UC San Diego
JACOBS SCHOOL OF ENGINEERING
IDEA Engineering Student Center

Guided Engineering Apprenticeship in Research

Program Impact Report 2019-2022

Table of Contents

Content Contributors: Lisa Trahan, Dean Rockwell
Design: Kaitlyn Wong, BS Mechanical Engineering '23

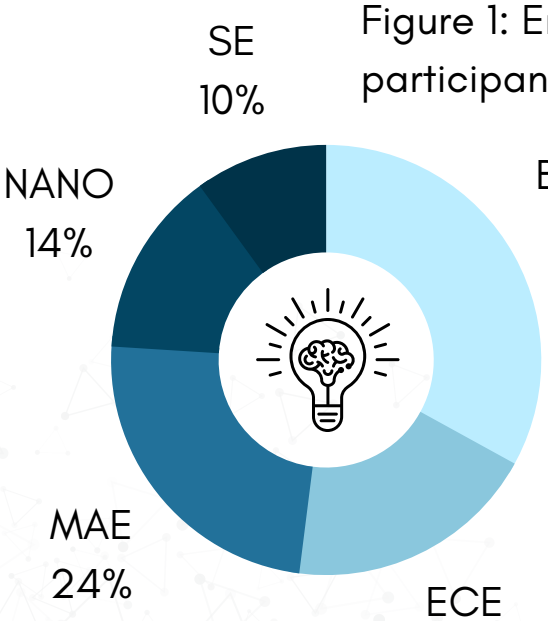
EXECUTIVE SUMMARY

What is GEAR?

GEAR, otherwise known as Guided Engineering Apprenticeship in Research, is a year-long program in which 2nd year undergraduate students are able to work with a teammate on a research project within a Jacobs School of Engineering faculty research lab.

Key Figures

Figure 1: Engineering department distribution for GEAR participants in 2021-2022



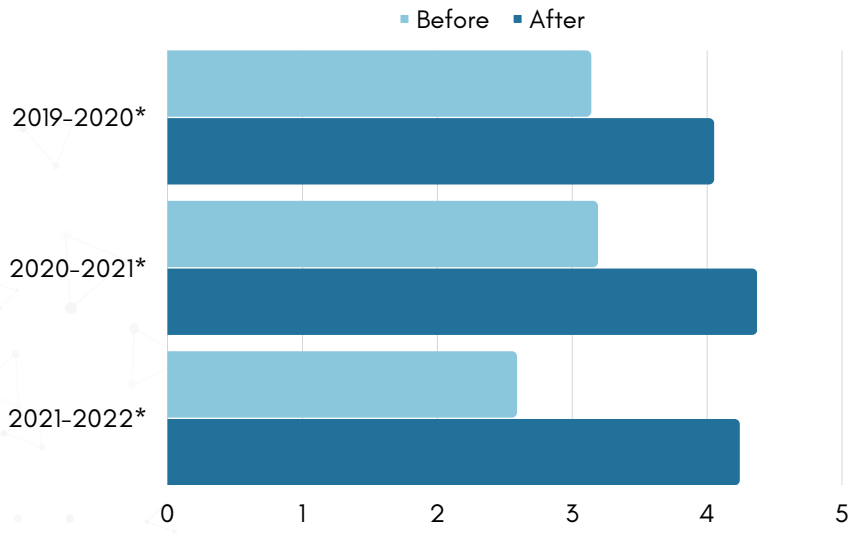


Figure 2: Students were surveyed before and after the program on whether they felt that they understood research methods and practices.

PROGRAM OVERVIEW

Background

Coordinated by the IDEA Engineering Student Center, GEAR is a year-long research apprenticeship program for undergraduate students in the Jacobs School of Engineering at UC San Diego. GEAR aims to provide a scaffolded research experience to support the development of early undergraduates' research self-efficacy, engineering identity, and sense of belonging and inclusion within the field. GEAR was launched during the 2019-2020 academic year, with a new cohort accepted each year. The program is based on the UC San Diego Computer Science and Engineering Early Research Scholars Program (CSE ERSP) and was launched to extend a similar opportunity to engineering students in the Jacobs School of Engineering's five other departments.

Program Structure

Each team of two GEAR participants engages in a Jacobs School of Engineering faculty research lab for the full academic year. During the year, participants engage in:

- **ENG 20 "Introduction to Engineering Research":** All GEAR participants take this 2-credit course in Fall quarter to get an orientation to engineering research and write a proposal for the research project that they will begin conducting in Winter quarter.
- **Research Lab Experience & Mentorship:** Research teams receive research direction and mentorship from faculty, graduate students, and/or post docs in their lab placement throughout the year.

PROGRAM OVERVIEW

Program Structure

Participant programs, continued:

- **Supplemental Mentorship:** A GEAR Central Graduate Student Mentor provides participants with additional support and guidance throughout the year as needed, related to general advice, career interests, teamwork, etc.
- **Workshops & Socials:** The GEAR Central Mentor provides workshops on select topics to support participant research skills and connection with their peers in Winter and Spring quarters.
- **Poster Presentation:** Research teams create a research poster to showcase their work in the Spring quarter.

