AC 2011-1221: BIOLOGICAL MATERIALS AND PROCESSES (BIOMAP) RESEARCH EXPERIENCES FOR UNDERGRADUATE

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I am a PhD student in Educational Leadership and policy studies with emphasis in higher education. I earned his Bachelor's degree in Industrial and Systems Engineering and Master's degree in Engineering Management both from Florida International University. I worked in companies such as CommerceBank, Johnson & Johnson, Electrolux and others as part of the operations, quality control, quality assurance and management teams. I started working at the office of Community College Research and Policy (OCCRP) as a Graduate Research Assistant in February 2009. I am currently working on a National Science Foundation funded project entitled the Pathway2STEM as Project Manager. I am also working in the Biomedical Materials and Process BioMaP REU project in conjunction with the ISU Engineering Department where he is conducting human interaction surveys, gathering data and coordinating logistics. One of his biggest passions is the study and encouragement of transfer students of all races and gender from Community College to a STEM program at the university.

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Dr. Jackson is a Postdoctoral Research Associate in the Office of Community College Research and Policy (OCCRP). She received her Bachelor's of Science degree in Psychology from the University of Arkansas at Pine Bluff in 2003. She obtained her Master's degree in Educational Leadership and Policy Studies with an emphasis in Student Affairs from Iowa State University in 2005. In 2010, Dr. Jackson obtained her doctoral degree in Educational Leadership and Policy Studies with an emphasis in Higher Education Administration. Dr. Jackson has worked as a Program Specialist in Multicultural Student Affairs at Iowa State University, as a Family Interaction Specialist at the Institute for Social and Behavioral Research (ISBR) at Iowa State University and has been working in OCCRP for the past 4 years. She currently works on National Science Foundation (NSF) funded projects such as Path2STEM degree and the Advanced Technological Education (ATE) project as well as additional projects that focus on the experiences of community college students and community college transfer student success. Dr. Jackson's dissertation is entitled "Transfer students in STEM majors: Gender differences in the socialization factors that influence academic and social adjustment." She is passionate about students, more specifically community college transfer students and women pursuing advanced degrees in STEM areas.

Biological Materials and Process (BioMaP) Research Experiences for Undergraduates (REU): Experiences of undergraduate students, graduate student mentors, and faculty.

Abstract

The goal of this study is to understand the experiences of undergraduate students at Iowa State University (ISU) in Biological Engineering REU, specifically in the areas of Biological Materials and Processes (BioMap). The integration of new techniques and knowledge is opening the door to the solution of biological questions (e.g. functioning of the immune system) deemed intractable only a few years ago. This new information, together with the deciphering of human, animal and plant genomes, has sparked a revolution, the result of which is an explosion of entirely new industries in medicine, food and nutrition, chemical synthesis, materials, and agriculture. Chemical and biological engineers are now making key research contributions at the interface of biology, chemistry and engineering. In fact, biology has become as much of an enabling science for chemical engineering as mathematics, physics, and chemistry. This new paradigm shift in the engineering field demands that undergraduate students should be exposed to biological engineering at an early stage of their career via research and discovery experiences. This will provide them with a better understanding about the importance of interdisciplinary research and science innovation.

There is a need for an increase in the representation of individuals in the areas of chemical and biological engineering. In this ever-increasing technology-driven and globalized society, we need more individuals who are trained in interdisciplinary sciences to address today's societal needs. According to the review of the literature, research experience for undergraduate students is an important educational tool to expose them to research, to increase their interest in graduate school, and to help them to develop their technical and communications skills. Additionally, Zydney, et al. found the interaction between undergraduate researchers and graduate students not only benefits undergraduates but also provides an important teaching experience for graduate students [3]. All these different factors have served as the greatest motivation to explore the student experience of participating in REU programs in chemical and biological engineering. This study demonstrates the benefits of REUs and how they can be improved in order to attract more undergraduate students to research careers and graduate school in the areas of chemical and biological engineering.

