Materials Connection REU Site (MacREU R'Side) Evaluation, 2021*

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Abstract

This is the evaluation for the eighth 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 2021 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 2021, in which 18 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 40 percent Hispanic, 25 percent non-Hispanic URM students, and 30 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 18 students, 5 hailed from two year colleges, 4 came from non-research intensive four year colleges and the remaining from research intensive universities. In particular, the students had the following home institutions: California Baptist University, California Polytechnic State University, Cornell University, East Los Angeles College, Harvey Mudd College, Palomar College, Riverside City College (3), UCR (7) and University of La Verne (2).

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 program alumni that describes their research and experience in the program.

This evaluation draws on three 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, and 3) a short survey of the graduate student mentors who participated in the program.

Overall, the eighth year of the program well met its academic goals and broader impacts of exposing these 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 2021 program equaled the extremely strong results we observed from the previous 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 18 NSF-funded students; each 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%	40%	0%	4.1	18
1.2 Figuring out the next step in a research project.	0%	0%	5%	20%	65%	0%	4.7	18
1.3 Problem-solving in general.	0%	5%	5%	30%	50%	0%	4.4	18
1.4 Formulating a research question that could be answered with data.	0%	10%	10%	45%	25%	0%	3.9	18
1.5 Identifying limitations of research methods and designs.	0%	5%	20%	20%	45%	0%	4.2	18
1.6 Understanding the theory and concepts guiding my research project.	0%	0%	5%	10%	75%	0%	4.8	18
1.7 Understanding the connections among scientific disciplines.	0%	10%	0%	20%	60%	0%	4.4	18
1.8 Understanding the relevance of research to my coursework.	0%	5%	0%	10%	70%	5%	4.7	17

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, virtually all students report good or great gains in developing this capacity.

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.	0%	5%	5%	30%	50%	0%	4.4	18
2.2 Comfort in discussing scientific concepts with others.	0%	0%	0%	40%	50%	0%	4.6	18
2.3 Comfort in working collaboratively with others.	0%	0%	5%	25%	60%	0%	4.6	18
2.4 Confidence in my ability to do well in future science courses.	0%	10%	5%	20%	55%	0%	4.3	18
2.5 Ability to work independently.	0%	0%	15%	20%	55%	0%	4.4	18
2.6 Developing patience with the slow pace of research.	0%	0%	15%	25%	50%	0%	4.4	18
2.7 Understanding what everyday research work is like.	0%	0%	0%	5%	85%	0%	4.9	18
2.8 Taking greater care in conducting procedures in the lab or field.	0%	0%	5%	30%	50%	5%	4.5	17

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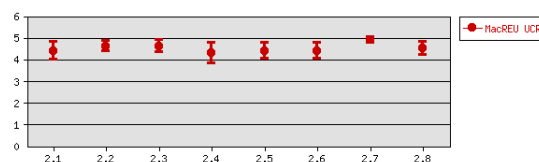

Figure 2: Personal Gains Related to Research Work

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

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[1] See https://salgsite.net/, accessed December 6, 2021.

to do well in future science courses, and understanding what everyday research is like. Each confidence interval equals or exceeds a good level of gain response.

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.	20%	5%	10%	25%	15%	15%	3.1	15
3.2 Making oral presentations.	0%	5%	0%	20%	60%	5%	4.6	17
3.3 Defending an argument when asked questions.	0%	5%	15%	30%	40%	0%	4.2	18
3.4 Explaining my project to people outside my field.	0%	0%	5%	5%	80%	0%	4.8	18
3.5 Preparing a scientific poster.	0%	0%	0%	15%	75%	0%	4.8	18
3.6 Keeping a detailed lab notebook.	15%	20%	10%	20%	10%	15%	2.9	15
3.7 Conducting observations in the lab or field.	5%	5%	10%	30%	30%	10%	3.9	16
3.8 Using statistics to analyze data.	15%	5%	10%	20%	30%	10%	3.6	16
3.9 Calibrating instruments needed for measurement.	10%	5%	10%	20%	30%	15%	3.7	15
3.10 Working with computers.	10%	5%	5%	10%	50%	10%	4.1	16
3.11 Understanding journal articles.	0%	0%	15%	35%	40%	0%	4.3	18
3.12 Conducting database or internet searches.	5%	15%	10%	15%	45%	0%	3.9	18
3.13 Managing my time.	5%	10%	25%	20%	30%	0%	3.7	18

