Materials Connection REU Site (MacREU R'Side) Evaluation, 2019*

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Abstract

This is the evaluation for the sixth year of the MacREU-UCR REU site. As it has in each of the past years, the program performed very well in exposing students to science and engineering, building their scientific skills and encouraging them to pursue a PhD. The evaluation of the program showed that the students gained considerable research skills and professional development over the summer in every respect we measured. This evaluation shows that the 2019 program equaled the already very strong results of the previous years. In particular, the program maintained high levels of exposure to research and mentoring, applying the experience they gained to development of research skills, professional development and aspirations of a career in science and engineering.

1 Introduction

"Materials Connection REU" (MacREU R'Side) was a 10 week REU site, held in the summer of 2019, in which 21 undergraduate students, mostly from Southern California colleges, had the opportunity to conduct research in science and engineering labs on the UCR campus. The students largely came from demographic groups that are under-represented in STEM fields, including 50 percent Hispanic/URM students, and 42 percent female or not gender identified.

The PI carefully screened students with Skype interviews and carefully selected among applicants those who showed promise in science but were at risk of not pursuing a career in science. Among the 21 students, 6 hailed from two year colleges, 7 came from non-research intensive four year colleges and the remaining from research intensive universities. In particular, the students had the following home institutions: Riverside City College, Fullerton Community College, Los Angeles Valley College, Fullerton College, Mount San Jacinto College, Biola Univeristy, California Baptist University, California State Polytechnic University Pomona, California State University San Bernardino, Loyola University-New Orleans, San Jose State University, University of California Riverside, University of California San Diego, University of Guam, and University of Massachusetts Lowell.

All of the students' research projects were related to the growth and application of thin films or monolayer materials. Students were placed in a variety of labs within the Materials Science and Engineering program. Participants are exposed to a wide area of fields from catalytic chemistry to semiconductor processing and from solar cell manufacture to the improvement of medical devices. To learn more about the MacREU site at UCR, visit http://macreu.ucr.edu/. At this site, one can view short video presentations from each of the students that describes their research and experience in the program.

This evaluation draws on two data sources 1) a survey of participating students based on the REU survey template available on the "Student Assessment of Learning Goals" website http://salgsite.org, providing both qualitative and quantitative evaluation data, and 2) qualitative responses from the participating students provided via open-ended responses in the survey itself.

Overall, the sixth year of the program well met its academic goals of exposing students to research, building their academic research skills, and gaining their interest in pursuing science and engineering as a career at the PhD level. In every measure in this evaluation, the 2019 program equaled the extremely strong results we observed from the previous four years of the program. In sum, the program was a strong success and met its goals of instilling an interest in science and engineering among students from under-represented backgrounds. In particular, the program maintained high levels of exposure to research and mentoring, and also showed significant improvements in the program's on-campus administration and students' experience.

2 Student Assessment of Learning Goals Survey Results

In this section, we present the results of a survey we administered to the 21 NSF-funded students, and all but one of these students filled out a survey. The survey comes from a template for REU evaluations available at the Student Assessment of Learning Goals website.[1] We used this website to administer the survey and to generate the figures showing results.

Gains in THINKING AND WORKING LIKE A SCIENTIST: APPLICATION OF KNOWLEDGE TO RESEARCH WORK.

1. How much did you GAIN in the following areas as a result of your most recent research experience?	1:no gains	2:a little gain	3:moderate gain	4:good gain	5:great gain	9:not applicable	Mean	N
1.1 Analyzing data for patterns.	5%	5%	10%	30%	45%	5%	4.1	19
1.2 Figuring out the next step in a research project.	0%	5%	0%	45%	50%	0%	4.4	20
1.3 Problem-solving in general.	5%	0%	0%	30%	65%	0%	4.5	20
1.4 Formulating a research question that could be answered with data.	0%	5%	15%	30%	50%	0%	4.2	20
1.5 Identifying limitations of research methods and designs.	5%	10%	5%	20%	60%	0%	4.2	20
1.6 Understanding the theory and concepts guiding my research project.	0%	0%	10%	20%	70%	0%	4.6	20
1.7 Understanding the connections among scientific disciplines.	5%	0%	0%	35%	60%	0%	4.4	20
1.8 Understanding the relevance of research to my coursework.	5%	0%	5%	25%	60%	5%	4.4	19

Summary of scale results

The graphic below lists the mean and confidence interval (±3 times the standard error) for each item.

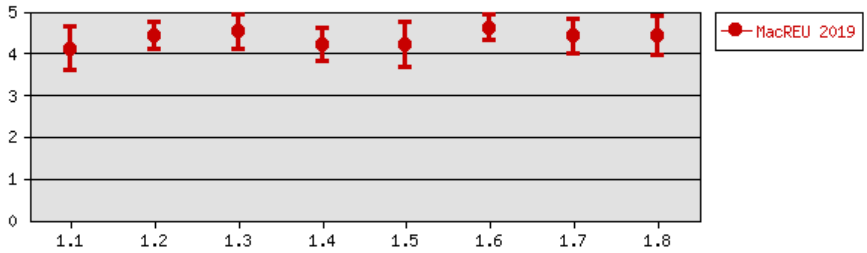

Figure 1: Gains in Thinking and Working Like a Scientist

Overall, the program well met its goals of introducing students to scientific research as a career and helping them to build capacity for conducting scientific research. This can be seen for example in Figure 1. In this section of the survey, students were asked to rate their own gains from the program in learning how to think scientifically and work like a scientist, and to apply scientific knowledge to research. Overall, students report good to great gains in skills such as analyzing data for patterns, formulating a research question and understanding theory and concepts. While there is a little variability in responses,

[1] See `https://salgsite.net/`, accessed February 13, 2020.

virtually all students report great gains in developing this capacity such that most of the confidence intervals exceeds the "good gains" category.