To assess the overall experience of the REU BioMaP students in relation to their interest in chemical and biological engineering, quantitative (pre-and post-surveys) and qualitative methods (interviews and focus groups) were performed. An analysis of the results revealed, that undergraduate students value research and the potential to continue their education journey in graduate school. When students were asked to rank the reasons why they chose to participate in the summer research program, 60% of them ranked as their first choice "*opportunity to conduct research*." While 30% of the students ranked as their first choice "*opportunity to determine if interested in graduate school*." However, 10% of the students ranked as their first choice "*good summer job*" as their primary reason for participating in the REU BioMaP Summer Research

Program. Additionally, students reported that they felt the program improved their computational and laboratory research skills as well as provide them with a better understanding of the research process. They believed the program helped them to clarify their goals regarding their majors and future career choices; the program also demonstrated to students the importance of networking with other colleagues in their field of study. Similarly, students stated that their projects were not only interesting; but also challenging, and that they were able to learn more about managing time and accomplishing different tasks in a short period of time. Moreover, students expressed that all workshops and activities during the REU BioMaP research program helped them to better develop their ability to write effectively, to think critically, to interact with others and to openly contribute to group discussions.

In addition to the quantitative data, a qualitative component will provide a rich, in depth-description of student experiences. Specifically, this component of the analysis will portray the experiences of students; their role in the labs and different tasks during the 10 weeks doing research. Findings will also address how students describe the factors that facilitate their success as engineering students.

Introduction and Background

In the past 30 years there has been a dramatic increase in the number of programs dedicated to engaging engineering students in undergraduate research activities. The National Science Foundation (NSF) began providing financial support for such programs in 1987 through the Research Experiences for Undergraduates (REU) program, which was specifically designed to attract talented students into research careers in science and engineering.

One of these research programs has been taking place at Iowa State University (ISU) under the name of Biological Materials and Processes (BioMaP) Research Experience for Undergraduates (REU). This program is a three-year renewal REU site program funded by the NSF. The purpose of the REU program is to provide an opportunity for undergraduate students to conduct hands-on research. The program has 2 areas of interest which include 1) Biological Materials, and 2) Biological Processes.

Literature Review

Several studies cover various components of the undergraduate research experience in science and engineering, focusing particularly on the benefits of these experiences. For example, Zydney, Bennett, Shahid, and Bauer stated that students who participate in research experiences are thought to develop expertise in an area of specialization, gain a better understanding and appreciation of the research process, and acquire team, communication, problem-solving, and critical thinking skills[1]. Also, Schowen states that research is an essential component of obtaining a bachelor's degree and students should be exposed to it[2].

In addition, the work of Zydney, et al. has demonstrated that the interactions between undergraduate students and graduate students not only benefited the undergraduates, but also provided important mentoring and teaching experience for the graduate students. Graduate students also developed skills that are important in both academic and industrial careers[3]. NSF has highlighted the involvement of undergraduate students in meaningful research with faculty

members as being one of the most powerful instructional tools[4]. Furthermore, Morley found that 92% of the participants in a summer research program in electrical engineering for minorities at Georgia Tech were either enrolled in graduate school or were planning to enroll within the next two years[5]. Thus, the literature makes clear the benefits of research experiences in science and engineering, revealing a win-win program for undergraduate students, graduate student mentors and faculty mentors.

Theoretical Framework

Astin's theory of involvement is perhaps the most appropriate when investigating and interpreting student involvement[6]. Astin defines involvement as the amount of physical and psychological energy that a student devotes to the academic experience[6]. He asserts that the more academically and socially involved individuals are and the more they interact with other students and faculty, the more likely they are to persist. These types of interactions, can lead to the success of many engineering students that aspire to finish their academic degree. This success can depend on their involvement. One thing we know about persistence is that involvement matters.

