2015 Program Evaluation: *Research Experiences for Undergraduates/Research Experience for Teachers*

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Technical Report

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Executive Summary

The Center for Remote Sensing of Ice Sheets (CReSIS) was established in 2005 through support from the National Science Foundation (NSF). CReSIS focuses on developing new technologies and computer models to measure and predict the response of sea level change to the mass balance of the Greenland and Antarctic ice sheets. CReSIS also conducts educational outreach programs to train next-generation scientists and engineers. The 2015 CReSIS Research Experience for Undergraduates (REU)/Research Experience for Teachers (RET) program targeted students who were highly motivated, were able to work independently and expressed a strong interest in climate-related studies and polar science. For the summer of 2015, twenty students were selected to join the REU/RET program on the basis of their academic background, research interests, the availability of faculty mentors and current research projects at CReSIS. Nine students were placed at Elizabeth City State University (ECSU), four students were placed at the University of Kansas (KU) and five students were placed at Indiana University (IU) and two students were funded by CReSIS and participated in the Juneau Icefield Research Program (JIRP). There were a large percentage of minority and underrepresented students participating in this year's program that 55% of the participants were female and 85% were minority students (African American and Native American).

The 2015 REU/RET program is an intensive eight-week summer program. REU/RET students worked as full-time research assistants and were involved in a range of STEM research and learning activities. The CReSIS REU/RET program is held on three campuses and one field

program (ECSU, KU IU and JIRP program) and each program has a different start and end date. Each campus has a coordinator who is in charge of travel and logistics and developing a schedule for the REU/RET students. REU/RET students' schedules varied by campus and some of the activities they were involved included attending tutorials (e.g. MatLab), professional development seminars and meetings and working on their supervised research projects under faculty mentors and graduate research assistants. In addition, a variety of social activities were conducted throughout the program to enhance REU/RET peer relationships. At the end of the program, REU/RET students presented their research work to CReSIS faculty, staff, and students in both oral and poster presentations.

To evaluate the effectiveness of 2015 REU/RET program, a pre-survey, post-survey and mentors' survey were designed to measure the degree to which this program met outreach objectives. The pre-survey included eighteen survey items and three open-ended questions. The post-survey consisted of five survey questions used in the pre-survey and four open-ended questions designed to collect REU students' thoughts about how to improve the quality of the REU/RET program. The mentor's survey includes four survey questions and two open-ended questions. Both quantitative and qualitative methodologies were utilized to analyze the results of the pre- and post-surveys and the mentors' survey.

The evaluation results suggest that this REU/RET program has provided such a valuable research experience that students have significantly improved their research skills, have largely increased their confidence in conducting research and have successfully encouraged them to be more likely to consider attending graduate school. The effect size analysis confirmed that

this program had a positive and large effect on students' three primary outcomes: research skills, confidence in doing research and STEM career aspirations. It is worth noting that in addition to these three expected goals, this year's REU program enabled students to form friendships with their peers, allowed students to form connections with faculty members and also encouraged students to persist in their STEM undergraduate studies.

The following recommendations are made based on the data analyzed from the REU/RET pre- and post-survey and the mentor survey.

- Given that this research experience has largely boosted minority students' confidence in conducting research, CReSIS needs to continue its recruitment efforts and keep increasing the number of minority and underrepresented students in the REU/RET program.

- As compared to survey results of 2014, this year's REUs were more satisfied with their interactions with their mentors however CReSIS may continuously look for mentors who are available for the whole program and encourage more faculty interaction with students throughout the program.

- CReSIS may set up a new webpage related to scientific writing since knowledge about scientific writing are critical for students to prepare for writing research papers and making research posters.

- As recommended in the mentor survey, CReSIS may consider updating the database that keeps track of former REU/RET students in order to follow up with their career plans and

to provide necessary help for their success in STEM fields. This should be made available to mentors.

Overview

Since 2005, CReSIS is committed to coordinating and hosting educational outreach programs to train next-generation scientists and engineers and to providing research and learning opportunities for underrepresented students. The 2015 CReSIS REU/RET program targeted students who could work independently and expressed a strong interest in climate-related studies and polar science. Students were required to have a minimum GPA of 3.0 in a relevant major (physics, engineering, geography, atmospheric science, geology, geophysics, computer science, and mathematics or science/math education). REU/RET students were recruited nation-wide and women and minority students were strongly encouraged to apply. The advertising strategies used were poster advertising, website advertising and email advertising to various sources. CReSIS recruited twenty students to join the REU/RET summer program in 2015. REU students were placed at three collaborating institutions and one field program (KU, ECSU, IU and JIRP) based on student's interest and availability of mentors. Under the guidance of mentors, REU students developed their research projects, created research posters and presented their findings/projects at the end of the program. For RET students, they developed research projects and their deliverables included developing a lesson plan, creating a research poster and giving a presentation. During this process, students also attended Matlab tutorials, professional development activities and participated in social/extracurricular activities.

Participants Profile

Twenty students were selected to join the REU/RET program. Nine students were placed at Elizabeth City State University (ECSU), four students were placed at the University of Kansas (KU), five students were placed at Indiana University (IU) and two students were funded by CReSIS and participated in the JIRP program. The 2015 REU/RET students represented various disciplines-computer science (N=9), engineering (N=4), mathematics education (N=2), Electronics Technology (N=2), Elementary education (N=1), Atmospheric and geography science (N=1), and Interactive design (N=1). Nearly half of REU students were juniors (N=11) and the remaining students were sophomores (N=5), seniors (N=3) and one graduate student (N=1).