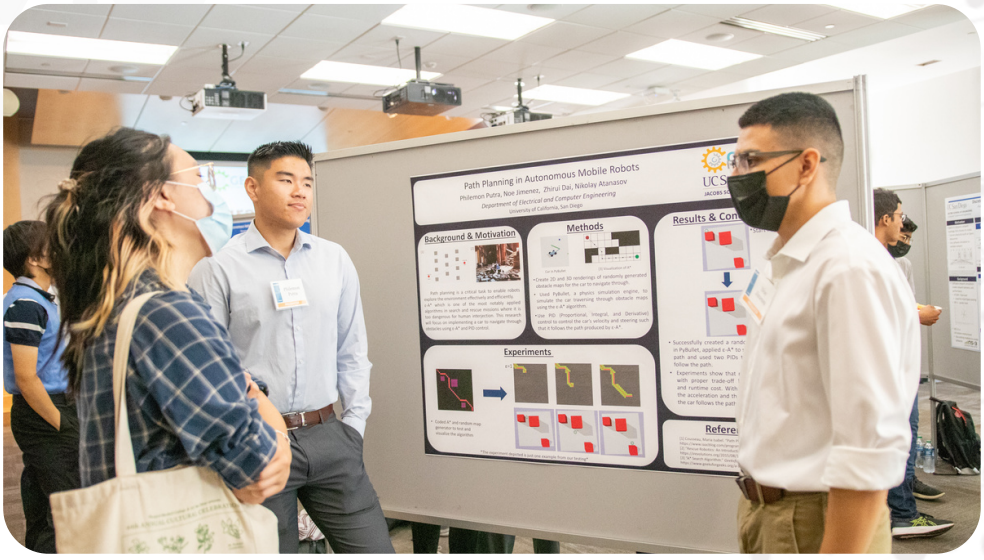
The first two years of GEAR were conducted partially (2019-2020) or fully remotely (2020-2021) due to the pandemic. The third year of the GEAR program (2021-2022) was conducted fully in-person and featured an in-person, joint Undergraduate Engineering Research Symposium with the CSE Early Research Scholars Program at the end of Spring quarter.

PROGRAM OVERVIEW

Cohort Descriptions

Background

76 undergraduates participated in the first three years of the program, with 30 in AY 19-20, 25 in AY 20-21, and 21 in AY 21-22. There is a noticeable decrease during COVID, but is current growing with the newest cohort of the program expanding significantly to 39 participants in AY 22-23. Participants come from five engineering departments, Bioengineering, Electrical and Computer Engineering, Mechanical and Aerospace Engineering, Nanoengineering, and Structural Engineering. Students in the Computer Science and Engineering Department are served by CSE ERSP. The majority of GEAR participants are second year, first time students. Up to 20% are transfer students or students in their third year. The GEAR program is structured to provide support to welcome undergraduates into engineering research, build their research self-efficacy, and build a sense of belonging in the field. GEAR provides this experience for a diverse group of participants, including 60%+ first generation, 70%+ Pell Grant eligible, 43%+ women, 20%+ Black/Latinx/Native American students.



PARTICIPANTS

Cohort Descriptions

Size of Cohorts

- 2019-2020: 30 students
- 2020-2021: 25 students
- 2021-2022: 21 students
- 2022-2023: 39 students

