

Work in Progress: Investing in Engineering Futures Through Summer Research Funding

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Introduction

This WIP paper explores the student experience in the Guided Engineering Apprenticeship in Research (GEAR) program as students transition from the academic-year program to the newly created GEAR Summer Research (GEAR-SR) program. It highlights the importance of offering financial support for summer research via the GEAR Summer Research Scholarship, allowing students from all backgrounds to share in the benefits of dedicated summer research including increases in research knowledge and skills, deeper relationships with mentors, and clarity and insight into career paths. This work involves thematic analysis of interviews with GEAR-SR participants and highlights student voices, including those traditionally marginalized in STEM.

The advantages of undergraduate research experiences (UREs) are widely recognized, leading to higher student retention, a sense of belonging in their field, improved academic outcomes, and a greater likelihood of pursuing advanced degrees [1, 5, 6]. This positive effect can be even greater for traditionally minoritized students [7], including students who are Black/African American, Hispanic/Latino(a), American Indian, and Pacific Islander. However, finding and performing research in a laboratory can be daunting for a novice researcher—especially for students from populations typically marginalized in engineering such as low-income, first generation, traditionally underrepresented minority, and women students. Structured research experiences match students with research laboratories and provide additional supports along the way. In 2014 the Computer Science and Engineering (CSE) department at UC San Diego created the Early Research Scholars Program (ERSP). ERSP provides research opportunities to CSE students through a structured, academic-year program and has many positive outcomes for students including higher GPAs and increased confidence [1]. In response to increasing demand for student research experiences, UC San Diego's IDEA Engineering Student Center created a similar program for engineering majors in other departments. The GEAR program was piloted in 2019 and is modeled heavily after ERSP [2, 3].

GEAR Academic-Year Program Structure

GEAR is an academic-year program for undergraduate engineering students, and while GEAR is open to all engineering students, it focuses on students from populations traditionally marginalized in engineering. GEAR is a scaffolded program specifically designed for students with little to no prior research experience. A typical GEAR student applies for the program at the end of their first-year and participates in GEAR during their second-year. GEAR seeks to help participants build a foundation of research knowledge and skills, gain confidence in their abilities, and increase their sense of belonging in engineering. GEAR has several key components:

- **Coursework:** All GEAR students enroll in a 2-credit introduction to engineering research course during Fall quarter. The course provides a foundation for understanding research and culminates with the creation of a research proposal.

- **GEAR Partners:** GEAR students are matched with a partner with similar research interests--offering peer support, collaborative learning, and shared accountability.
- **Lab placement and research:** GEAR recruits engineering research labs to participate in the program, and each GEAR pair is matched with a lab based on major and interest. Students begin engaging with the lab in Fall quarter—forming relationships with their lab mentor, becoming familiar with the lab research, and developing a research plan for the Winter and Spring Quarters. GEAR students then spend Winter and Spring quarters conducting their research project in the laboratory.
- **Mentorship:** GEAR offers an extensive support system through various levels of mentorship including the GEAR Central Mentor who acts as a bridge between the GEAR students and laboratories, graduate lab mentors who provide regular guidance to the GEAR students, and faculty Principal Investigators (PIs).
- **Socials and Workshops:** GEAR socials and workshops offer opportunities for relaxing, team building, and exploring professional development topics.
- **Presenting Findings:** The academic-year GEAR program culminates with the Undergraduate Research Symposium (URS). Each GEAR pair creates a poster and presents their findings at the URS attended by students, faculty, and industry.

GEAR Summer Research and Summer Research Scholarship

Moving beyond the academic-year, participation in summer research experiences has positive outcomes including increases in research knowledge, research skills and understanding of career pathways [5]. Summer research experiences have also led to increased participation in PhD programs, particularly for traditionally underrepresented minority students [6]. In 2021-22 GEAR piloted a summer program for four students. Thanks to the critical support and partnership of General Atomics Aeronautical Systems, Inc. (GA-ASI), GEAR expanded to include a full-time, paid, summer research opportunity in 2022-2023—allowing many more students to participate who may not otherwise have had sufficient financial resources. Students who participated in GEAR during the 2022-23 academic-year were invited to apply for a GEAR Summer Research Scholarship (SRS). Interest was incredibly high with 67% of GEAR students who were participating in the academic-year program applying for the GEAR SRS. Additionally, support from engineering faculty was overwhelming with 79% of GEAR faculty and laboratories indicating that they both had ongoing summer research and would like their GEAR students to continue in the summer. Eleven GEAR students were selected to receive the GEAR SRS and participate in the 10-week summer research experience. One student had an unexpected, last-minute change in circumstance and was not able to participate, so there ended up being 10 GEAR Summer Research (GEAR-SR) participants.