PERSONAL GAINS RELATED TO RESEARCH WORK

2. How much did you GAIN in the following areas as a result of your most recent research experience?	1:no gains	2:a little gain	3:moderate gain	4:good gain	5:great gain	9:not applicable	Mean	N
2.1 Confidence in my ability to contribute to science.	5%	0%	0%	25%	70%	0%	4.5	20
2.2 Comfort in discussing scientific concepts with others.	0%	5%	20%	15%	60%	0%	4.3	20
2.3 Comfort in working collaboratively with others.	5%	0%	5%	20%	70%	0%	4.5	20
2.4 Confidence in my ability to do well in future science courses.	0%	0%	5%	25%	70%	0%	4.6	20
2.5 Ability to work independently.	5%	0%	10%	10%	70%	5%	4.5	19
2.6 Developing patience with the slow pace of research.	5%	10%	10%	20%	55%	0%	4.1	20
2.7 Understanding what everyday research work is like.	0%	0%	0%	5%	95%	0%	5.0	20
2.8 Taking greater care in conducting procedures in the lab or field.	5%	0%	5%	25%	65%	0%	4.5	20

Summary of scale results
The graphic below lists the mean and confidence interval (±3 times the standard error) for each item.

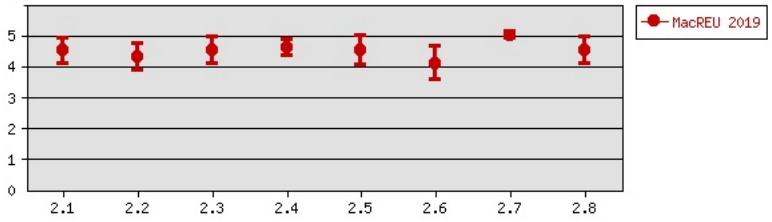

Figure 2: Personal Gains Related to Research Work

Likewise, in figure 2 students reported considerable personal gains in their own capacity to do research, in areas such as their own ability to contribute to science, their confidence to do well in future science courses, and understanding what everyday research is like. Like in Figure 1, the confidence intervals exceed a good level of gain response.

Figure 3 also presents firm evidence that students improved their professional skills such as how to prepare a scientific poster, keeping a detailed lab notebook and understanding journal articles. Students tend to report moderate to great gains in these skills across the board. That said, the overall scores are indicate that students overall only make modest gains for many of the research skills, which might reflect that working in labs over the summer does not impart the same amount of research skills that one would get in coursework.

Figure 4 continues to support the view that students gained in their self-efficacy for conducting research, where students typically indicated their gained a fair amount or a great deal in their own feelings of efficacy in engaging in real-world science research, feelings of responsibility for their research project, feeling part of the scientific community, confidence in their own ability to try out new ideas or procedures on their own and interacting with scientists from outside of the school.

Overall, figure 5 shows that students rated the quality of their research experience as excellent, including their working relationships with their research mentor, the amount

Gains in SKILLS

3. How much did you GAIN in the following areas as a result of your most recent research experience?	1:no gains	2:a little gain	3:moderate gain	4:good gain	5:great gain	9:not applicable	Mean	N
3.1 Writing scientific reports or papers.	10%	25%	20%	25%	20%	0%	3.2	20
3.2 Making oral presentations.	0%	5%	10%	20%	65%	0%	4.5	20
3.3 Defending an argument when asked questions.	5%	15%	15%	25%	40%	0%	3.8	20
3.4 Explaining my project to people outside my field.	5%	5%	10%	15%	65%	0%	4.3	20
3.5 Preparing a scientific poster.	0%	5%	5%	25%	65%	0%	4.5	20
3.6 Keeping a detailed lab notebook.	10%	5%	25%	20%	25%	15%	3.5	17
3.7 Conducting observations in the lab or field.	5%	0%	10%	35%	50%	0%	4.2	20
3.8 Using statistics to analyze data.	10%	20%	20%	10%	25%	15%	3.2	17
3.9 Calibrating instruments needed for measurement.	10%	20%	15%	5%	45%	5%	3.6	19
3.10 Working with computers.	5%	25%	20%	20%	30%	0%	3.5	20
3.11 Understanding journal articles.	5%	5%	15%	30%	45%	0%	4.1	20
3.12 Conducting database or internet searches.	5%	15%	10%	5%	65%	0%	4.1	20
3.13 Managing my time.	0%	0%	20%	30%	50%	0%	4.3	20

Summary of scale results

The graphic below lists the mean and confidence interval (±3 times the standard error) for each item.

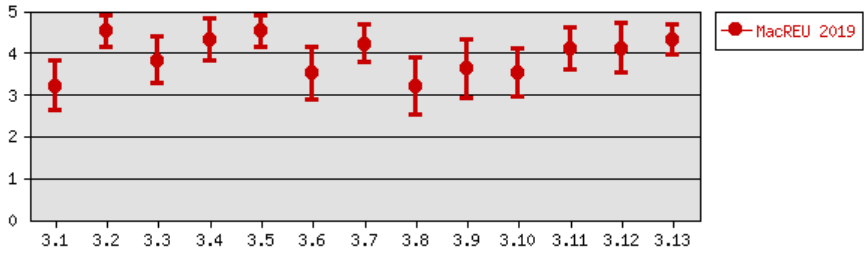

Figure 3: Gains in Academic Skills

of time doing meaningful research and the overall experience, and the amount of time spent with their mentors and getting advice from their mentors about graduate schools. Remarkably, virtually every student (90 percent) indicated that the overall research experience in the program was excellent.

The questionnaire also give students an opportunity to add more thoughts on the quality of their research experience and they wrote as follows. With two exceptions, the students overall write very positive comments about their experiences in the lab. One student indicates an initial poor experience but that that was corrected by placement in a different lab.

- Working with my research mentor was an amazing part of this experience, it really helped me understand what daily life as a grad student was like.
- It was a great time and I really enjoyed working with my mentor. Although we did not spend a great amount of time together that is not me saying it is a bad thing at all, the nature of our work requires us to be in separate places.

The following questions ask about your overall research experience and about any changes in your attitudes or behaviors as a researcher.