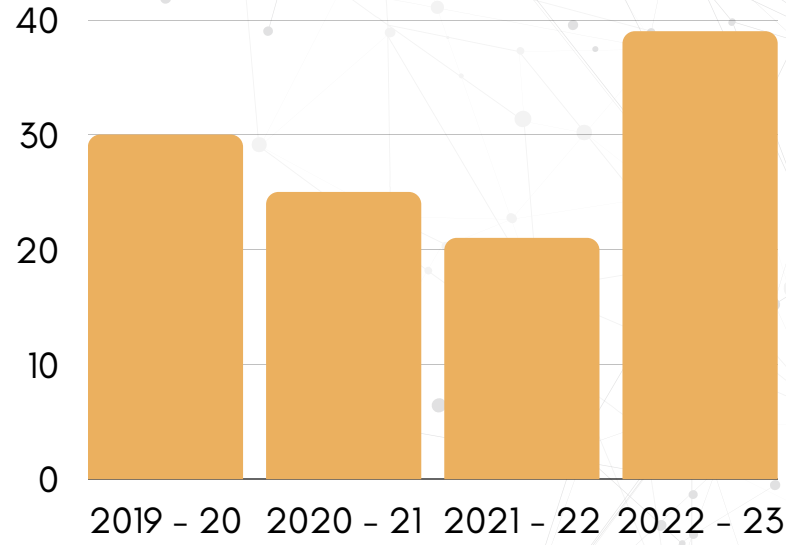
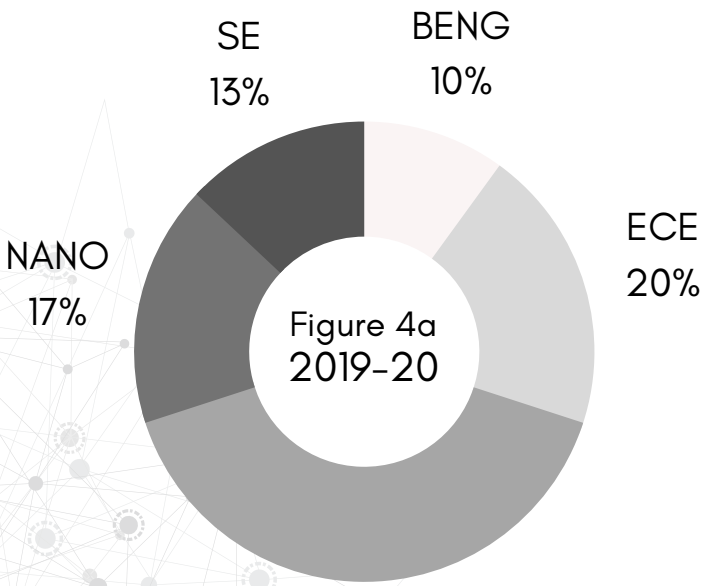
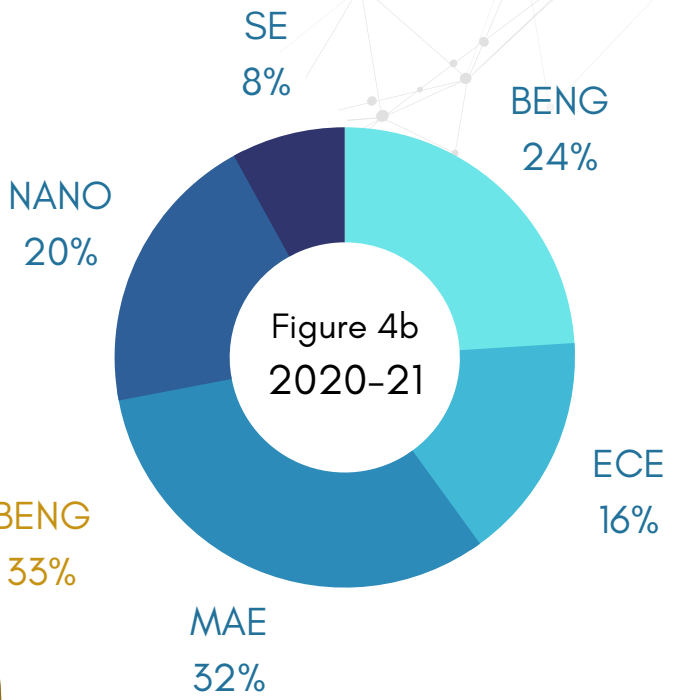
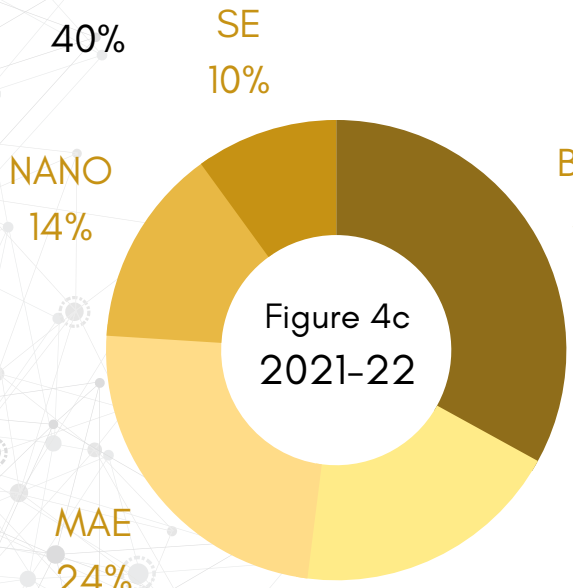