Purpose

The purpose of this study is to learn more about undergraduate's research experiences and attitudes regarding research topics, and program effectiveness. Additionally, an aim of this program is to explore best practices for attracting women and minorities into this area of research and graduate school. At the same time, the BioMaP summer program sought to enable students to gain life-long learning skills that will impact their contribution to science, engineering and society.

Background of the REU-BioMaP

The 10-week REU BioMaP Summer research program at Iowa State University allows students from different interdisciplinary groups to have the opportunity to interact with faculty, post-docs, graduate students, and industry. In addition to the novel research experiences, the students will be exposed to various enrichment activities such as short courses, joint seminars/meetings, workshops, tours of research facilities, and field trips.

It can be stated that the overall goal of the REU BioMaP summer program is to create relevant research experiences at Iowa State University (ISU) for undergraduate students in "Biological Engineering," specifically in the areas of Biological Materials and processes (BioMaP). The undergraduate students (BioMaP) summer group is integrated by domestic students from different universities within United States as well as international students. This international component consists of a partnership between The Instituto Tecnologico y de Estudios Superiores de Monterrey (ITESM) in Mexico and Iowa State University.

Research Questions

The following research questions will guide this study:

1) What are the background characteristics of the 2010 REU BioMaP summer research participants?

2) How effective is the BioMaP program in engaging undergraduate Chemical and Biological engineering students in research and graduate school activities?

3) How do the participants of the REU BioMaP program describe their overall experiences?

Methodology

This study is a part of a large evaluation of the REU BioMap summer program which includes undergraduate students, faculty mentors, graduate mentors, and middle school teachers. The methodology for this evaluation of the BioMaP REU program consists of a broad mix of assessment tools. For the purpose of this study we are only focusing on the REU undergraduate students. The data collection will consist of both: quantitative (pre- and post- surveys) and qualitative research methods (focus groups). At the beginning of the program students were required to fill out a pre-survey. This pre- survey collected data such as demographic information about the students, including sex, race, ethnic background, and other data such as their understanding of research and their familiarity with the research process (including computational research and/ or laboratory research). The purpose of the post-survey and qualitative focus groups was to evaluate the overall learning experience and satisfaction of the students during and after the BioMaP summer research program. Three focus groups were conducted with the students to understand and explore their experiences while in the summer research experience. Also, the data collected assist in improving the BioMaP summer research program.

Participants. The participants included; undergraduate students, faculty mentors, graduate mentors and middle school teachers. For the purpose of this study only the experiences of the REU undergraduate students will be highlighted.

Focus groups. The research team conducted focus groups with undergraduate students.

Student surveys: As part of the evaluation a pre- and-post survey were conducted via Qualtrics which is electronic software used to develop surveys. The pre-survey assessed student' interest and familiarity with the different tasks and material that was covered during the program and the post-survey assessed students regarding their experiences during the program as well as to evaluate the strength and possible weaknesses of the program in order to make future improvements.

Data Analysis

The results from the survey included descriptive statistics, frequencies, means, standard deviations and inferential paired samples T-test. For the purpose of the study, only the highest and statistical significant values are reported. Also for some of the responses only percentages were reported.

Additionally, all the qualitative data including focus groups and open-ended questions from the surveys were clustered into groups. Themes emerged from the cluster and were classified and supported with direct quotes from REU BioMaP participants' summer program.

Findings from 2009-2010

Quantitative and qualitative results are reported for the REU BioMaP. The quantitative findings for the REU BioMaP summer program used a five-point and a four-point likert scale. Regarding the qualitative portion, themes were developed and supported by students' quotes reflecting their feelings and experiences during the 10-week program.

Background Characteristics

Table 1 reports the descriptive statistics of the BioMaP undergraduate participants. Over 50 percent (54.8%) of participants were male. In terms of the racial/ethnic background of students, more than half (61.35%) were white students (non-Hispanic), followed by Hispanic or Latino/a (22.7%), and Asian or Pacific Islander (6.5%). Over 50% of students were classified as Senior and about the same percentage were majoring in chemical engineering (64.5%). Students who majored in bioengineering comprised 19.4% of the sample.