4. During your research experience HOW MUCH did you:	1:none	2:a little	3:some	4:a fair amount	5:a great deal	9:not applicable	Mean	N
4.1 Engage in real-world science research	0%	0%	0%	20%	80%	0%	4.8	20
4.2 Feel like a scientist.	5%	0%	10%	20%	65%	0%	4.4	20
4.3 Think creatively about the project.	0%	5%	15%	30%	50%	0%	4.2	20
4.4 Try out new ideas or procedures on your own.	20%	15%	0%	15%	50%	0%	3.6	20
4.5 Feel responsible for the project.	0%	0%	5%	20%	75%	0%	4.7	20
4.6 Work extra hours because you were excited about the research.	15%	0%	10%	10%	65%	0%	4.1	20
4.7 Interact with scientists from outside your school.	15%	10%	5%	15%	50%	5%	3.8	19
4.8 Feel a part of a scientific community.	5%	0%	5%	35%	55%	0%	4.3	20

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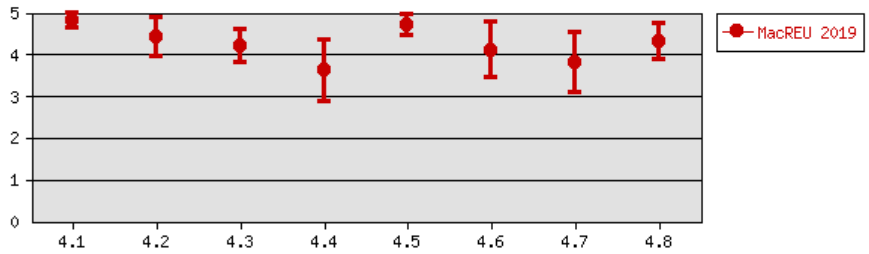

Figure 4: Attitude and Behavioral Changes

- Mark Lohmann was a great mentor. I learned so much through him and am very grateful that I was paired with him.
- My mentor was incredibly patient with me, he allowed me to learn and fill in my gaps of my knowledge. This would allow me to be proficient enough to contribute to the research, which was appreciated by him. It is clear that we have different ways of working that was difficult of adjusting to, but ultimately I adjusted to his pace.
- Relationship with mentor was good, plenty of advice and information on both undergrad life and grad school life.
- I never was really welcomed in the lab and no one other than my mentor ever engaged with me other than some very minimal small talk on occasion.
- This research experience helped me gain great knowledge and confidence in my field. I did meaningful research and had a fantastic relationship with my mentor.
- My Mentor was rude from the very beginning, he made things extra hard just to teach me a lesson about how hard grad is and to prove to me I was not as good as a scientist as him or grad school material, which he vocally expressed several times.

These questions ask about your research experience.

5. Please rate the following:	1:Not applicable	2:Poor	3:Fair	4:Good	5:Excellent	Mean	N
5.1 My working relationship with my research mentor	0%	10%	0%	25%	65%	4.4	20
5.2 My working relationship with research group members.	0%	5%	0%	25%	70%	4.6	20
5.3 The amount of time I spent doing meaningful research.	0%	5%	0%	50%	45%	4.3	20
5.4 The amount of time I spent with my research mentor.	0%	10%	10%	30%	50%	4.2	20
5.5 The advice my research mentor provided about careers or graduate school.	0%	20%	10%	10%	60%	4.1	20
5.6 The research experience overall.	0%	0%	5%	5%	90%	4.9	20
5.7 Please comment on any of these aspects.	Enter codes for text answers					--	17

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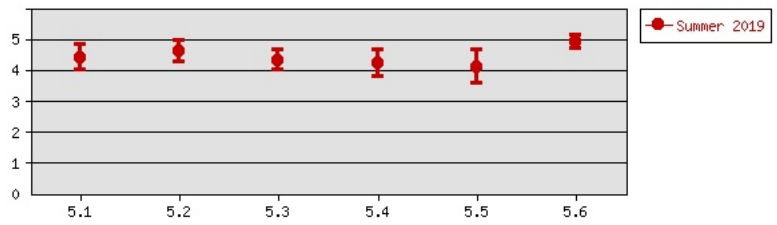

Figure 5: Quality of Research Experience

My mentor did not act as a mentor at all he just wanted free coffee. I expressed my concerns and was not taken seriously until Mike joined the team and got me out of that bad environment. I went on to join another lab where everyone was very welcoming and I was able to learn what research was really like and enhance my skills in the lab.

- The research experience with my graduate student was exceptional.
- My research mentor was not a part of my experience, aside from having me run errands for her. I worked directly with my PI, who I would rate as follows: 5.1:Excellent 5.4:Excellent 5.5:Good
- I loved working with my mentor and seeing her work hard pushed me to do better. My PI has instilled a nurturing environment for undergraduates to flourish and investigate in.
- There was a large learning curve in the beginning. This lead to frustrating times with my mentor, but by the end of the summer my mentor and I were able to have meaningful conversations about the project we were working on. Overall I very much enjoyed the experience.
- My mentor was patient with me and repeated herself multiple times in order for me to understand .

- Mark Gale, my mentor, has really helped me feel more confident with my own problem solving skills and my ability to conduct research. He has made me feel as though I am capable of pursuing research as a career and made me consider continue to apply to graduate programs for STEM.
- My mentor was great, I also had another grad student who I talked a bunch with and I learned a lot about science and grad school
- Dr. Yarmoff is definitely the most influential and progressive professor I have had the opportunity working with.
- My mentors had a tremendous affect in teaching me how to think like a scientist. I believe no matter what field I go into, that is one of the most important aspects I can take out of this program.

Research experience

6. As part of my most recent research experience...	1:yes	2:no	Mean	N
6.1 I presented a talk or poster to other students or faculty	100%	0%	--	20
6.2 I presented a talk or poster at a professional conference	30%	70%	--	20
6.3 I attended a conference	20%	80%	--	20
6.4 I wrote or co-wrote a paper that was published in an academic journal	20%	80%	--	20
6.5 I wrote or co-wrote a paper that was published in an undergraduate research journal	0%	100%	--	20
6.6 I will present a talk or poster to other students and faculty	95%	5%	--	20
6.7 I will present a talk or poster at a professional conference	100%	0%	--	20
6.8 I will write or co-write a paper to be published in an academic journal.	55%	45%	--	20
6.9 I will write or co-write a paper to be published in an undergraduate research journal.	40%	60%	--	20
6.10 I won an award or scholarship based on my research	0%	100%	--	20

Figure 6: Research Activities

Figure 6 summarizes the research communication activities students participated in. The program expected students to prepare a scientific poster as a part of the program, and all of them (100 percent) indicated that they presented a poster. The program did provide students an opportunity to prepare a talk, but they did not have the opportunity to attend a conference or publish a paper during the summer session. All of them however plan to present a poster or talk to other students and faculty and at professional conferences.