Figure 3: Size of cohort by year

Major Distribution by Year







Figures 4a-c: Distribution of engineering department by year

PARTICIPANTS

Cohort Descriptions

Year in Undergraduate Career

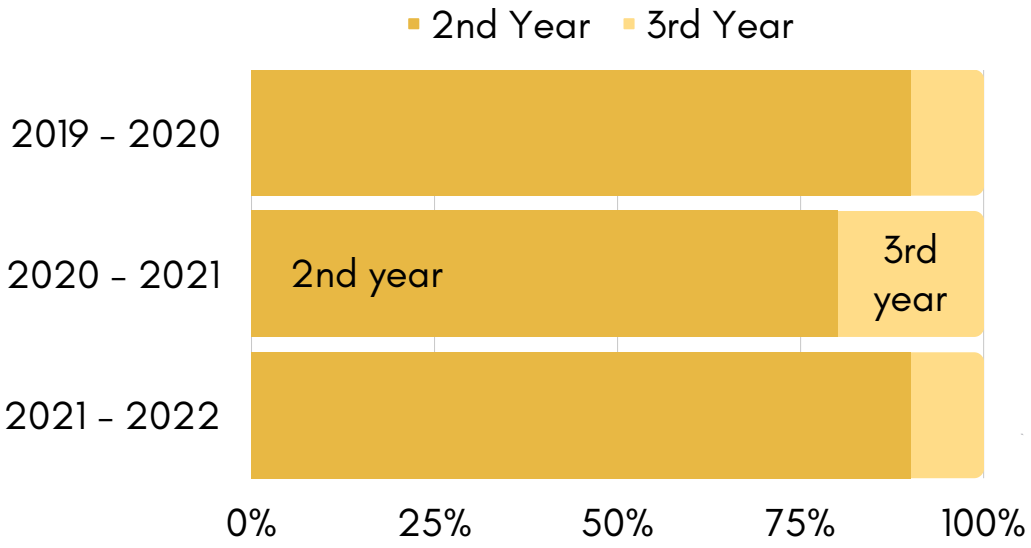


Figure 5: Distribution of class years by year of program

First-Time Student vs. Transfer Student %

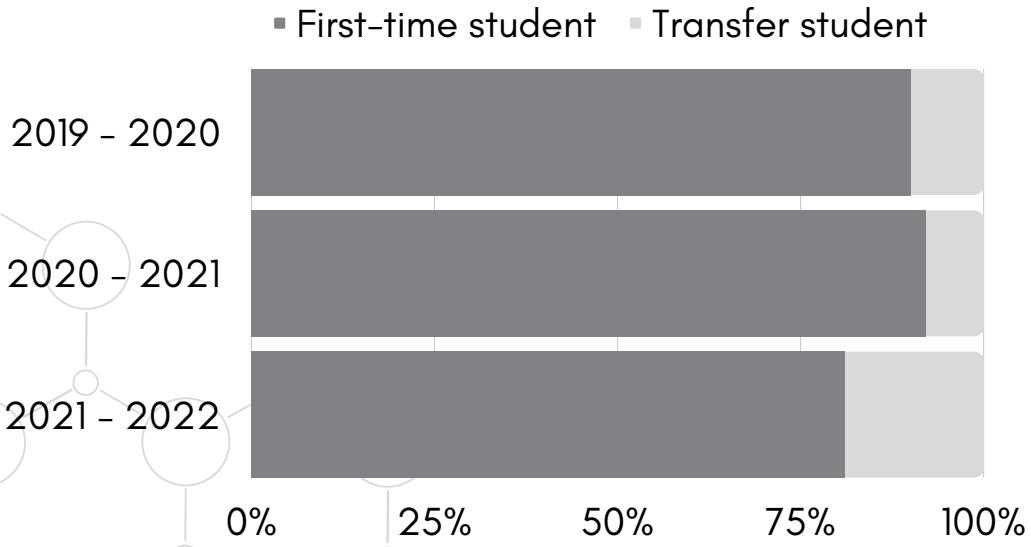


Figure 6: Distribution of transfer student vs. first-time student participants by year of program