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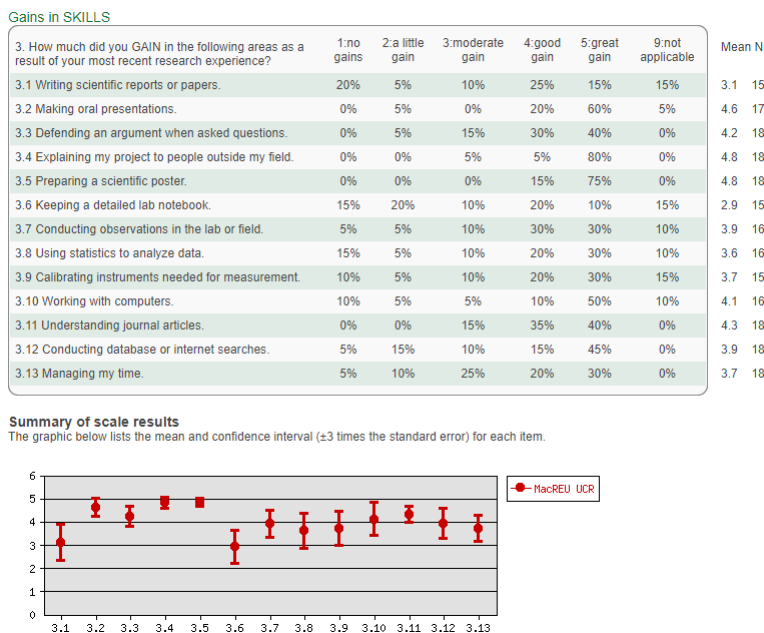

Figure 3: Gains in Academic Skills

Figure 3 also presents firm evidence that students improved their professional skills such as how to prepare a scientific poster, communicating their research to others, and understanding journal articles. Students tend to report moderate to great gains in these skills across the board. That said, students report only making modest gains for some of the research skills, such as writing scientific papers or keeping a detailed lab notebook, which might reflect that working in labs over the summer does not impart the same amount of writing skills that one would get in coursework. It is possible too that some of the labs use some system other than notebooks to record procedures and outcomes.

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 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.

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. A couple of students mention they felt their lab had communication or bandwidth issues, but some
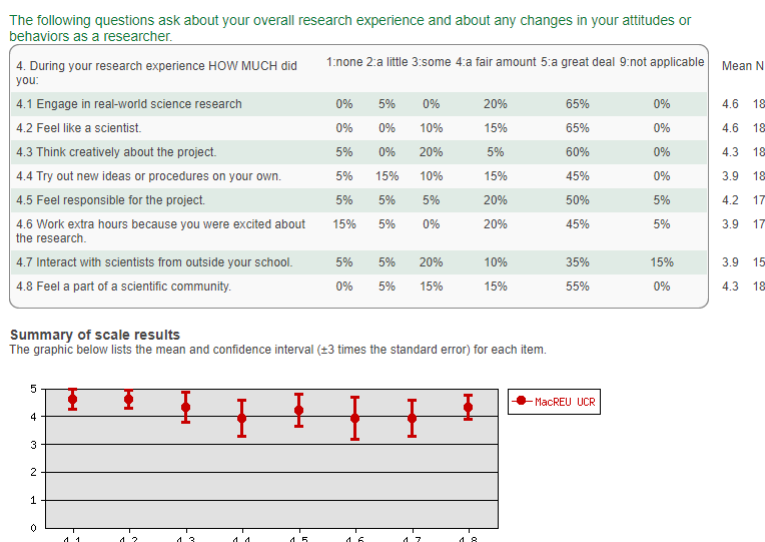
The following questions ask about your overall research experience and about any changes in your attitudes or behaviors as a researcher.