In terms of students' previous research experiences, more than half (58.1%) indicated that they had no experience. About one-fourth (25.8%) of students had one research experience and (12.9%) of students had two research experiences prior to the REU BioMaP Summer Research Program. Students were asked to indicate their reasons for attending the summer program. The highest responses were *opportunity to conduct research* (60.0%), followed by *opportunity to determine if interested in graduate school* (30.0%), and *good summer job* (10.0%).

Insert Table 1

Understanding of Research - Paired Mean Comparison

Table 2 provides the paired mean comparison of students' opinions about their understanding of research before and after participating in the REU BioMaP program at Iowa State University (ISU). The majority of students stated that they were "not sure" or "agreed" with most of the statements on the pre-survey. However, in the post-survey, students reported that they agreed with all the statements, indicating that they have a better understanding about research, career choices and professional development. Below are the 14 items where students reflected significant changes during the program.

- I can easily see connection among multiple disciplines.
- I am good at applying knowledge from different areas to solve current problems.
- I am comfortable thinking about ideas and beliefs different from my own.
- I have a good understanding of career choices and options in my discipline or field of study.
- I understand ethics that apply to my discipline.
- I can effectively apply the scientific method and develop a procedure to address a research problem.
- I am good at analyzing and interpreting data generated from analytical procedures.
- I am good at asking questions that help clarify the problem.
- I have a good idea of the type of depth of information that should be included in an excellent research report.
- I can establish an objective and neutral tone in a project report, avoiding subjectivity and bias.
- I know how to use figures, graphs, charts, and drawings effectively in a project report.
- I am comfortable interacting with an audience and responding to their questions.
- I effectively and comfortably interact with people from other cultures or ethnic groups.
- I have a good understanding of diverse cultures and values.

Insert Table 2

Familiarity with Research Process-Paired Mean Comparison

Table 3 shows paired mean comparisons of students' ratings of experience and familiarity with the research process. The pre-survey results indicated that students have a basic understanding of general safety regulations and laboratory procedures, find and use reference manuals, literature research skills, follow guideline for ethical research, use of statistic in research, technical writing requirements and technical communications skills (average ratings of 2.25-2.97). At the time of the post-survey, students made improvements regarding familiarity with research with an average rating of 3.16+. Out of the seven areas, six of them yielded statistically significant differences between the pre- and post-test.
The six areas that students indicated an increased familiarity with the research process were the following:

- How to find and use reference manuals such as current protocols
- Literature research skills
- Guidelines for ethical research
- Use of statistics in research
- Technical writing requirements
- Technical communication skills

Insert Table 3

Familiarity with Research Process-Computational Research-Paired Mean Comparison

Table 4 shows paired mean comparisons of students' ratings of their familiarity with the research process in the computational area. A total of four out of 15 students responded to the questions in the computational area. These students had direct experience working in this area during their BioMaP summer program. Students scored higher on their post-survey results as compared to their pre-test assessment. The three areas that were statistically significant in terms of change from pre to post regarding programming skills related to computational modeling and use of databases for biological research are listed below:

- Computational modeling of molecules
- Programming skills related to computational modeling
- Use of databases for biological research

Insert Table 4

Familiarity of Research Process-Laboratory Research-Paired Mean Comparison

Table 5 shows paired mean comparisons of students' ratings of their familiarity with laboratory research processes. At the time of the pre-survey, students reported a basic understanding about chemical and biological safety, chemical hygiene and making chemical solutions. By the end of the program, the items with statistically significant gains included the following:

- Chemical and biological safety
- Chemical hygiene
- Making chemical solutions and buffers
- Sterile techniques
- Spectrophotometer use
- Media preparation and autoclave

Insert Table 5

Level of skills prior to start and at the end of the BioMaP Program-Paired Mean Comparison