DEMOGRAPHICS

Cohort Descriptions

Demographics of Participants

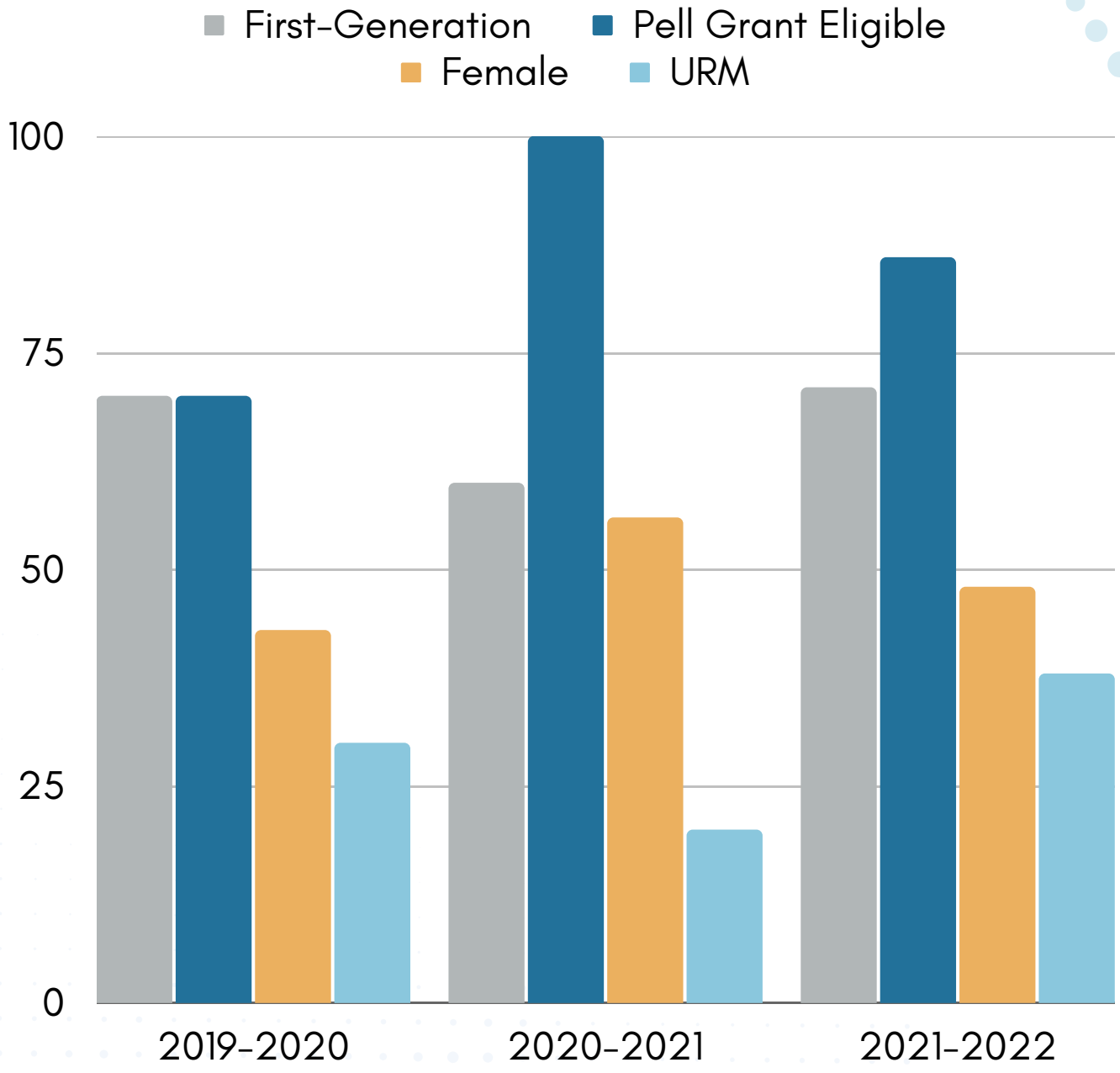


Figure 7: Distribution of student demographics by year of program, covering students who are First-Generation, Pell Grant Eligible, Female, and an Underrepresented Minority (URM).

DEMOGRAPHICS FOR 2021-2022

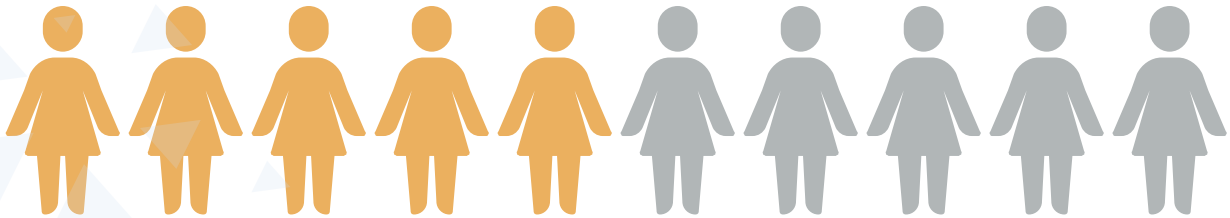
Cohort Descriptions

Demographics at a Glance for the 2021-2022 Cohort

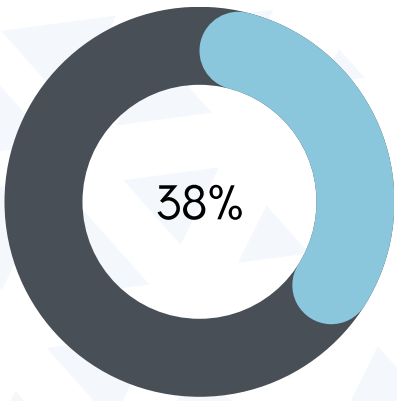
71% of the cohort identified as First Generation.

2021-2022 *2020-2021* *2019-2020*

86% of the cohort was Pell Grant eligible, in contrast to 100% in during 2020-2021 and 70% in 2019-20.



48% of the participants identified as female, a decrease from the previous year's 56%.



38% of the participants were an underrepresented minority (URM), an increase from last year's 20%.

LABS

Cohort Descriptions

Lab Participation

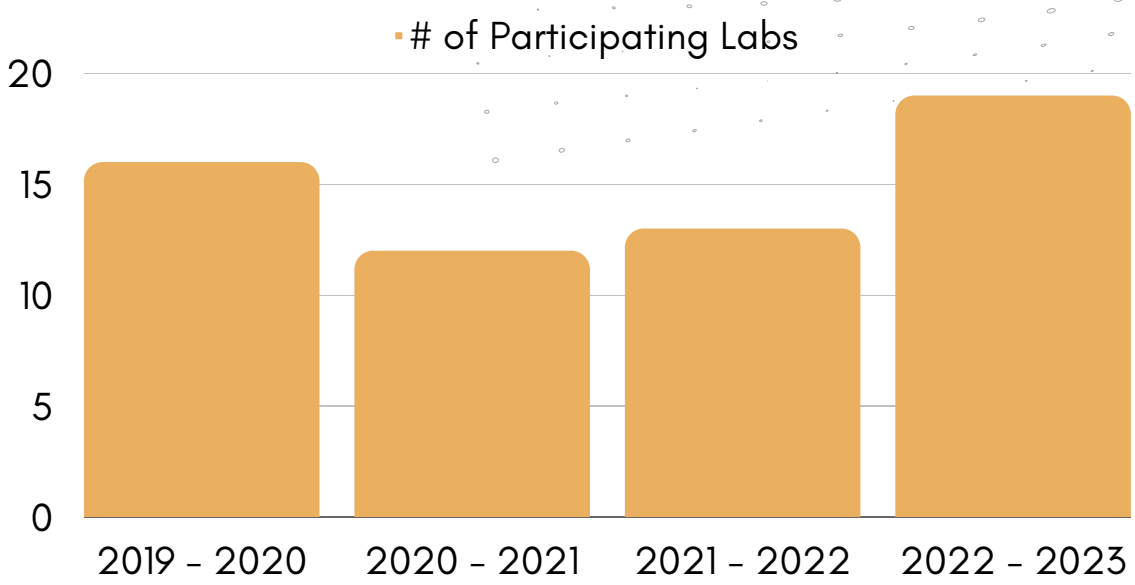
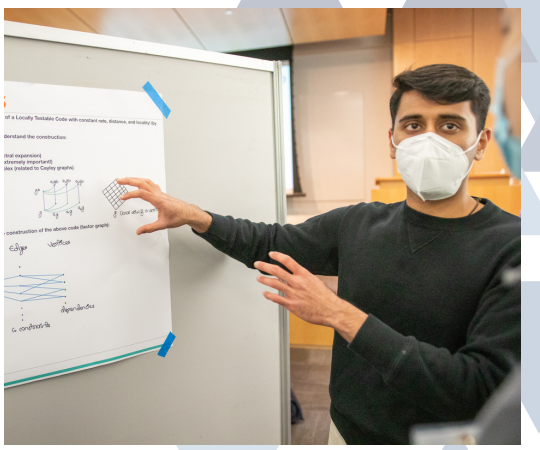