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%	5%	0%	20%	65%	0%	4.6	18
4.2 Feel like a scientist.	0%	0%	10%	15%	65%	0%	4.6	18
4.3 Think creatively about the project.	5%	0%	20%	5%	60%	0%	4.3	18
4.4 Try out new ideas or procedures on your own.	5%	15%	10%	15%	45%	0%	3.9	18
4.5 Feel responsible for the project.	5%	5%	5%	20%	50%	5%	4.2	17
4.6 Work extra hours because you were excited about the research.	15%	5%	0%	20%	45%	5%	3.9	17
4.7 Interact with scientists from outside your school.	5%	5%	20%	10%	35%	15%	3.9	15
4.8 Feel a part of a scientific community.	0%	5%	15%	15%	55%	0%	4.3	18

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

Figure 4: Attitude and Behavioral Changes

of that might be due to the fact that the campus had only recently reopened and much interaction was still over remote work.

- I had an incredible time with my mentor Soham, he did a great job teaching me about how to prepare for graduate school success, my lab overall was a great work environment

- I had a great relationship with my mentor throughout the 10 weeks. He provided me a lot of guidance when I needed it and when I had questions regarding research and graduate school.

- i wish i had more in person and hands on experience with my mentor. research was great and building professional relationships with labmates went well, but really wished i had more hands on, engaging mentor

- My mentor was pretty busy throughout my research experience, so I was not able to come into the lab everyday.

- My graduate student was able to communicate with me the questions I had regarding graduate school, but could I could have spent more time doing "meaningful research"

- Overall great experience, mentor taught well and walked me through all of the processes

- My research mentor was very very good. I think the lab in general knows how to guide undergrad students.

- My mentor being remote was pretty hard to work with. Nothing against them personally, however, it was much harder to communicate freely and build a relationship with.
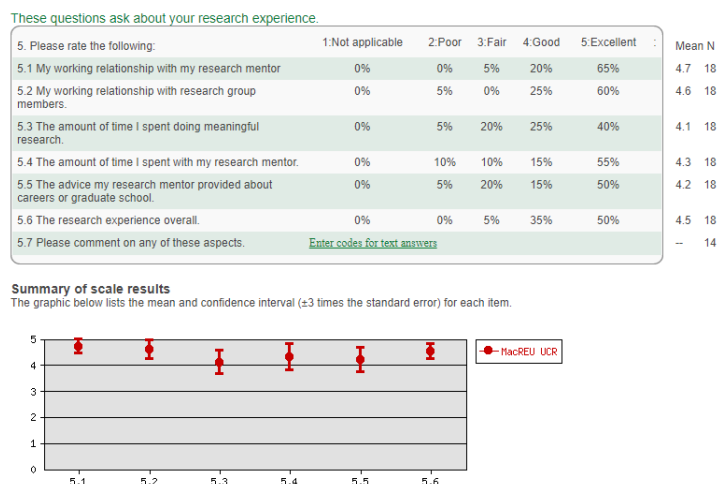
These questions ask about your research experience.

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%	0%	5%	20%	65%		4.7	18
5.2 My working relationship with research group members.	0%	5%	0%	25%	60%		4.6	18
5.3 The amount of time I spent doing meaningful research.	0%	5%	20%	25%	40%		4.1	18
5.4 The amount of time I spent with my research mentor.	0%	10%	10%	15%	55%		4.3	18
5.5 The advice my research mentor provided about careers or graduate school.	0%	5%	20%	15%	50%		4.2	18
5.6 The research experience overall.	0%	0%	5%	35%	50%		4.5	18
5.7 Please comment on any of these aspects.	Enter codes for text answers						–	14

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

Figure 5: Quality of Research Experience

- Working closely with my mentor provided great perspective on what a PhD actually means.

- I feel my mentor was extremely knowledgeable and helpful. She helped me to feel confident in my research

- I felt very comfortable to make mistakes and asking questions with my mentor.

- It was good overall

- My two mentors were the best. They helped me out whenever I needed help and they were always there for every step of the way.

- I felt the knowledge I gained about, not just conducting research, but about the process and decision of entering grad school was invaluable and really helped me narrow my focus on what I want to do after obtaining my Bachelors degree.

