are always highly rated and eye-opening for students and showing videos of some of the facilities does not fully capture the experience of visiting them in person. These were of course some of the downsides of having to run the program in a virtual setting.

Pivoting to simulation-based projects

With the switch to a virtual format in summer 2021, what was traditionally a primarily hands-on, experimental research program had to pivot to completely simulation/analytical based projects. Faculty mentors were asked to propose research projects that could be completed using a variety of simulation tools. Five out the six team projects involved the use of numerical simulation software packages such as GT-SUITE, ANSYS Fluent, MATLAB and Lumerical FDTD; the sixth project was part of a NASA design challenge that involved conceptual design and hence access to CAD software. While many REU programs (including AERIM) at times involve simulation projects, we encountered several challenges along the way. The biggest issue was related to remote access to commercial software. While all students were provided with OU computer login IDs and access to various School of Engineering and Computer Science computing resources, we didn't fully anticipate some of the challenges that some would encounter while trying to access software needed for their research remotely. These included issues related to software licensing, stability of the remote desktop function, computer crashes, as well as variability in the quality of the home internet service of the students. Some students who lived in more remote areas had poor or unreliable internet connections, which led to much frustration when trying to run software remotely. We also did not anticipate delays in setting up access to other university computing systems (such as the high performance computing clusters) when it was determined part-way through the program that a student team needed higher computing capabilities for their project. In some cases, students were able to access computing resources through their own institutions or to download student versions of some software packages onto their own personal computers. It is critically important to have all software and virtual access (remote server access) in place at the very start of the program to avoid delays and work slowdowns. Furthermore, out of equity concerns, when possible, it might be preferable to design simulation projects that students can complete using software that they can download (rather than software that they must access remotely each time), so they are not disadvantaged or experience setbacks due to internet connection issues.

Another challenge with simulation-based projects had to do with time lags and difficulties with engaging students while computer simulations were running remotely. In some cases,

simulations would take hours or days to run. In a normal REU summer, students would get to interact with their teammates or advisors during these downtimes, or would work on other tasks such as report writing, documentation, etc. With the students working more independently from their own homes and feeling at times "zoomed out," they were less likely to interact with each other, and in group meetings reported more frustration with their projects, particularly midway through the program (which in of itself is not an unusual feeling). With students more isolated and potentially with more downtime on their hands, perhaps it would be helpful to design virtual projects that have a clear structure, are somewhat less open-ended and that include several sub-tasks that students can work on while their simulations are running. This requires more intentionality and guidance by the faculty mentors, particularly during the middle stages of the project when lulls in progress tend to often occur.

Establishing Connections

Finally, with students logging in from their homes across the country and across different time zones rather than living together in the Oakland University dorms, the usual bonding and group interactions that would normally occur over the summer were difficult to replicate. In a focus group discussion with the program evaluator, some students made comments such as: "*It's been difficult to connect with everyone just because we're on zoom*." In a normal year, REU students, including local OU students, are purposely housed in a dorm together to help them build bonds and develop a sense of belonging. Not only would the students come together during REU group activities, but many of them would typically spend time together socially as well. This was difficult to replicate in a virtual setting and is apparent in the average student response in the exit survey to the question that asked them to *rate their level of satisfaction with their interactions with other REU students (not on your team)*. While the average rating was a 4.0 on a scale of 1 to 5 (where 1 stands for low satisfaction and 5 is high satisfaction), that is to be compared for example to the rating of 4.56 given to interactions with their team members or of 4.67 given to interactions with professionals from industry.

Attempts were initially made by some of the students to organize virtual game nights, but participation quickly dwindled as students went about their daily lives. In prior in-person REU programs, the PI would organize a couple of social gatherings (in addition to multiple weekly group activities), but learned over the years that students preferred most of the time to socialize on their own without faculty presence. Perhaps one ought to be more diligent about organizing such social gatherings (game night, movie night, etc. via Zoom) in a virtual setting to provide more opportunities for students to connect with each other. Having a graduate student rather than a faculty member do the organizing might help.