Figure 8: Count of participating labs by year of program

About

More than a dozen Jacobs School of Engineering faculty labs participate in GEAR each year. Labs host a pair of GEAR participants and provide mentorship from the PI and an assigned mentor, usually a graduate student or occasionally a post-doctoral researcher. Below are the labs who participated in the first three years of the program. An impressive 19 labs are also participating in AY 22-23 to support the larger cohort of participants.



OVERVIEW

Participating Labs

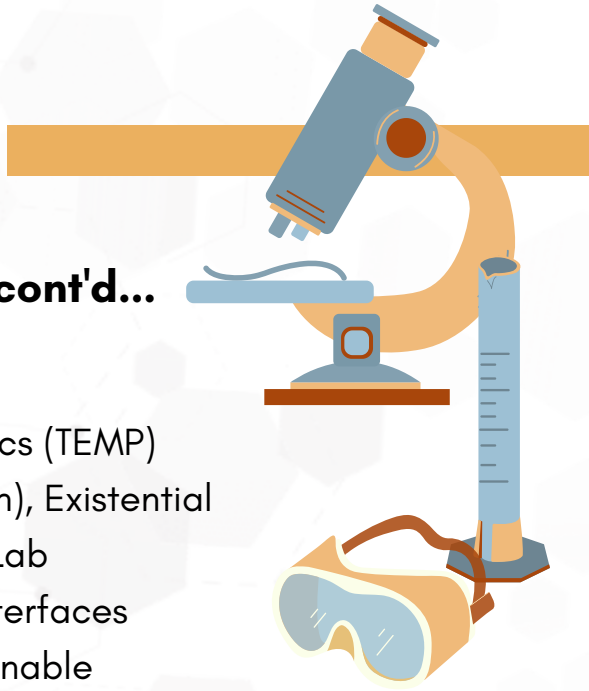
Lab and Principal Investigator (PI) Names

- 2019-2020:

  Adaptive Computing and Embedded Systems Lab (PI Farinaz Koushanfar), Advanced Material Processing and Synthesis (AMPS) Lab (PI Javier Garay), Banadrau Group (PI Prabhakar R. Bandaru), Caltrans Seismic Response Modification Device (SRMD) Laboratory (PI Gilberto Mosqueda), Flexible Printed Electronics (PI Tse Nga (Tina) Ng), Gravish Lab (PI Nick Gravish), Laboratory for Sustainable Materials and Energy (PI Zheng Chen), Large-Scale Design optimization: The Bioinspired Robotics and Design Lab (PI Michael T. Tolley), Liu Research Group - Electrochemical Materials Science (PI Ping Liu), Morimoto Lab (PI Tania Morimoto), Nanoscale Materials and Cell Engineering Lab (PI Nisarag J. Shah), Statistical Visual Computing Lab (PI Nuno Vasconcelos), Structural Components Lab (PI Pui-Shum (Benson) Shing), Translational Neuroengineering Lab (PI Vikash Gilja), Zengler Lab (PI Karsten Zengler)

LAB NAMES & PRINCIPAL INVESTIGATORS

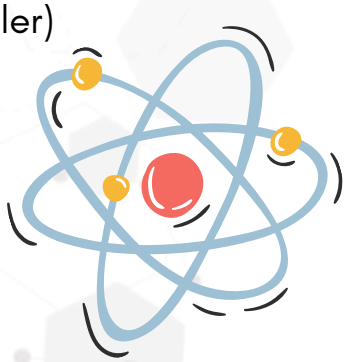
Participating Labs



Lab and Principal Investigator (PI) Names, cont'd...

- 2020-2021:

  Chen Group - Thermal Energy Materials and Physics (TEMP) Laboratory (PI Renkun Chen), Chen Lab (PI Yi Chen), Existential Robotics Lab (ERL) (PI Nikolay Atanasov), Gravish Lab (PI Nick Gravish), Integrated Electronics and Biointerfaces Laboratory (PI Shadi Dayeh), Laboratory for Sustainable Materials and Energy (PI Zheng Chen), Large-Scale Design Optimization Lab (PI John Hwang), Liu Research Group - Electrochemical Materials Science (PI Ping Liu), Luo Group (PI Jian Luo), Neuromuscular Bioengineering Lab (PI Sameer Shah), Structural Components Lab (PI Pui-Shum (Benson) Shing), Zengler Lab (PI Karsten Zengler)