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 virtually all of them (90 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. Virtually 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 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,"

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	90%	0%					--	18	
6.2 I presented a talk or poster at a professional conference	10%	80%					--	18	
6.3 I attended a conference	10%	80%					--	18	
6.4 I wrote or co-wrote a paper that was published in an academic journal	0%	90%					--	18	
6.5 I wrote or co-wrote a paper that was published in an undergraduate research journal	0%	90%					--	18	
6.6 I will present a talk or poster to other students and faculty	80%	10%					--	18	
6.7 I will present a talk or poster at a professional conference	80%	10%					--	18	
6.8 I will write or co-write a paper to be published in an academic journal.	35%	55%					--	18	
6.9 I will write or co-write a paper to be published in an undergraduate research journal.	15%	75%					--	18	
6.10 I won an award or scholarship based on my research	0%	90%					--	18	

Figure 6: Research Activities

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%	10%	35%	40%			3.2	18
7.2 Doing research clarified for me which field of study I want to pursue.	0%	10%	45%	35%			3.3	18
7.3 My research experience has prepared me for advanced coursework or thesis work	5%	15%	25%	45%			3.2	18
7.4 My research experience has prepared me for graduate school.	0%	10%	35%	45%			3.4	18
7.5 My research experience has prepared me for a job.	0%	20%	30%	40%			3.2	18

Summary of scale results
The graphic below lists the mean and confidence interval (±3 times the standard error) for each item.
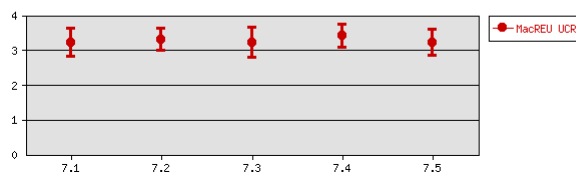
Figure 7: Effects of Research Experience on Personal Advancement

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
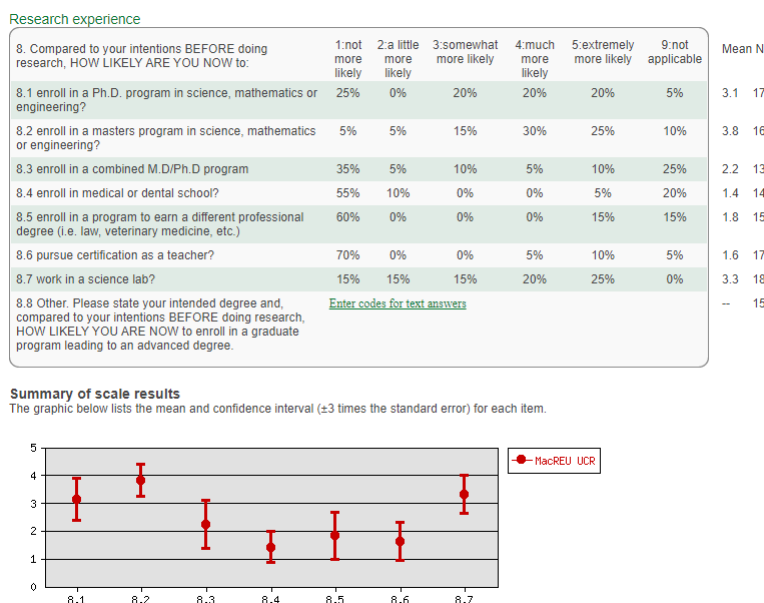
Research experience

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?	25%	0%	20%	20%	20%	5%	3.1	17
8.2 enroll in a masters program in science, mathematics or engineering?	5%	5%	15%	30%	25%	10%	3.8	16
8.3 enroll in a combined M.D/Ph.D program	35%	5%	10%	5%	10%	25%	2.2	13
8.4 enroll in medical or dental school?	55%	10%	0%	0%	5%	20%	1.4	14
8.5 enroll in a program to earn a different professional degree (i.e. law, veterinary medicine, etc.)	60%	0%	0%	0%	15%	15%	1.8	15
8.6 pursue certification as a teacher?	70%	0%	0%	5%	10%	5%	1.6	17
8.7 work in a science lab?	15%	15%	15%	20%	25%	0%	3.3	18
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						--	15

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

Figure 8: Effect of Experience on Entering the Pipeline

in a graduate program leading to an advanced degree." Students wrote,

- I had always intended to get my PHD in MSE, and this program confirmed that I can do that, additionally, it has changed how I want to do my career path, initially I wanted to be a PI but now I am more inclined to be a national lab researcher because it is a better fit for my career, I am almost entirely certain I want to enroll in a phd program

- My intended degree is a masters, however before the program I was only interested in completing a bachelors. I am extremely more likely to enroll in a graduate program after completing this program.