Table 6 presents the pre-and post-survey results of students' self-rating on a number of skills. Students were asked to respond to each statement on a five-point likert scale:
1=strongly disagree; 2=disagree; 3=not sure; 4=agree; and 5=strongly agree. At the end of the program out of nine items, three of them were statistically significant:

- Act as a leader
- Understanding scientific finding
- Approach problems creatively

Insert Table 6

POST-SURVEY: Rating of the REU BioMaP Experience and General Satisfaction

At the end of the program, students were asked to rate their experience during their participation in the REU BioMaP. **Table 7** reports the findings. Students were asked to respond to each statement on a five-point likert scale: 1=strongly disagree; 2=disagree; 3=not sure; 4=agree; and 5=strongly agree. Overall, students reported agreement on the improvement of various experiences. Items with the highest scores regarding their experiences were:

- Helped me to better understand the nature of my major and how it relates to other disciplines (4.58)
- Improved my research skills (4.54)
- Helped me to improve skills that are needed for my future career (4.41)
- Improved my ability to think critically (4.41)
- Provided me support to help my learning (4.38)
- Increased my interest in continuing research (4.35)
- Improved my ability to think of different ways to solve problems (4.32)
- Helped me develop connections with professionals from my career area of interest (4.32)
- Improved my ability to write effectively (4.22)
- Improved my ability to work cooperatively and productively with others (4.16)

Insert Table 7

General Satisfaction

Table 8 presents the post-survey results regarding students' general satisfaction of the BioMaP summer program. Students reported agreement with the following statements:

- My project was interesting and challenging (4.19)
- My research project was well defined (4.45)
- I was able to meet with faculty and/or graduate student mentor when needed (4.06)

Insert Table 8

REU Students Focus Groups

REU Student Focus Group I

The objective of Focus Group I was to explore the early experiences of the REU students in the summer program. The students were able to discuss their interaction with faculty and share their reactions to early research opportunities and graduate school. Three main themes emerged from focus group I: 1) Great research experience; 2) better understanding of graduate degree options; and 3) interaction with peers, faculty and graduate mentors matter.

Great research experience

"It makes me realize that there are a lot of techniques that are just cutting edge and new that is good to learn when doing research."

"You can read what research people are doing but to actually be doing it and seeing it done is something that is a lot more valuable."

"I have learned a lot. And labs things are never perfect. I make mistakes but it is a learning experience so I'm gaining. I am acquiring skills that make me better at my job and future endeavors."

Better understanding of graduate degree options

"I was not sure if I wanted to do grad school before this and now I am thinking that I do want to go in that direction."

"Seeing what grad school is like and exploring graduate school and research. It is about getting more information to gain direction for the future."

Interaction with peers, faculty and graduate mentors matter

"*I like that in some seminars we had contact with people from other REU's and I think this has a positive aspect to interact with people that aren't just in our group that they are here for a different reason."*

"I have enjoyed that graduate students are so welcoming and friendly."

"We need to have more activities as group/teachers vs. students' activities."

REU Focus Group II

The objective of Focus Group II was to collect information regarding students' research experiences, and their interactions with graduate and faulty mentors after three weeks in the program. Students reported feeling more comfortable and confident about their different tasks assigned in the program. Some of the male students expressed that there was good communication and interaction with their mentors, especially faculty. Some students also asserted that the "learning strategies" provided a great experience in constructing solid ideas when writing a lab report. Students also felt that the REU BioMaP program has helped them to develop self confidence. This mainly came by working in a research project on their own.

Regarding the second focus group, three main themes emerged: 1) great exposure and learning experience in the lab; 2) development of technical communication skills; and 3) increased understanding of diverse cultures and values.

Great exposure and learning experience in the lab

"I have learned a lot of techniques in the lab so far and they will be helpful as I continue to do research."

"After a couple of weeks being in the program, I have learned how to follow procedures and instructions, become more independent and take charge."