We are interested in learning about the experiences of GEAR-SR participants to understand how providing financial support and extending the GEAR experience to include full-time summer research impacts student outcomes and professional trajectories. In addition, we hope to identify areas for program improvement. More specifically, we would like to understand:

- How did the GEAR Summer Research Scholarship impact the student's ability to participate in full-time summer research?
- How did the GEAR summer research experience differ from academic-year experience in general and in terms of research skills, confidence, and mentor relationships?

- What impact did participating in GEAR and/or GEAR summer research have on the student's future career or educational goals?

Methodology

To learn more about the experience of GEAR-SR participants we conducted semi-structured interviews. An invitation to participate was extended to all 10 GEAR-SR participants. Four GEAR-SR students volunteered and were available for an interview. Of the four interviewees, one was female and three were male, and 50% were traditionally underrepresented minorities. The interviewees were from the following departments: Bioengineering (BENG), Mechanical and Aerospace Engineering (MAE), and Electrical and Computer Engineering (ECE).

Four semi-structured interviews were conducted, each lasting approximately 40 minutes, and each session was recorded with the consent of the participants. The semi-structured format allowed for in-depth exploration of the GEAR-SR participants' experiences as well as the flexibility to delve into unexpected topics and solicit participant feedback on potential program improvements.

Preliminary Analysis and Findings

The interview data will be analyzed using thematic analysis to identify and interpret themes and patterns. This qualitative analysis involves several stages including familiarization with the data, identifying preliminary themes, generating codes, coding data, and defining and exploring the themes and patterns that emerge. Given the work-in-progress nature of this paper, the thematic analysis has focused on becoming familiar with the data and identifying preliminary themes. Initial analysis shows themes emerging as follows:

Financial Support: An overarching theme that emerged is the importance of the financial support provided by the GEAR Summer Research Scholarship. There appear to be three sub-themes related to financial support (1) Students would not have been able to engage in full-time summer research without financial support. (2) Engineering students rely heavily on summer employment as their academic-year coursework requires extensive study time and the need to be involved in extracurriculars to “pad their resumes”. This leaves little time for paid work during the academic year, making paid-summer work pivotal for covering the cost of tuition and expenses. (3) Despite feeling passionate about research, some GEAR-SR students would have foregone research and sought industry internships if financial support was not available. Examples of student quotes that highlight these themes are below. (Note: Small edits, such as removing “um and like” were made to student quotes for readability.)

*The scholarship was really attractive to me because it allowed me **not** to search out an internship. It was either I work for the summer or I do this research with the scholarship. Because I felt like my experience had been so fruitful already, I was working on papers and trying to get them published, that would be more beneficial to my professional career to stay in the lab and continue the work I was doing. (Participant 2)*

Getting paid over the summer was one of my goals because throughout the year I didn't really have time to get into any jobs or anything. So, I think the paid aspect was pretty important. (Participant 4)

It would be hard to spend a summer not making any money because, especially during the school year engineering is such a time-consuming degree you don't have a lot of time to get a job. (Participant 2)

I am trying to save up money as much as possible for tuition...My passion is to do research even though I might sometimes just want to work in industry just to get some more money and overall experience. (The GEAR summer scholarship) was a good way to make money and do what I'm interested in at the same time. (Participant 1)

Summer vs. Academic-year Research Experience: An area of interest that was probed during interviews was the differences between the academic-year and summer research experience. Four themes emerged. (1) Participating in full-time summer research allowed students to engage in more hands-on research and develop additional research skills beyond those gained in the academic-year. (2) GEAR-SR students took on more independent research and project leadership roles in the summer. Examples of student quotes that highlight these two themes include:

As far as research skills ... I was definitely able to dive in. I got my own project. A little of an easier introductory project to get my hands on designing a project from start to finish, running the test, doing the analysis. So, I definitely got more experience designing and conducting experiments. (Participant 2)