- i am unlikely to go to grad school as a computer science major with a focus on software development. Before i was clouded on where my career path should be but going through this research made me realize that industry is my intended path

- Before doing my research this summer, I intended to obtain a Doctor of Optometry degree. After doing my research, I am slightly more likely to enroll in a graduate program

- I'm a bioengineer major and I was thinking about going to get my masters degree but now after this program, I will at least get a masters Emad maybe go back to get my PhD.

- My views on my future degree in graduate school have not changed. I have been able to solidify my view in perusing a PhD for graduate school due to my experience in this program.

- Things haven't changed much for me, I've wanted to pursue a Ph.D in the Biomedical Sciences since 10th grade. This program has confirmed I enjoy research and will continue with it while at university

- I originally wanted to do research and get a phD, but I've always had doubts. This research experience confirmed my doubts, and now I am clear to pursue a masters degree in chemical engineering to work in industry.

- Right now, I'm just focused on getting my bachelor's degree. I don't feel more inclined to pursue graduate school as a result of this program because I would rather enter the workforce as early as possible.

- biochem, very likely

- My intended degree is Biochemistry. I plan on enrolling in a pharmacy school however, my backup plan is a masters in chemistry

- Im interested in pursuing research in machine learning an AI.

- My intentions have not changed much before and after the program. I already knew that I wanted to pursue a Masters in Mathematics so that I can teach at a community college, however, after completing the program I am now 100% assertive that I want to stick with my plan.

- My intended degree right now is a Bachelor's in Chemistry and Chemical Biology. I am somewhat more likely to enroll in a graduate program leading to an advanced degree.

- My intended degree is in chemical engineering. Before the program I wasn't too sure what I wanted to do with regards to graduate work and I wasn't that familiar on the difference in the research process between the two. Now I know that I want to pursue graduate work although I'm not sure yet if I will be ready to make the 4-5 year commitment of a Ph.D program.

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,

- I had always wanted a PHD, but I had initially wanted to be a PI, but I realized through this program that while I will still keep being a PI open as an option later in life, I think I would much rather be a national lab researcher because PI's are not hands on in the laboratory doing experiments, which I found about through MAC REU

- My research has shown me the different fields of science my education can be applied to and it really inspires me to pursue a career in research.

- working in a research lab confirmed my interst in working in industry.

- I would like to take a gap year between my BS and my D.O degrees and I would like to look into finding job that requires lab work.

- It helped strengthen the idea of going to get a masters or a PhD.

- It helped me to understand what a graduate career in chemistry would be like and showed me research is a route that I would want to take.

- Same as above, I've always wanted to pursue a Ph.D and pursue research. This program confirmed by interests

- I know want to do science and I am confident that I still want to do science. Maybe research itself is not the best way to find the enjoyment in science. I think I enjoy direct problem solving a lot (engineering) than research.

- My experience has made me much more informed about the realities of attending grad school. I am uncertain if I want to pursue that path at this point, but I feel more confident that I will make the right decision for myself.

- This research experience has made me think about what my life would be if I pursued a Ph.D rather than get a job right after graduating. Although, I am still unsure between industry and academia, I more willing to consider academia than I was before.

- My research experience has influenced my thoughts and stance on my career and graduate school plans significantly. Given this is my first experience outside of the classroom, knowing how research works has given me experience on real-world applications. I now know how it is like, how you must think, the lifestyle one must be in to be in this field. I personally do not think I like it. I do, to an extent, but if I were to do something again similar to this, I would want to do it in a field more in my interest. Not necessarily field, but more so a focus that I am more likely to pursue. Although, my stance on going into grad school has changed in the slightest. As much as I appreciate the experience, it isn't something I would initially find interested in.

- PhD actually seems fun, research and teaching and what not, so I might pursue one

- It made me think about wanting a masters in chemistry and furthering my career as a scientist

- I became excited for my future pursuits for research.

- My research experience exposed me to what it is like being a graduate student and applying to a grad program. The research I did help me realize I like doing research.

- My research experience made me assertive on what graduate program I would like to pursue. I had planned it to be in Mathematics but I was a little bit unsure. However, now I am completely sure that I want to be in Mathematics.

- My plans are to get a job in the industry for a year after graduating undergrad, and then strongly consider the possibility of attending graduate school.