Figure 7 continues to lend support to our belief that the program enhanced students' interest in science and engineering as a career, typically indicating that the program confirmed and clarified their scientific career interests. Across all of the measures, students

Research experience

7. Rate how much you agree with the following statements.	1:Strongly disagree	2:Disagree	3:Agree	4:Strongly agree	Mean	N
7.1 Doing research confirmed my interest in my field of study.	5%	0%	45%	50%	3.4	20
7.2 Doing research clarified for me which field of study I want to pursue.	5%	5%	45%	45%	3.3	20
7.3 My research experience has prepared me for advanced coursework or thesis work	5%	10%	55%	30%	3.1	20
7.4 My research experience has prepared me for graduate school.	5%	0%	45%	50%	3.4	20
7.5 My research experience has prepared me for a job.	5%	0%	60%	35%	3.2	20

Summary of scale results

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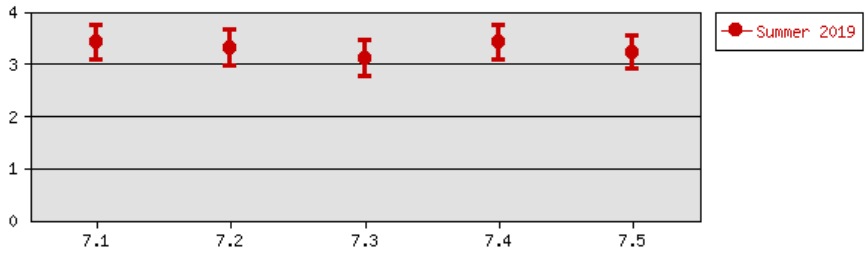

Figure 7: Effects of Research Experience on Personal Advancement

report agreeing that participating in the program enhanced their preparation for a career in science, especially items 7.1 "Doing research confirmed my interest in my field of study," 7.2 "Doing research clarified for me which field of study I want to pursue," and 7.4 "My research experience has prepared me for graduate school."

Figure 8 also confirms that the program enhanced students' expectations and interests in pursuing research and science as a career, indicating gains in interest in enrolling in a STEM PhD or masters' program and working in a science lab. The program did not enhance students' interest in medical, dental or law school which is expected. This figure overall indicates both the effectiveness of the program in enhancing students' interest in science and also that the program did not typically select students already on the science track, since if students entered program on a science career track they also would have indicated no gains.

The questionnaire also asked students to type in their intended degree and, "compared to your intentions BEFORE doing research, HOW LIKELY YOU ARE NOW to enroll in a graduate program leading to an advanced degree." Students wrote,

- I was on the fence about pursuing a Ph.D. program and thought I would maybe attempt to get my Masters. Now it has solidified my desire to pursue graduate school and obtain my doctorate.

- I am a biochemistry major. Coming into this program I really thought biochem was what I wanted to do because the chemical applications in biology are what I really

Research experience

8. Compared to your intentions BEFORE doing research, HOW LIKELY ARE YOU NOW to:	1:not more likely	2:a little more likely	3:somewhat more likely	4:much more likely	5:extremely more likely	9:not applicable	Mean	N
8.1 enroll in a Ph.D. program in science, mathematics or engineering?	5%	10%	0%	45%	40%	0%	4.1	20
8.2 enroll in a masters program in science, mathematics or engineering?	15%	10%	0%	25%	50%	0%	3.9	20
8.3 enroll in a combined M.D/Ph.D program	20%	5%	10%	30%	30%	5%	3.5	19
8.4 enroll in medical or dental school?	60%	5%	5%	5%	5%	20%	1.6	16
8.5 enroll in a program to earn a different professional degree (i.e. law, veterinary medicine, etc.)	65%	0%	0%	5%	10%	20%	1.7	16
8.6 pursue certification as a teacher?	50%	10%	15%	10%	10%	5%	2.2	19
8.7 work in a science lab?	0%	5%	5%	30%	55%	5%	4.4	19
8.8 Other. Please state your intended degree and, compared to your intentions BEFORE doing research, HOW LIKELY YOU ARE NOW to enroll in a graduate program leading to an advanced degree.	Enter codes for text answers						--	20

Summary of scale results

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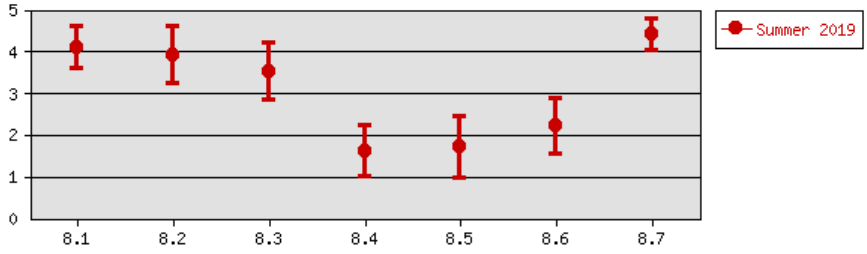


Figure 8: Effect of Experience on Entering the Pipeline

enjoy. Now I am realizing I can still do that with a chemistry degree alone.

- My intended degree used to be bachelors but now I want to enroll into a graduate program.
- My intended degree is Electrical Engineering, and prior to this program I was not sure what I wanted to pursue as higher education. After this program I have come to realize that I am interested in branches of bioengineering, particularly those that intersect with electrical engineering but pure bioengineering does not interest me. As such, I am much more likely to enroll in an electrical engineering focused graduate program.
- BS Mechanical Engineering, looking towards MS or Ph.D program
- Before coming here I wanted to obtain my masters in a science related field and through this program I do not think that is where I would thrive. I love working in a lab, but I do not think that research is a good option for me.