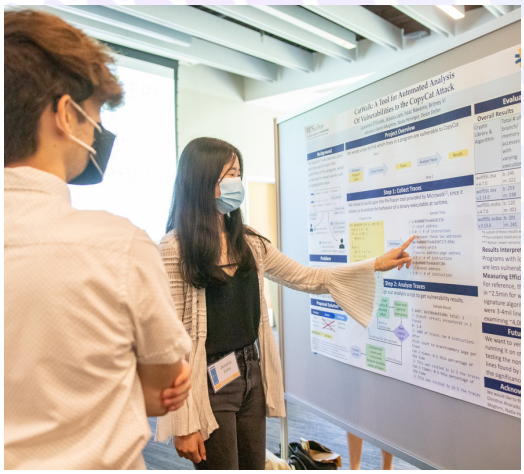


- 2021-2022:

  Chen Group - Thermal Energy Materials and Physics (TEMP) Laboratory (PI Renkun Chen), Existential Robotics Lab (ERL) (PI Nikolay Atanasov), Gravish Lab (PI Nick Gravish), Large-Scale Design Optimization Lab (PI John Hwang), Luo Group (PI Jian Luo), Morimoto Lab (PI Tania Morimoto), Nanoscale Integration Lab (PI Oscar Vazquez-Mena), Neuromuscular Bioengineering Lab (PI Sameer Shah), Seismic Response Modification Device (SRMD) Laboratory (PI Gilberto Mosqueda), Spatiotemporal Machine Learning Lab (PI Rose Yu), UCSD Simulation Training Center (PI Preetham Suresh), Zengler Lab (PI Karsten Zengler)

Assessment

Assessment of the GEAR program includes a pre- and a post- survey, administered via Qualtrics. The pre-survey is administered at the start of the Fall quarter and the post-survey is administered at the end of the Spring quarter. The survey includes attitude items on research self-efficacy, sense of belonging, engineering identity, and career aspirations. Additionally, the surveys also contain a research skills self-assessment rubric to track participants' growth in particular skill areas.



> I used to think that only top tier scientists did research and other graduates were just helping with small parts of it. But now I realized if research is just solving a problem that exists in a structured scientific way, then
>
> ***anybody can be a researcher.***
>
> *- GEAR Participant, 2019-2020 Cohort*

GAINED RESEARCH KNOWLEDGE AND SKILLS

Impacts

Each year, **GEAR participants reported a statistically significant increase in their understanding of research methods and practices after participating in the program**. During the 2019-2020 pilot year, participants were asked to complete a skills self-assessment rubric each quarter. Their responses showed that they gained research knowledge and skills each quarter in ways that aligned with the program structure. Analysis of the 2020-2021 and 2021-2022 pre/post skills self-assessments show that participants made statistically significant gains in each of these skill areas except "Work cooperatively with others," which was rated highly both pre- and post-GEAR.

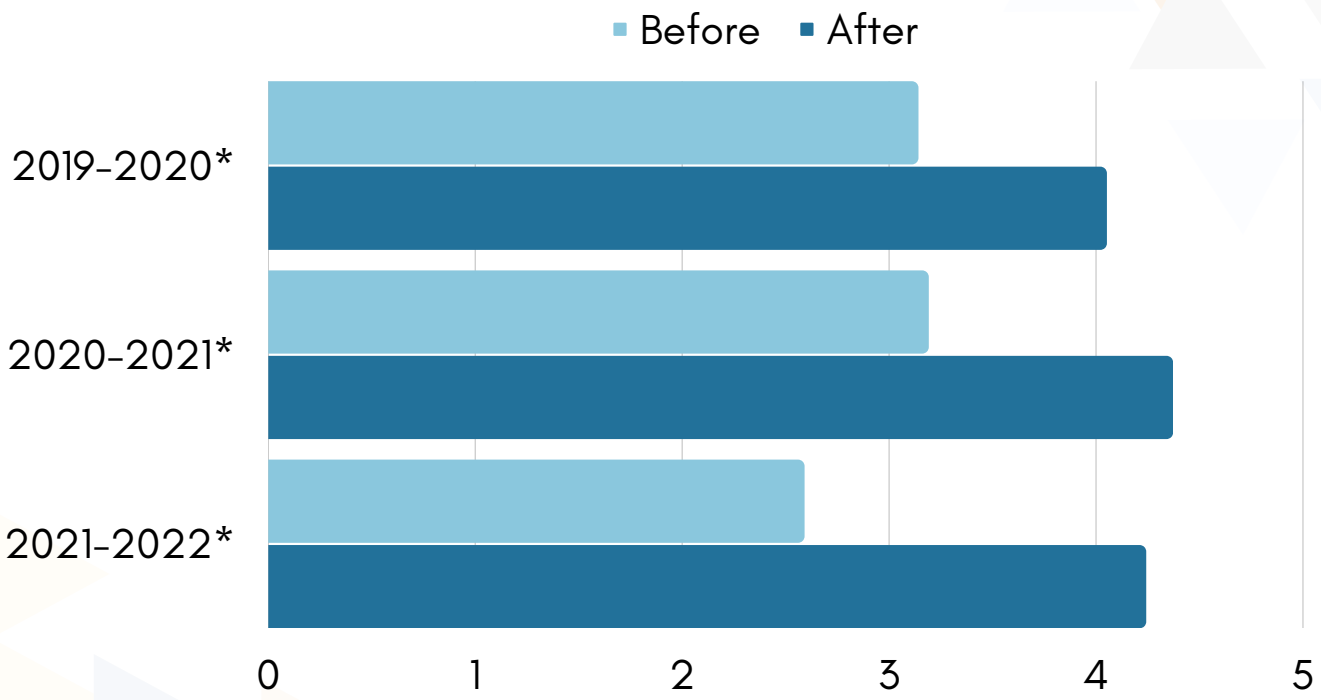


Figure 2: Students were surveyed before and after the program on whether they felt that they understood research methods and practices.