Development of technical communication skills

"Learning to ask the right questions so that you can get the right answer, the right help to solve the problem."

"It has been a great learning experience about strategies to construct solid ideas when writing a lab report. Additionally, workshops have been very helpful to develop and exercise our writing skills."

Increased understanding of diverse cultures and values

"I have two roommates from Mexico and it is been pretty cool learning about different cultures and kind of learning their language a little bit, and also it is cool that we have a couple of people from Iowa State so to, kind of lead the way a little bit, that was a big help because they kind of pulled us all together at first so it was nice."

"Have diversity and minorities into the program has been a great plus because we can learn a lot from each other. Some students even expresses it has been excited to learn some Spanish from other international students."

REU Focus Group III

The objective of the third and final focus group was to assess the overall experience of the students during their participation in the REU BioMaP program. Students expressed that the REU BioMaP program helped them to get a clear direction on where they would like to go and what they would like to do after finishing undergraduate school. Students also indicated that they would like to see an extension regarding the duration of the program as well as some participation from other science majors. The students felt that the skills and knowledge they were getting from the program prepared them and gave them clear insight about graduate school.

Regarding Focus Group III, three main themes emerged. The themes are 1) the REU Summer Program was challenging; 2) better vision about their future regarding career path; 3) high level of satisfaction at the end of the program; and 4) involvement matters.

The REU Summer Program was challenging

"Students in general were agreed about some of the challenging aspect during the program were: Away from the family and enjoy their summer with them, writing a long report related to research results, preparing for a poster presentation, and achieving tasks in a short period of time."

"I think it is a challenge to get a good data in 10 weeks. At first I was like 'how am I supposed to get all this done in 10 weeks and I finally have."

Better vision about their future regarding career path

"At first I was not really sure if I wanted to just go to industry right out of college, or to go to grad school and I think that the program changed my mind to go right to grad school. It has been a good experience."

"The program helped me to get a clear direction where I would like to go and what to do after I finish my undergraduate school."

High level of satisfaction at the end of the program

"I think the BioMaP was a good opportunity to grow up both personally and professionally and it was a very good opportunity to have some interaction with lots of people from different backgrounds and it was also a good opportunity to do some self discovery and I think I learned a lot both in the lab and from people around me and myself."

"I feel really immersed in my project and I want to do as much as I can and I feel like I have done enough to like be in the program, but I kind of want to do everything I can, so I can feel connected to my project and my work now. I am very satisfied with my project and what I have done this summer."

Involvement matters

"*It is cool that we are all from different places and have similar interests in engineering and in that way we all have similar ways of thinking, too."*

"It is cool meeting other people from other parts of the country and outside of the country. We will always be friends on Facebook."

Discussion and implications for Research, Policy and Practice

The REU BioMaP examined the experiences of 31 undergraduate students from different universities within United States as well as 6 students from Mexico. Descriptive analyses were provided that included frequencies, means, standard deviations as well as inferential paired samples T-test. For the purpose of the study, only the highest and statistical significant values were reported. Also for some of the responses percentages were reported depending on the questions and the scale used to measure these responses. Future studies should examine the

recruitment policies of engineering students, in order to increase female and minority representation in the program. Also future studies can discuss if there are any differences between the experiences of the international student versus domestic students in the engineering field. Additionally, analysis by gender can also be done to better understand specific experiences of students in engineering majors.