- Most of all it provided me with information about the process of applying, choosing a lab, determining a research focus, and the day to activities and responsibilities of graduate students. This allowed me to develop a more substantial interest in research, but, by talking to other engineers, it also helped me realize that I'm still not sure if I want to make such a long Ph.D commitment before establishing myself in industry and starting a family.

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,

- My coding skills got much better, which are an invaluable skill in STEM, so learning how to work with computer science has been a net positive for me as a researcher

- No, everything was mentioned.

- I did not make other gains.

- I have nothing else to add.

- The other knowledge that I gained was definitely being more confident in my knowledge of what graduate school is going to be like and showing me that it is something that I can now realistically achieve.

- N/A

- I think seeing the research culture at a non-cal-state college opened my eyes. I know what it is like now and it is so much more different than what we call "research opportunities" at our school.

- Other gains that were not mentioned was the social aspect of this program and research in general. Just as much as it is an individual experience, it is a collaborative one as well. Working alongside my peers with similar intentions and goals, motivates me to push harder and be more open-minded to ideas. Hearing what others can do, what have been doing, pushes me to be more ambitious and think higher of myself. Making friends with my mentors, with people much higher in their academic career than myself, and hearing their way of thinking and advice gives me a window of growth. Seeing what they can do, I am able to picture myself in their shoes which pushes me to grow even further.

- the friends I made along the way

- I got to expand my network

- I gained experience on navigating furnaces and being exposed to other type of machines such as XRD.

- Overall, I am more aware of the entire research process leading up to a publication.

- Mentors. Not just my assigned graduate mentor, but everyone else in my lab who all played a part in helping inform me and guide me in both my own planned educationnal path and in my lab skills. I am extremely grateful to all of them and learned a lot this summer in regards to both research and the undergraduate/graduate processes.

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.	5%	0%	20%	40%	25%		--	18
11.2 Support and guidance from program staff.	0%	5%	0%	25%	60%		--	18
11.3 Support and guidance from my research mentor.	0%	5%	5%	15%	65%		--	18
11.4 Support and guidance from other research group members.	0%	5%	5%	15%	65%		--	18
11.5 Research group meetings.	10%	0%	0%	40%	40%		--	18
11.6 Financial support.	0%	0%	5%	45%	40%		--	18
11.7 Group social activities.	0%	10%	10%	20%	50%		--	18

Figure 9: Satisfaction with the Program

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 more planned social activities. Overall we see high levels of satisfaction, especially on items 11.2 "Support and guidance from program staff," 11.3 "Support and guidance from my research mentor," 11.4 "Support and guidance from other research group members," and 11.7 "Group social activities."

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.	35%	5%	10%	25%	15%		--	18
12.2 Training in library/internet/database search methods.	40%	10%	20%	20%	0%		--	18
12.3 Safety training	0%	0%	40%	30%	20%		--	18
12.4 Ethics seminar(s)	55%	15%	15%	0%	5%		--	18
12.5 Training in human or animal subjects regulations.	55%	10%	15%	5%	5%		--	18

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 continue to 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 4.1, "I knowe this institution offered researchopportunities for undergraduates before coming here," item 14.2 "In class," 14.4 "An announcement," and 14.5 "A presentation given by professors or students about their research."

Figure 11: Ways to Learn about Research Opportunities on Campus

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:

- Two years ago, I had a peer mentor that encouraged me to apply to REUs. The next year, I applied to more, so I discovered this on the REU website.

- looked at opportunities for research in UCR website

- academic advising told us to look at the NSF website for things to do during the summer.

- I talked to my Chemistry professor about research opportunities and she recommended checking out the REUs on the NSF website.

- a former MacREU participant.

- A professor from my home campus motivated me to apply

- My organic chemistry professor at Riverside City College told me about the program and recommended that I apply.

Figure 12: Motivations to do research

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," 15.4 "Clarify whether graduate school would be a good choice for me," 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.

- I wanted to get a paid opportunity for the summer that was going to be relevant to my field.

- publications

- I also thought it simply sounded fun as I already loved science.

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.

- Doing GRE practice (though useful) made me aware of the infeasibility of grad school in regards to my career path

- We did not have specific graduate school sessions. However, we had speakers who would discuss their experiences that helped me clarify my plans.

- These allowed me to view what other opportunities arise after completing a PhD.