REU faculty advisors are generally dedicated to mentoring undergraduate students and to providing them with a great learning experience. Yet virtual REUs require even more engaged and active faculty mentors. With students working remotely, independently and unable to just stop by their advisor's office for a quick question or chat, it is even more critical that faculty mentors engage with their students, establish clear lines of communication and set up easy ways for students to quickly get in touch with them. Faculty mentors must be responsive to emails or chat messages and able to meet multiple times per week, at least at the beginning as the program is getting started. They should also be attuned to any challenges that their students might be

encountering and should help them plan their time and tasks so they don't get overwhelmed or disengaged.

Yet, despite the challenges to connection that are inherent to a virtual experience, students still seemed to have developed strong connections with their teammates, faculty advisors and with the PI and co-PI who met at least once a week with all of the program participants. In a focus group discussion with the program evaluator, one student reflected that this "*experience made me realize there's other people struggling the same as I am. So I have to rely on them and ask questions as well, and which I believe as a valuable experience*." While Zoom posed challenges to connection, the struggle was common and created a sense of cohesiveness. The students relied on their connections in this way and found that asking questions created value in the entire experience. Commenting on their connection with faculty, another student indicated "*I tend to go into situations like engineering, school, engineering jobs feeling less than or inferior than other people just because I don't have that much field experience yet but doing this program makes me feel like the professors and faculty are kind of peers—So it's given me a lot of confidence in my personal abilities.*" While it cannot be determined that these students will remain connected, the use of social media and platforms such as LinkedIn may provide ways for them to remain connected and act as sources of support for one another after the REU experience.

Final Words

Is a virtual REU optimal? The answer in our opinion is no, at least not for a program that generally focuses on more hands-on experiences. Yet, are there ways to make it better and more rewarding? The answer is of course yes. As with any REU program, the key is to have a team of faculty and mentors who are passionate about undergraduate research and mentorship and who are willing to invest the necessary time to experience the ultimate reward: watching students grow, gain confidence and take ownership of a research project, all in a matter of ten weeks. While those of us who run the program felt that the absence of some of the program components reduced the quality of the experience for the students, their overall assessment of the program and of the impact on their skills was very good as can be seen in Table 1 which, for conciseness, shows a subset of the exit survey responses on a scale of 1 to 5. The comment below summarizes the student experience.

> *I am so thankful and grateful towards all the time and effort the OU staff took in order to make sure that we students had the best time in the program we could. The schedule planning of all the various events we [sic] really nice along with asking our opinions if more events were desired or not. I also loved that they took the time to check in with everyone weekly through zoom and through emails to go over future events or to check up on us after certain events.*

While students still appreciated the virtual experience, we surmise that most would have preferred an in-person experience if given a choice. Yet, as most educators have learned during the pandemic from having to suddenly switch courses online, there are aspects of an online REU that are likely to persist in the future. First, the availability of virtual meeting options such as Zoom means that we are likely to setup virtual meetings with REU students prior to the start of the program, something we didn't do in the past. Virtual meetings or chat messaging are also

likely to be used at times by faculty mentors with their groups in addition to in-person meetings, allowing for more frequent check-in and communication. We also anticipate being able to attract more industry seminar speakers if a virtual option is more convenient given their work schedule.

Table 1: Responses to some of the exit survey questions; a scale of 1 to 5 was used, where 1 stands for low satisfaction and 5 is high satisfaction.

Question	**Average Rating**
Satisfaction with your research project	4.67
Interactions with professionals from industry	4.67
Improving my written communication skills	4.67
Improving my oral presentation skills	4.89
Improving my self-confidence	4.44
Learning more about how to plan for graduate school and careers in mechanical engineering	4.56
Learning more about careers in the automotive and energy industries	4.56
Developing a sense of how my research benefits society	4.44
Developing a mentor relationship with faculty on whom I can call for guidance in the future	4.44

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