Throughout the academic year. I was in a group--it was me and (my GEAR partner) working under the PI and the mentor. But over the summer it was just me. It was my own project that I built from scratch, and I was working directly under the PI. So in that sense it was completely different where I had to take lead of... (Participant 4)

(Over the summer) there was also a few new students who wanted to join the lab during that time, so I was also helping train them a little bit for like understanding like what's going on and getting them off the speed with things. (Participant 1)

Additional themes relating to the students' summer versus academic-year experience include: (3) The absence of academic-year stressors such as attending classes, studying, and extracurricular activities allowed students to focus solely on research leading to a deeper exploration of the material. (4) Students developed deeper relationships with their GEAR lab mentors and lab mates during the summer. Comments that underscore these themes are:

It was a major difference, I would say, participating in research over the academic year and the summer. While academic it was kind of stressful because I had to manage classes and extra curriculums so that was a bit tricky...over the summer we definitely have more time to explore, to truly explore, and go into the depths of what we learn. (Participant 4)

(In the summer) I actually did have a lot more in person interaction with my teammates because we were meeting regularly to...collaborate together. And I think this was just probably because everyone had more time on them, and had more of dedication towards it, because everyone was only focusing on one thing in the summer. (Participant 1)

(More time in the lab during the summer) definitely helped me improve my relationship with my professor and all my other lab mates. We shared space with people from other labs as well, so I got to know people who are working with different professors. I got to know what they were doing as well, and I don't think that would have happened during the academic

year, because I would be too focused to like, just get my work done and get out of there.
(Participant 4)

Career Insights and Goals: A clear theme emerged that GEAR (either the academic-year and/or summer) played a pivotal role in helping participants define their career interests, shifting from an uncertain path or a default path into industry. Both the research experience itself and discussions with mentors led to students considering, and in some cases deciding, to pursue graduate school. Student remarks that emphasize this are:

I had no clue if I wanted to go to grad school beforehand. I had no clue if I wanted to go straight to industry after or if I wanted to pursue a career in academia. Because of how much I enjoyed the work I did during the school year and over summer it influenced me to say I want to do academia at least to the level of my Masters...definitely the GEAR program has resulted in me wanting to pursue academia and grad school. (Participant 2)

I even talked to my PI about what I should do after I graduate and it gave me a better idea of what I want to do. I wasn't ever planning to go to grad school...(now) I want to go into industry for 4 or 5 years and then (consider returning for grad school). (Participant 3)

Before (GEAR), I was sure that I would just directly get into industry. You know, finish my undergrad and start working. But working on the project...definitely helped me realize that it's something I really love, setting up experiments, finding out new things, learning new things. That influenced my decision because I've seen my peers get into jobs directly, and there's not much of a learning curve there...Through research it doesn't matter what field you're in. You always have to learn about like 50 fields and that expands your point of view. That gives you a new perspective on things. So, I did feel like pursuing a PhD after the summer. (Participant 4)

Discussion and Future Work

The preliminary findings underscore the transformative potential of the GEAR Summer Research Scholarship on engineering students' engagement in research, skill development, and career trajectories. By providing financial support, the program enables all students, including low-income, first-generation, and traditionally minoritized students, to engage in full-time summer research, a privilege often reserved for more resourced peers. Without financial support students who are passionate about research may need to forgo full-time summer opportunities to pursue summer employment elsewhere—particularly engineering majors who rely on summer income since academic-year course loads make working during the year challenging.

GEAR students had a positive experience during the academic-year, and GEAR summer research experience served to enhance this experience, allowing GEAR-SR students to immerse themselves deeper into research and their laboratories. The distinction between summer and academic-year experiences highlights the unique benefits of focused research time without the competing demands of coursework and extracurricular activities. Participants reported gains in research skills and confidence, attributing these improvements to the hands-on experience and increased mentorship opportunities available during the summer.

This work is ongoing, and we have just begun the thematic analysis process. As we continue, this analysis will further define, code, and validate the preliminary themes presented in this paper and explore additional themes that emerge. While 40% of the GEAR-SR cohort participated in

interviews, additional interviews may be conducted to ensure a broader representation of participant backgrounds and experiences. Investigating the specific elements of the GEAR program that most significantly contribute to student outcomes will inform program enhancements and exploring the differential impacts of the GEAR program on students from diverse backgrounds, including those traditionally marginalized in engineering, could provide valuable insights.

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