- The presentation we got during the seminar felt like hearing things i've heard before. What really decided it for me was the experience of the "test drive" of grad school here.

- These activities were very insightful as to what I want to do in my career. It has showed me that this isn't exactly what I would like to do for the rest of my life.

- was fun, very eye-opening in regards to what hurdles one might face

- I think the GRE training wasn't very helpful. I think it was a lot of doing things on our own and not in a group and I think we should have spent more time working together on things such as math

- I am more understanding of what graduate school entails, however, I am still not sure whether that's something that aligns with my interests.

- The speakers we had helped me determine that I want my graduate degree to be in materials science to boost my chemical engineering bachelors degree.

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

- tips on presenting in science near deadline presentations

- Meeting different people from outside your research field has expanded my knowledge and cultivated my tolerance for other personalities and mindsets

- The graduate student mentors being more trained on what we should be doing in the program. Also, have PIs officially meet program members.

- If it was a bit longer with a bigger stipend to allow more costs to be included like gas for an example

- Being trained by my graduate student mentor, and then been given the chance to work independently on the project given by my PI. I felt that I was not able to achieve as much as I could have because I was not encouraged to work independently in the laboratory without the supervision of my mentor. more time to run experiments

- I think this experience itself is great. I wouldn't actually change anything. Everyone in lab is very nice and they teach well.

- GRE training was kind of a waste of time and it was too early in the morning and too frequent. GRE training once a week would be enough.

- My research experience would have been made better if my mentors knew what was going on in the program (the expectations, the meetings, the deadlines).

- more money, and also more organized social events

- Nothing

- N/A

- More stability within lab group in terms of mentors

- I feel like COVID restrictions made the experience somewhat limited. My mentor couldn't come into lab for a couple of days because the wellness survey did not clear him to come to campus due to traveling. Although, he couldn't come in, he still helped us out through video call to make sure we were doing the right thing. Other than that, everything went well.

- Dealing with the two program coordinators was frustrating/not possible at times, excluding Marissa who was responsive every time. I've had emails be completely ignored and be put in uncomfortable situations due to inadequate regard for students' concerns and safety (excluding Marissa) and this made attending this program much more stressful/difficult than it needed to be. I would have appreciated more respect and just in general, care for the students' wellbeing (not Marissa). The video editing was also not well done in my opinion, and it did not show what I wanted to say so I would have appreciated being able to be more a part of that process, for example seeing videos before they are shown to loads of people and being able to give suggestions or mention which parts were not the way I would have wanted them to be. But the lack of regard from the two program coordinators (again, not Marissa) was a bigger issue for me personally.

- Dropping the masks, having an open Starbucks on campus, and allowing for the group activities that I heard took place in previous years.

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

- more concise deadlines for some events, some speaker events seemed to have information being passed through too hastily on the presentation date

- A clearer line of communication between the participants and the program staff.

- having timely announcements (preferrably 2 weeks prior from the intended activity/event)

- Have more social events, more hands on demonstrations that are chemistry related. More topic specific discussions that are not just about a professors life.

- More social gatherings would be helpful. Also for meetings that aren't required for you to be in person should be done through zoom. There isn't a need for someone to travel an hour to hear someone speak and then go back home when it could've been done at home even though there're speaking through zoom. As well as some guest speakers should be told not to give lectures but talk more about their experiences when applying to grad school. Parking shouldn't limited in time.

- If the students in the program have a more similar experience in terms of how long they are in lab and their ability to work on their own so that it encourages independent research similar to what would be seen in a graduate level research.

- N/A

- I believe the midterm presentations don't need to be 4 hours long. Other than that, I wouldn't change other things. The program is solid.

- Some of the chosen speakers were extremely boring. The program was disorganized because Dr. Bartels did not communicate well with us.