- I am a computer science major for my undergraduate degree, and after doing research in this program I am highly considering enrolling in a masters program.
- My intended major when I arrived here was chemistry with an emphasis on molecular synthesis. im very likely going to enroll in a graduate program. The program here extremely boosted my confidence in my abilities to apply and conquer graduate school.
- I am pursuing a BA in Chemistry and I was not sure if I wanted to go to grad school but after this program and all the adversity I endured I think I am more likely to consider applying to a masters program but not a PhD program just yet.
- Mechanical Engineering, and I am much more likely now to enroll
- I was quite likely to enroll in a Masters/Ph.D program to begin with, and this program helped solidify that decision. However, increasing 95 percent to 98 percent is not the largest change, which reflects my responses
- Chemistry-Biology, this REU has opened my eyes to pursuing engineering related fields. Before, I wanted to pursue medicine but my summer research has shown me how all these (research and medicine, and creativity) discipline can come together. I would say I am EXTREMELY MORE LIKELY to pursue a graduate school.
- I intended to finish my B.S and go into industry then maybe go back to graduate school but I believe that I want to go straight into graduate school after I get my B.S
- I am a biochemistry major that was previously undecided between applying for a pharmacy school or a Ph.D program. After this program, I am almost certain that a Ph.D program will better suit my career interests.
- I wanted to pursue either medical school or graduate school and now I'm more inclined to graduate school .
- I am more likely to apply. I've already been doing research for two years so it only cemented that I" be going to grad school.
- I am currently pursuing a second bachelor's in Applied Mathematics. Before the beginning of the research experience I was not too sure about applying to a Ph.D, but now I feel as though I would love to complete one doing my own research in mathematical applications in neural science. Having the hands-on research experience has really made me feel as though I can continue to work in a lab doing research.
- I want to get a bachelors in chemistry, and maybe a Ph.D or masters in material science. I was interested in material science before the program, This just increased that interest.

- My intended degree has remained Neuroscience, however I will continue working in the Yarmoff lab
- I would like to eventually pursue a Ph.D in either neuroscience, chemistry, or material science. Before the program, I did not have the best idea of what degree would suit me. This research experience had a large impact on what I would want to do in the future.

The questionnaire included an open-ended question asking students to reflect on how their research experience influenced their own thinking about future career and graduate school plans. The students wrote,

- It has made me want to pursue graduate school. From this experience, I have a better understanding of what it takes to obtain a Ph.D. and I has solidified my drive to do so.
- It has encouraged me to follow through with my plans of attending graduate school.
- This research experience influenced me very much to want to apply to graduate school.
- It has shifted me closer to going to electrical engineering, rather than bioengineering and as such I am considering a graduate degree in electrical engineering. Besides this I am also really interested in the R and D departments of companies and the benefits of joining a company to do research.
- I originally wanted to go into industry after BS, but now I'm seriously looking into teaching as a profession.
- Being in this program solidified for me what I already thought I knew—I do not want to research as a profession. How my brain works does not function well with the self paced and creative environment that is needed to research. I love science and I love labs, but research is not where my heart lies.
- This research experience helped me understand the importance of doing research. I have learnt so much in such this short amount of time that I am way more excited for my future career than before. I am planning to enroll in a Masters program once I finish my Bachelors in Computer science.
- During my research I started to develop a love for a field I have never seen myself in before and because of that I think I may find a degree that involves both my love for chemistry and my new found love for physics.
- After being under the mentorship of Dr. Tang and all the advice she gave to as to how to pursue a career in the cosmetics field, I think I am more willing to go on to graduate school with a focus on Organic Chemistry. The first lab I worked in showed me how I can manage working in a toxic environment and then the second lab I worked in proved my skills set in the lab is solid and a bit advance than others

in my level. I had the chance to personally develop my skills as a scientist and to self grow in the last three weeks of this program. The first seven weeks made me consider to pursue a different career as my mentor made me believe I would never be a good scientist. However after working with Dr. Tang, I am confident I will succeed in the scientific community.

- This has influenced me to apply to Ph. D programs
- I wanted to go to graduate school to begin with, but this program has given me the experience to say for certain that it would be a good fit for me.
- I like the environment of research and this summer has increased my appreciation even more. I definitely have enjoyed it more than my hospital l/ambulance job environment. It is clear to me that I have more space for creativity in grad school than in med school, which I value greatly.
- I know that I want to stay within the STEM field and go to graduate school after conducting this research. But I'm not too entirely sure what I would focus on going on to graduate school. I plan to go for a Phd.
- After this program, I believe my dream career would be to use computational techniques to research drug discovery.
- It made me feel much more capable of going through with my graduate school applications .
- It cemented the idea that I'll be going to grad school.
- Before the MacREU program I was thinking of only earning a master's degree because I felt as though I was not capable of completing a Ph.D program. I also felt as though I would not enjoy doing research. However, after this summer I feel excited for the challenges included in a Ph.D program and would like to continue with lab research.
- My research experience definitely gave me the opportunity to continue exploring the field of physics, and the responsibilities that come with working in a lab
- It definitely showed me how much I enjoy focusing on research. There have been many days where it felt like I was too tired to go in but there was not one day where I did not enjoy what I was doing. This was such a fulfilling experience and this program helped me figure out what I would want to do with my future.

The questionnaire also asked students to reflect on other ways the program enhanced their interest in science as a career and led to personal gains, and they wrote,

- I made many good connections with current researchers in my field as well as many students who are going to become amazing researchers one day.
- I learned so much about what my life would be if I were to enter research.

- Connections, meeting a lot of new people who can help me in the world.
- I gained a much better understanding of how to operate equipment that I formerly had little to no experience using.
- I also gained knowledge by observing my research mentor and getting to know his thought process. I believe it has allowed me to think about solving problems differently and has given me a lot of confidence to work on future projects.
- I learned how to use many different machines and how to work properly in a lab setting.
- I gained a sense of camaraderie unparalleled at my college campus.
- I have also learned to mentor a student and help to watch over and teach her how to work in our lab, as opposed to her previous one. (a student transferred into my lab midway through the program, and I was given the responsibility of helping her when my PI was not)
- The amount of knowledge gained from my peers and other collaborators on the project was a huge lesson for me and the importance of collaboration to move your research forward.
- I was able to create new relationships with people I would have never met outside of the lab and its a completely new atmosphere that was absolutely great experiencing
- I do believe I made significant progress learning the research process much more than if I were to just take a class for research credit.
- Other than learning to feel more confident when giving presentations and explaining research to people both in and outside of my field work, I learned how to feel more comfortable asking questions and asking for help. It has always been challenging for me to formulate the questions that will answer what I am struggling with, but now I realize that it is important to simply ask as many questions as needed until I feel as though I understand the subject better.
- I made some good connections.
- I learned so much more about working with ultra high vacuum chambers, and how they function
- I learned how to better interact with my lab and saw the importance of team work in this profession. This is not a career where you can fly completely solo and it gives a support system that I can rely on in case I ever need it.