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Table 1
Frequencies of REU Student's Background Characteristics
N= 31

	Frequency	Percent
Gender		
Female	14	45.2%
Male	17	54.8%
Ethnicity American Indian/ Native Alaskan	1	3.2%
Asian or Pacific Islander	2	6.5%
Black (non-Hispanic)	2	6.5%
Hispanic or Latino/a	7	22.6%
White (non-Hispanic)	17	54.8%
White/Asian	2	6.5%
Classification		
Sophomore	2	6.5%
Junior	13	41.9%
Senior	16	51.6%
Major		
Chemical Engineering	20	64.5%
Bio Engineering	6	19.4%
Other	5	16.1%
Previous Research Projects		
None	18	58.1%
One	8	25.8%
Two	4	12.9%
More than two	1	3.2%
Number one reason for attending Summer Research Experience		
Good summer job	3	10.0%
Opportunity to determine if interested in graduate school	9	30.0%
Opportunity to conduct research	18	60.0%

Table2
Understanding of Research-Paired Mean Comparisons

	Pre-test (n=31)		Post-test (n=31)		Paired Mean Comparison	
	Mean	SD	Mean	SD	t	*p*
I can easily see connections among multiple disciplines.	4.19	0.75	4.58	0.56	-3.01	0.01*
I am good at applying knowledge from different areas to solve current problems.	3.93	0.57	4.16	0.58	-2.04	0.05*
I am comfortable thinking about ideas and beliefs different from my own.	4.03	0.49	4.30	0.65	-2.11	0.04*
I have a good understanding of career choices and options in my discipline or field of study.	3.58	1.06	4.38	0.62	-3.67	0.00*
I understand ethics that apply to my discipline.	3.71	0.94	4.35	0.55	-4.28	0.00*
I can effectively apply the scientific method and develop a procedure to address a research problem.	3.58	0.76	4.22	0.62	-4.50	0.00*
I am good at analyzing and interpreting data generated from analytical procedures.	3.83	0.73	4.19	0.65	-2.48	0.02*
I am good at asking questions that help clarify the problem.	3.93	0.63	4.16	0.64	-1.32	0.20*
I have a good idea of the type and depth of information that should be included in an excellent research report.	3.13	0.92	4.23	0.67	-5.00	0.00*
I can establish an objective and neutral tone in a project report, avoiding subjectivity and bias.	3.74	0.68	4.58	0.5	-6.36	0.00*
I know how to use figures, graphs, charts, and drawings effectively in a project report.	3.83	0.73	4.54	0.62	-4.79	0.00*
I am comfortable interacting with an audience and responding to their questions.	3.25	1.09	3.90	0.91	-4.09	0.00*
I effectively and comfortably interact with people from other cultures or ethnic groups.	4.22	0.56	4.71	0.46	-4.73	0.00*
I have a good understanding of diverse cultures and values.	4.00	0.97	4.39	0.67	-2.68	0.01*

Scale: 1= Strongly disagree, 2= Disagree, 3= Not sure, 4= Agree, 5= Strongly Agree

*$p \leq .05$ level

Table 3
Familiarity with Research Process

	Pre-test (n=31)		Post-test (n=31)		Paired Mean Comparison	
	Mean	SD	Mean	SD	t	*p*
General safety regulations and laboratory procedures	2.97	0.84	3.29	0.9	-1.67	0.11*
How to find and use reference manuals such as current protocols	2.32	0.87	3.16	0.78	-6.36	0.00*
Literature research skills	2.83	0.82	3.32	0.75	-3.32	0.00*
Guidelines for ethical research	2.29	0.97	3.25	0.86	-4.61	0.00*
Use of statistics in research	2.16	0.82	2.83	0.86	-4.15	0.00*
Technical writing requirements	2.33	0.88	3.40	0.77	-6.44	0.00*
Technical communication skills (e.g., interdisciplinary language and terms)	2.25	0.89	3.38	0.72	-5.22	0.00*

Scale: 1= Unfamiliar, 2= Basic understanding, 3= Understand and experiment, 4= Apply concepts
*$p \leq .05$ level

Table 4

Familiarity with Research Process-Computational Research - Paired Mean Comparison

	Pre-test (n=10)		Post-test (n=10)		Paired Mean Comparison	
	Mean	SD	Mean	SD	t	*p*
Computational modeling of molecules	1.50	0.71	3.50	0.71	-5.07	0.00*
Programming skills related to computational modeling	1.80	1.03	3.00	0.82	-3.34	0.01*
Use of databases for biological research	1.80	0.92	3.00	1.05	-2.57	0.03*