- Having a workshop specifically on applying to graduate school

- What would my research experience better is if there was more inclusion to the CS students and staff. Most, if not all, the speakers were speakers that were geared to those in material science. Although, yes, this is a materials science program, the program has accepted CS students as a pilot program which I feel it be necessary to consider this as well. I do think too there should be some sort of small orientation for our mentors so that the first half of the program, given the CS pilot program, my mentors had no idea what was going on, or how this program had worked. There was also small communication between the program. What also could have made this program better was if, things were better organized. I am specifically talking about the filming. Watching the videos, it made me wish I could have made it. I emailed program directors before the program even started that I would be missing that

specific day. Given that it was in the contract to be there for filming, I had hoped the day that I told I would be missing would be taken into consideration. Another aspect of this program that would have improved the experience overall would be if there were socials that were covered by the program. A lot of money spent from the stipend would be on outings the group decided on. Yes, I do understand that these are our decisions to spend money and the amount, however, if there were organized events by the program, there wouldn't be much of a need to spend such a significant amount just to initially get to know each other.

- not much, I thought it was great, I had a great experience

- Working on organization of the program

- N/A

- Someone to take over if the coordinator is not available

- I think moving the GRE trainings a bit later in the day would improve the research experience.

- I know there were a number of people who had mentors or principal investigators who were not as present as they should have been. I think there should have been some sort of meeting to inform them (specifically graduate student mentors) of their responsibilities and what is expected of them.

- Some of the event communication was very last minute. I understand some of this was due to ever changing COVID regulations, but many times it wasn't, such as with event schedules or presentation rubrics. It put me in the position of having to make clarifications to my lab which made the overall program look disorganized. Fixing this with more ahead-of-time and consistent communication would have made the program better.

3   Pilot Graduate Mentor Survey

For the first time this year, we fielded a survey among the graduate student mentors in order to gain their perspectives and feedback on the program. We fielded the pilot survey to 15 graduate student mentors, and after a total of three follow ups (as necessary), six responded to the survey. We fielded the survey in December, 2021 as a pilot, and we plan to include the survey in the formal evaluation for Summer of 2002, when we will ensure that all graduate student mentors respond as a part of their participation. For this year we simply report the responses from the six mentors, and learn from them as we can. The responses were fully anonymous so we do not know if these mentors are representative of the full set of 15.

The survey consisted of four closed-ended questions and one open-ended response field. The questions and results are:

1. **Did you find that working with your undergraduate mentee helped in advancing your research?** For this item, one mentor chose "Definitely not - advising the student only took time away from my research." Three chose "Might or might not - advising the student took time but also led to improvements in my research." And one chose "Definitely yes - advising the student led me to clarify and deepen my own understanding of my research."

2. **Did advising your undergraduate mentee help you grow professionally?** Two mentors chose "Definitely yes - I improved my mentoring and other personal and professional skills." Two chose "Probably yes." One chose "Might or might not - the experience might have reinforced skills I already have." None chose "Probably not," or "Definitely not - working with the mentee had no value-added for me."

3. **Would you want to supervise a MacREU student again based on your experience this past summer (and assuming there is an opportunity before you graduate)?** Two chose "Definitely yes;" two chose "Probably yes;" one chose "Might or might not;" and none chose "Probably not" or "Definitely not."

4. **Overall, do you believe that participating as a mentor in the MacREU program is a positive or negative aspect of your graduate student career?** Two chose "Extremely positive;" three chose "Somewhat positive;" and none chose "Neither positive nor negative," "Somewhat negative," or "Extremely negative."

It appears that among the six mentors responding, five found the experience to be unqualified positive, while one mentor had a mixed experience. The mentors were asked to share their perspective in an open-ended question, "In the space below, please share with us any thoughts you have about your experience in the program, and especially any thoughts about how we can improve the graduate mentor experience." The responses to this question help us to understand these different experiences. The responses are:

- I appreciated that there was an effort to have social interaction among the undergraduates. I do wish that there were more of an effort to connect other undergraduates and their mentors, perhaps through a coffee meetup!

- The program served to help the student grow.

- It would have been beneficial to have been compensated for my time, seeing as how it took away from my research more than it contributed to it. It would have been useful to have a clearer understanding of the objectives and requirements of the MacREU program prior to the experience. It is my opinion that MacREU students should not be assigned to graduate students who are preparing to defend/graduate, which was the case for me - if it wasn't, I anticipated I would have had a much better experience.

Thus it seems that the one student who had a mixed experience with the program found participation difficult as they were focused on finishing their resesarch in order to graduate. They seem to recommend that we not recruit students in their final stages, or alternatively to provide compensation.

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) and equalled the high scores from the program's previous year (2019 – the 2020 program was cancelled due to the campus closure). 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 2022.