Figure 9 indicates that students overall were satisfied with the organization and structure of the program itself. The program included training and involvement with lab personnel; we had a dedicated staff person (Rebecca Ryan) and graduate research assistant who were able to provide constant attention to the group training and activities, and

The following questions ask about aspects of the research program.

11. How satisfied were you with the following aspects of the research program?	1:Not applicable.	2:Very dissatisfied	3:Somewhat dissatisfied	4:Somewhat satisfied	5:Very satisfied	Mean	N
11.1 The application process.	0%	0%	5%	40%	55%	--	20
11.2 Support and guidance from program staff.	0%	5%	10%	25%	60%	--	20
11.3 Support and guidance from my research mentor.	0%	10%	0%	35%	55%	--	20
11.4 Support and guidance from other research group members.	0%	5%	0%	25%	70%	--	20
11.5 Research group meetings.	0%	5%	5%	20%	70%	--	20
11.6 Financial support.	0%	0%	0%	25%	75%	--	20
11.7 Group social activities.	0%	10%	5%	20%	65%	--	20

Figure 9: Satisfaction with the Program

more planned social activities. Overall we see high levels of satisfaction, especially on items 11.2 "Support and guidance from program staff," 11.4 "Support and guidance from other research group members," 11.5 "Research group meetings," and 11.6 "Financial support."

Training Sessions

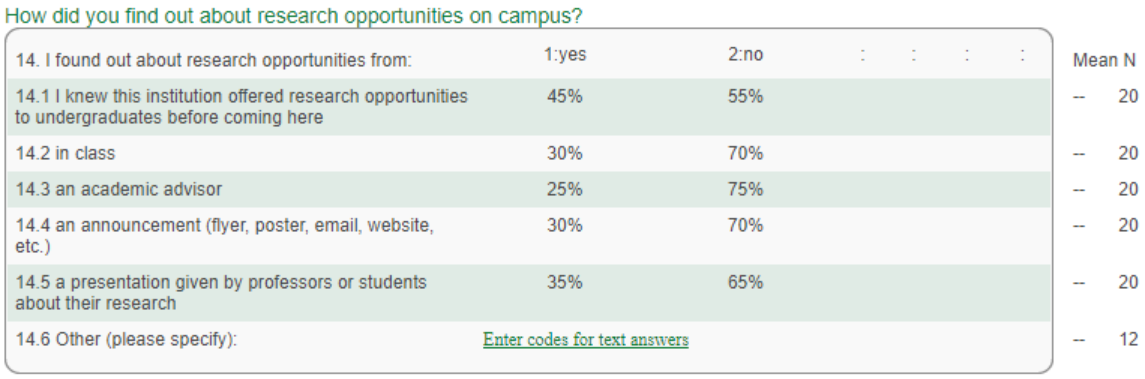
12. How MUCH did the following activities support your learning?	1:Did not do this activity	2:Not at all	3:A little	4:A good amount	5:A great deal	Mean	N
12.1 Workshop(s)on science writing and presentation.	10%	5%	15%	45%	25%	--	20
12.2 Training in library/internet/database search methods.	30%	5%	25%	25%	15%	--	20
12.3 Safety training	0%	10%	20%	45%	25%	--	20
12.4 Ethics seminar(s)	15%	5%	10%	40%	30%	--	20
12.5 Training in human or animal subjects regulations.	50%	15%	15%	15%	5%	--	20

Figure 10: Gains from Professional Training

Figure 10 indicates mixed views of the training offered, although in each case students typically report gaining a good amount or a great deal of learning from each program element such as a workshop on science writing and presentation, safety training, and ethics. This might be an area for future improvement, although there is only so much training students can do over the course of a 10 week program.

Figure 11 indicates that students learn about research opportunities such as MacREU from a variety of sources, including item 14.2 "In class," 14.3 "An academic advisor," and 14.5 "A presentation given by professors or students about their research." These results clearly show a strong improvement in the advertising, publicizing and communication of the program to prospective students.

Students also indicated other sources for this information in an open ended question, including two that learned of the program from the previous year's participants:



How did you find out about research opportunities on campus?

14. I found out about research opportunities from:	1:yes	2:no	:	:	:	:	Mean	N
14.1 I knew this institution offered research opportunities to undergraduates before coming here	45%	55%					--	20
14.2 in class	30%	70%					--	20
14.3 an academic advisor	25%	75%					--	20
14.4 an announcement (flyer, poster, email, website, etc.)	30%	70%					--	20
14.5 a presentation given by professors or students about their research	35%	65%					--	20
14.6 Other (please specify):	Enter codes for text answers						--	12

Figure 11: Ways to Learn about Research Opportunities on Campus

- My professor that I am currently working under has been my PI for the last two semester and she recommended me for the program.s
- Many professors from my university promote this program
- One of the students who attended this program a few years earlier gave a talk at our community college about this program and the research that he did. That is how I got to know this research opportunity.
- A professor from UCR working at my school as a Lab instructor told me to apply.
- MacREU alumni Henry Kouyoumdjian
- The listing on the NSF REU website
- NSF website
- My professor suggested I apply to this program.
- My current p.i.
- My math professor in Riverside City College mentioned that MacREU would be hosting a meeting for undergraduate research.
- The website was the NSF website for REUs
- My PI was the person who told me about this program and helped me obtain a spot.

Figure 12 shows that students report a wide range of motivations for participating in research, with high responses on items 15.1 "Explore my interest in science," 15.2 "Gain hands-on experience in research," 15.3 "Clarify which field I wanted to study," 15.5 "Clarify whether I wanted to pursue a science research career" 15.6 "Have a good intellectual challenge," and 15.10 "Enhance my resume."

The questionnaire also provided students an open-ended question to report motivations they have to do research.

What motivated you to do research?