Scale: 1= Unfamiliar, 2= Basic understanding, 3= Understand and experiment, 4= Apply concepts
*$p \leq .05$ level

Table 5
Familiarity with Research Process-Laboratory Research-Paired Mean Comparison

	Pre-test (n=26)		Post-test (n=26)		Paired Mean Comparison	
	Mean	SD	Mean	SD	t	*p*
Chemical and biological safety (e.g., waste disposal, use of fume hood, chemical spills)	3.03	0.72	3.61	0.57	-2.98	0.00*
Chemical hygiene (e.g., cleaning up, discarding excess, use of clean materials)	3.19	0.75	3.70	0.55	-2.69	0.01*
Making chemical solutions and buffers	2.73	1.00	3.61	0.50	-5.89	0.00*
Sterile techniques	2.80	0.96	3.24	0.83	-2.11	0.05*
Spectrophotometer use	2.53	1.14	3.34	0.89	-3.89	0.00*
Media preparation and autoclave	2.07	1.26	2.58	1.20	-2.05	0.05*

Scale: 1= Unfamiliar, 2= Basic understanding, 3= Understand and experiment, 4= Apply concepts
*$p \leq .05$ level

Table 6
Rating level of skills prior to start the program and at the end of the program

	Pre-test (n=31)		Post-test (n=31)		Paired Mean Comparison	
	Mean	SD	Mean	SD	t	*p*
Solve problems independently	3.06	1.31	3.00	1.57	0.37	0.71
Act as a leader	3.00	1.23	2.83	1.19	1.15	0.26*
Understanding scientific findings	2.90	1.25	3.03	1.54	-0.89	0.38*
Maintain openness to new ideas	3.00	1.32	3.03	1.64	-0.25	0.80
Work as part of a team	2.93	1.39	3.00	1.55	-0.42	0.68
Adapt to changing technology	2.97	1.17	3.00	1.53	-0.24	0.81
Approach problems creatively	2.83	1.00	3.06	1.50	-1.19	0.24*
Develop intellectual curiosity	3.09	1.35	3.06	1.61	0.27	0.79
Tolerate ambiguity	3.00	0.82	2.87	1.31	0.55	0.59

Scale: 1= Strongly disagree, 2= Disagree, 3= Not sure, 4= Agree, 5= Strongly Agree
*$p \leq .05$ level

Table 7
Rating of REU BioMap Experience

	Post-test (n=31)	
	Mean	SD
Improved my ability to work cooperatively and productively with others	4.16	0.89
Improved my ability to interact with others and contribute to group discussions	4.09	0.90
Improved my ability to put team goals above my own personal goals	4.00	0.95
Improved my ability to write effectively	4.22	0.84
Improved my ability to speak effectively	4.03	0.91
Improved my ability to think of different ways to solve problems	4.32	0.75
Improved my ability to think critically	4.41	0.76
Helped me to better understand the nature of my major and how it relates to other disciplines	4.58	0.56
Helped me develop connections with professionals from my career area of interest	4.32	0.90
Helped me to improve skills that are needed for my future career	4.41	0.76
Provided me support to help my learning	4.38	0.76
Improved my research skills	4.54	0.72
Increased my interest in continuing research	4.35	0.95

Scale: 1= Strongly disagree, 2= Disagree, 3= Not sure, 4= Agree, 5= Strongly Agree

Table 8
Rating of REU BioMap General Satisfaction

	Post-test (n=31)	
	Mean	SD
My project was interesting and challenging.	4.19	0.91
I was able to meet with faculty and/or graduate student mentors when needed.	4.45	0.77
My research project was well defined.	4.06	0.81

Scale: 1= Strongly disagree, 2= Disagree, 3= Not sure, 4= Agree, 5= Strongly Agree