**Significant difference (Related-Samples Wilcoxon Signed Rank Test, p<0.05)*

PROGRAM SUMMARY

Impacts

Below is a summary of the skills that pilot year participants reported gaining most during each quarter of the program:

Fall Quarter: ENG 20

During Fall Quarter, through the ENG 20: Introduction to Engineering Research course, participants gained the most in:

- Explaining how their project contributes to existing knowledge
- Identifying and using a range of sources
- Producing written descriptions of their research

Winter Quarter: Conduct Research

During Winter Quarter, while conducting their projects, participants gained the most in:

- Communicating about their research area and discussing concepts in a scholarly way
- Demonstrating an in-depth knowledge and understanding of research techniques and their application
- Using feedback and constructive criticism effectively for self-understanding and personal/professional growth

Spring Quarter: Analyze & Present Research

During Spring Quarter, while creating their posters, participants gained the most in:

- Analyzing and evaluating research results
- Producing written descriptions of their research
- Monitoring progress towards goals and managing task plans to achieve them

INCREASED CONFIDENCE IN FUTURES WITHIN ENGINEERING

Impacts

Each year, students were asked about how their research experience impacted their vision of their future in engineering. Participants regularly described how they gained clarity in their research interests and the impact this would have on their future plans. Sometimes this clarity came in the form of pursuing research within industry. Other times, it motivated them to be resilient when it comes to research, especially now that they understand the process. Finally, the GEAR program also led to an increase in the number of students planning to attain advanced degrees. On average, 56% of participants planned to pursue graduate studies at the start of the program and 69% planned to pursue graduate studies after participating in GEAR.

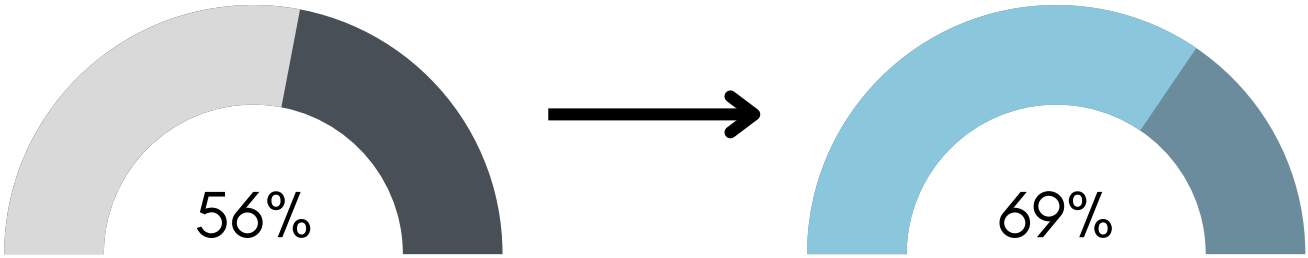


Figure 10: Students were surveyed before and after the program on whether they wanted to pursue graduate studies. By the end of the program, the proportion of students seeking graduate studies after their undergraduate career increased by 13 percentage points.

Impacts

Improved Sense of Belonging

The 2019-2020 pilot year and subsequent 2020-2021 year were partially and fully virtual, respectively, which appeared to have limited students' sense of belonging as it did not significantly increase between the pre- and post- surveys. In 2021-2022, however, there were significant improvements to students' sense of belonging and community. Participants in the post-survey indicated significant improvement for the item "I feel like I belong in the engineering field" and "I feel a sense of community in my department," which are positive signs for the program moving forward.

Successful Research Foundations

The GEAR Program has been rigorously assessed during its initial 3 years of operation. The results of this assessment have been positive, showing that the program has led to increased understanding of research methods and practices, gains in key skills for engineering and increased confidence and clarity on research, industry and future education. When the program was fully in-person in 2021-2022, students reported an improved sense of belonging in the engineering field. These early results show promise for continued impact on undergraduate researchers.

FUTURE EFFORTS

Impacts

Extending Impact through GEAR-to-Career

To deepen the research skills GEAR participants have learned and further their professional preparation, we plan to expand the "GEAR to Career" pipeline with support and mentorship by corporate partners. First, summer research scholarships will fund students' time to continue doing research in a UC San Diego lab the summer after GEAR. Then, students will benefit from internship networking opportunities with corporate partners. Sponsors of summer research scholarships include Lawrence Livermore National Laboratory and General Atomics. General Atomics will also partner to provide mentorship to summer research scholars and internship networking opportunities for GEAR participants. We look forward to growing this new initiative with support from additional corporate partners.

IDEA Engineering Student Center
UC San Diego
Jacobs Hall (EBU-1)

Phone: (858) 534-6105
E-mail: idea@ucsd.edu
Website: jacobsschol.ucsd.edu/idea

YouTube: youtube.com/user/IDEAStudentCenter
Facebook: facebook.com/ucsdidea
Instagram: instagram.com/ucsdidea