15. I WANTED TO DO RESEARCH TO: (select all that apply)	1:yes	2:no	Mean	N
15.1 explore my interest in science	100%	0%	--	20
15.2 gain hands-on experience in research	100%	0%	--	20
15.3 clarify which field I wanted to study	95%	5%	--	20
15.4 clarify whether graduate school would be a good choice for me	85%	15%	--	20
15.5 clarify whether I wanted to pursue a science research career	90%	10%	--	20
15.6 have a good intellectual challenge	90%	10%	--	20
15.7 work more closely with a particular faculty member	55%	45%	--	20
15.8 participate in a program with strong reputation	70%	30%	--	20
15.9 get good letters of recommendation	75%	25%	--	20
15.10 enhance my resume	95%	5%	--	20
15.11 Other (please specify)	Enter codes for text answers		--	5

Figure 12: Motivations to do research

- I needed research units to graduate
- To better the world in which we live. To help forward the project I am placed on.
- Have an immersive experience in research and to get an idea of what graduate school is like.
- To think like a scientist.

Students were also given the opportunity to reflect on how the program impacted their career plans, and they wrote as follows. Typically the responses were quite positive although we do note some suggestions.

- I learned so much about the multiple ways I could take my career.
- I do not remember any specific activities that discussed graduate programs in depth
- The sessions were very insightful.
- The GRE prep courses where not as helpful as I had hoped it would be. I learned very little about graduate school and how to apply or decide what programs to pursue. Not much information from sessions
- GRE Preparatory classes were helpful to increase our understanding of how the test is run
- I very much enjoyed the speaker events because they gave me a better understanding of the career pathway I would like to take

- I think a session based completely on graduate school admissions would be very helpful .
- My favorite part of the speaker events was hearing the stories about how the researchers had ended up in graduate school doing research. I learned that not everyone's path is clear right away and that is okay, but it should not discourage you from applying to the programs.
- I started off motivated to do GRE prep, but after how hectic the transition was and the students took charge, I never got motivated to study GRE.
- It gave me a better idea of which field would fit me best.

Students also were given an opportunity to write suggestions on how to make the program experience better.

- n/a
- More training in different facilities. Like a once a week thing. I think I had the best research experience I could have had, especially when dealing with brand new materials. I would have appreciated being paired with an extremely motivated mentor but then again I am not unhappy with it.
- Perhaps a better apartment complex, the International Village was sub par.
- I would have like to have interacted with my PI, my lab members to have engaged with me, and I would have liked to be invited to group meetings
- I really liked this research experience.
- N/A
- I think a tour of more labs and projects would have been beneficial. Learning more lab techniques used in the field through hands on or demonstrations. More importantly learning about the different scopes of science one may pursue.
- More consistency and structure from GRE prep program
- If my graduate student mentor was doing what they were supposed to.
- If there was more solidified structure in the program in terms of planning and having information about events, activities and lab integration ahead of time.
- I believe that the research experience I had was really great and I would not have wanted to spend my summer in any other way.
- The program was amazing but if I could provide a suggestion it would be to have mentors that enjoyed teaching.
- I enjoyed my research experience, maybe if we were allowed to continue for the rest of summer and get compensated for it .

- More organization in the program. It felt like it was not structured most of the time.
- I was placed with a mentor that was only beginning his research so at first I felt as though I was not doing much. However, I am glad to have been a part of the beginning of a much bigger project. If anything, I felt as though I needed more background in organic chemistry, but that did not discourage me from continuing to be a part of the lab.
- Nothing I can think of
- Less emphasis on GRE meetings. I would have liked the program to focus much more on the research aspect, rather than GRE preparation. Instead of holding meetings for GRE prep, I would have liked to have them instead revolve around the research of all the students.
- It was great. I don't know what could have made it better.

And students were asked an open-ended question on how to make the experience better overall.

- n/a
- A little bit more organization.
- It would be really helpful that the paperwork be done on time, so we don't miss any events.
- I'm not sure
- I think it was already very good.
- N/A
- More exposure to different areas of science and what careers one may pursue.
- More structure and coordination
- Accommodation for the more intense labs
- I believe the process regarding applications and other paperwork could be improved or made more simple and the GRE prep sessions (first half) could have also been better. But overall the program was a great success
- The program was great and I cannot think of any better imporvements
- If the participants of the program where only allowed to be students and not teach GRE.
- T-shirts with the program logo. More organization and better ideas about what exactly is expected from us.

- More organization and attention to event details.
- Getting around was hard at first, so it was hard to get to the grocery store, once I started using public transit, it got better. Educate participants about their transportation options.
- Less emphasis on GRE preparation, definitely
- I felt satisfied with the program.

3 Aggregate Evaluation 2014-2019

In this section of the evaluation report we examine summary measures of the responses across sets of items in the survey. We compare whether the responses vary across important subgroups (not male and Hispanic), and we test whether the average of the response change across the years that we have administered the program. In each year of the program we submitted a detailed evaluation of the SALG data; please see those reports for detailed findings across all of the items of the survey for each of the individual years.

Over the six years we had 107 students compete the survey (including students in the same program in 2015 and 2016 but funded through the Semiconductor Research Corporation). In the survey 40 percent identify as not male (one student did not gender identify) and 50 percent identify Hispanic and we will use these self-reports to examine whether there are any differences in perspectives regarding the program for these two groups (the program also had a number of students from other URM groups who identify as African American, Native American, and Pacific Islander, but there are not enough observations from the students to reliably make statements, and it would not be sensible to collapse them into a single group, and so as a result we only examine the Hispanic category).

The SALG survey contains blocks of questions that are intended to create a scale relevant to important objectives of an REU site. The annual reports show the outcomes for each year for each of these questions. For this report, we condense the items into summary scales. To construct each scale, we first used factor analysis to confirm the items formed a coherent scale. One block of items (the third block regarding skill acquisition) yielded two factors, one related to communication skills and the other related to research skills so we separate these into two indexes. The remaining blocks each yielded a single factor. All skipped responses or "not applicable" responses are set to missing.

The first factor measures students' gains in thinking and working like a scientist: application of knowledge to research work. The responses ranges from 1 (no gains) to 5 (great gain). The question prompt was, "How much did you GAIN in the following areas as a result of your most recent research experience?" and the questions were:

- Analyzing data for patterns.
- Figuring out the next step in a research project.
- Problem-solving in general.

- Formulating a research question that could be answered with data.
- Identifying limitations of research methods and designs.
- Understanding the theory and concepts guiding my research project.
- Understanding the connections among scientific disciplines.
- Understanding the relevance of research to my coursework.

The second factor measures students' personal gains related to research work. The responses ranges from 1 (no gains) to 5 (great gain). The question prompt was, "How much did you GAIN in the following areas as a result of your most recent research experience?" and the questions were:

- Confidence in my ability to contribute to science.
- Comfort in discussing scientific concepts with others.
- Comfort in working collaboratively with others.
- Confidence in my ability to do well in future science courses.
- Ability to work independently.
- Developing patience with the slow pace of research.
- Understanding what everyday research work is like.
- Taking greater care in conducting procedures in the lab or field.

The third factor (part a) measures students' gains in communication skills. The responses ranges from 1 (no gains) to 5 (great gain). The question prompt was, "How much did you GAIN in the following areas as a result of your most recent research experience?" and the questions were:

- Writing scientific reports or papers.
- Making oral presentations.
- Explaining my project to people outside my field.
- Preparing a scientific poster.
- Conducting observations in the lab or field.
- Managing my time.
- Defending an argument when asked questions.

The third factor (part b) measures students' gains in research skills. The responses ranges from 1 (no gains) to 5 (great gain). The question prompt was, "How much did you GAIN in the following areas as a result of your most recent research experience?" and the questions were:

- Keeping a detailed lab notebook.
- Working with computers.
- Using statistics to analyze data.
- Calibrating instruments needed for measurement.
- Understanding journal articles.
- Conducting database or internet searches.

The fourth factor measures students' overall research experience and about any changes in attitudes or behaviors as a researcher. The responses ranged from 1 (none) to 5 (a great deal). The question prompt was, "During your research experience HOW MUCH did you:"

- Engage in real-world science research
- Feel like a scientist.
- Think creatively about the project.
- Try out new ideas or procedures on your own.
- Feel responsible for the project.
- Work extra hours because you were excited about the research.

The fifth factor measures students' perceptions of their research experience and interactions with mentors and colleagues. The responses ranged from 1 (not applicable) and 2 (poor) to 5 (excellent). The question prompt was "Please rate the following:" and the questions were:

- My working relationship with my research mentor
- My working relationship with research group members.
- The amount of time I spent doing meaningful research.
- The amount of time I spent with my research mentor.
- The advice my research mentor provided about careers or graduate school.
- The research experience overall.

The sixth block of items asked about students' ability to give presentations or to collaborate on journal articles and we report on those outcomes elsewhere in the final report.

The seventh factor measures students' perceptions of their research experience as preparation for a future career in science. The responses ranged from 1 (strongly disagree) to 4 (strongly agree). The prompt was "Rate how much you agree with the following statements." And the questions were:

- Doing research confirmed my interest in my field of study.
- Doing research clarified for me which field of study I want to pursue.
- My research experience has prepared me for advanced coursework or thesis work
- My research experience has prepared me for graduate school.
- My research experience has prepared me for a job.

The eighth and final factor measures students' plan to pursue an advanced degree and career in science or engineering. The response categories ranged from 1 (not more likely) to 5 (extremely more likely). The question prompt was "Compared to your intentions BEFORE doing research, HOW LIKELY ARE YOU NOW to:" and the questions were:

- Enroll in a Ph.D. program in science, mathematics or engineering?
- Enroll in a masters program in science, mathematics or engineering?
- Pursue certification as a teacher?
- Work in a science lab?

Table 1 presents the ANOVA (OLS regression) results that examine differences between female or Hispanic students from the other students, and also the average outcomes across the six years. Cell entries that reach statistical significance are indicated with an asterisk.

The constant row gives the average index score for each factor for the year 2016. For factors 1 to 5, the average response indicated a "great gains" response, and an "agree" response on factor 7. The average for the eighth factor, changes in career plans, centered on "much more likely." Overall, the results from 2016 were exceptionally good since they average at the top response category on nearly each dimension. The rows for years 2014, 2015, 2017, 2018 and 2019 indicate the change in this average compared to 2016. Note that a cell entry of "1" in these rows would indicate an expected change of one full response category on the survey. Examining the cells for these two rows we observed no difference between the baseline year (2016) and the results in years 2015, 2017, and 2019.

The 2014 results for F3a (communication skills development), F5 (research experience), F7 (preparation for a career and science) and F8 (intent to pursue a career in science) are statistically lower than the base year, but only by a small amount, and are big enough only to change the predicted result for F3a to "good gains" and for F8 to

Table 1: ANOVA results

	F1	F2	F3a	F3b	F4	F5	F7	F8	Combined
Not Male	-0.12	-0.08	-0.19	-0.29	-0.12	-0.04	-0.19	-0.25	-0.11
Hispanic	0.06	-0.07	0.02	0.11	-0.13	-0.05	0.11	0.28	0.18
Year 2014	-0.28	-0.23	-0.54*	-0.21	-0.42	-0.34*	-0.75*	-0.45*	
Year 2015	0.20	0.26	0.09	0.11	0.24	-0.05	0.19	-0.09	0.12
Year 2017	0.01	-0.04	0.13	0.23	0.09	-0.06	0.08	-0.26	0.09
Year 2018	0.10	-0.09	-0.23	-0.17	-0.31	-0.04	-0.12	-0.90*	-0.07
Year 2019	-0.14	-0.02	-0.17	-0.34	-0.16	0.03	-0.10	-0.13	-0.08
Constant (baseline 2016)	4.52*	4.58*	4.37*	4.09*	4.58*	4.44*	3.41*	3.70*	5.29*
N	97	103	96	86	105	106	106	90	66
Maximum	5	5	5	5	5	5	4	5	6.1

*$p < 0.10$ two tail test

"somewhat more likely." These lower scores can be attributed to 2014 being the first year of the program when we were still establishing procedures and best practices. The results for 2018 are somewhat lower for F8.

Next note that the point estimates for the "not male" (one student does not gender identify) and Hispanic categories are all small and not statistically significant, which indicates that the students in these two categories do not tend to experience the program any differently from all students on average.

4 Conclusion

Overall, the program was very successful in its goals of interesting students in a career in science and engineering, in equipping them for such a career, and providing with strong research experience and skills. Furthermore, the evaluation scores for this year were equal to or greater across the board compared to the the baseline year of the program (2106). In addition, while the program maintained high levels of exposure to research and mentoring, it also showed significant improvements in the program's on-campus administration and students' experience.

We look forward to building on this evaluation and even improving MacREU even more in 2020.