There were a large percentage of minority and underrepresented students participating in the program, with 55% of female students and 80% of minority students (African American, and Native American students). Also, 44% of the participants (9 out of 20 students) who provided information regarding their socio-economic status shared they were from single-parent households with an annual income of less than $45,000.

Table 1: 2015 CReSIS REU Demographic Profiles (Gender)

2015 REU	Number	Percent
Female	11	55%
Male	9	45%
Total	20	100.00%

Table 2: 2015 CReSIS REU Demographic Profiles (Race)

2015 REU	Number	Percent
White	3	15%

Black	16	80%
Native American	1	5%
Total	20	100%

Assessment Methodology

This evaluation employed an objective-oriented evaluation approach. A review of prior literature on REU program yields general objectives of REU programs, which is also used for designing the evaluation surveys. In order to assess this REU/RET program, the pre-survey, post-survey and mentors' survey were analyzed to determine the extent to which these primary objectives were met.

Objectives of REU program

After reviewing the literature for the REU evaluation reports, three main objectives were summarized as follows. First, a number of articles shared that participants increased their research skills by performing research projects with scientists (Russell et al., 2007; Seymour et al., 2004; Ward et al., 2002). Also, research experiences were found to have a positive effect on participants' attitudes toward research and their confidence in their research skills (Alexander et al., 2000; Kardash, 2000; Russell et al., 2007). Further, several studies reported that REU programs increased participants' awareness of graduate schools and encouraged them to persist in their own scientific areas (Russell et al., 2007; Ward et al., 2002;Granger, et al., 2006). Based on the literature review above, the CReSIS REU program established three main objectives: 1. The research experience can increase students' knowledge of research methodology and skills; 2. Participants' confidence in learning and research is expected to be

improved by attending the REU program; and 3. REU program can have a positive effect on students' career choice or students' persistence in STEM fields.

Along with the literature review of prior REU evaluation reports, Kirkpatrick's Four Levels of Evaluation model for training and learning programs (Kirkpatrick, 19941) also guided our evaluation framework. According to this model, evaluation should always begin with level one, and then, as time and budget allows, should move sequentially through levels two, three, and four. These four levels include Reaction (how participants in a training program are satisfied), Learning (the extent students have advanced in skills, knowledge, or attitude), Behavior (transfer that has occurred in learners' behavior due to the training program) and Results (tangible results of the learning process) (Kirkpatrick, 1994). The goal of this evaluation is to begin with level one and aim to reach level two by using the pre- and post-survey. In other words, this evaluation attempts to gauge REU students' four general outcomes, including satisfaction, knowledge, skills and attitude. Overall, based on the literature review and Kirkpatrick's Four Levels of Evaluation model, this REU/RET evaluation attempts to answer the following questions:

1. Have students improved their scientific knowledge after the program?

2. Have students improved their confidence in doing scientific research after the program?

3. Can this program successfully strengthen students' interests in science careers?

4. To what extent are students satisfied with this REU program

5. Overall, does this year's REU program meet the primary objectives?

Evaluation Design

The pre-survey, post-survey and mentors' survey were designed to measure the degree to which this program can meet the primary objectives stated above. The pre-survey included eighteen survey items and three open-ended questions (See Appendix B). The post-survey consisted of five survey and four open-ended questions designed to collect students' thoughts about how to improve the quality of the REU/RET program (See Appendix C). Along with collecting demographic information, the goal of pre-survey was to assess REU/RET students' knowledge background, program expectations, self-efficacy and their career goals prior to the REU/RET program. The post-survey consisted of five items that were used in the pre-survey with a purpose of comparing the differences between pre- and post-survey. The mentor's survey includes four survey questions and two open-ended questions (See Appendix D). Mentors were asked to complete a survey and to provide perspectives of student's involvement in the REU/RET program and effectiveness of the research experience.

Evaluation methodologies

Both quantitative and qualitative data were utilized to gauge the effect of REU/RET program. Quantitative data collected in pre- and post-surveys were analyzed using descriptive statistics and paired-samples t test. The mean differences of the Likert-scale items between pre-test and post-test were used to judge whether the comparison result was positive or not. Other than the mean difference, the T test value and the P value were reported in data analysis. The qualitative data, including the open-ended questions and the mentors' survey would

provide unique views for assessing the quality of this REU/RET program and were coded by common themes.

Further, although the descriptive statistics and paired-sample t test can test if the statistically significant difference exits after the treatment, they can't measure the size or magnitude of the effect. Thus, to better evaluate this outreach effort, the effect size, Cohen's d is calculated and interpreted. Often used in experimental studies, Cohen's d is an effect size used to indicate the standardized difference between two means (Cohen, 1988). Cohen's d can be calculated as the difference between the means divided by the pooled standard deviation:

$$(1). \ d = \frac{m_1 - m_2}{s_{pooled}}$$

Pooled standard deviation is the standard deviation remaining after removing the effect of special cause variation, which is:

$$(2). \ s_{pooled} = \sqrt{\frac{df_1.s_1^2 + df_2.s_2^2}{df_1 + df_2}}$$

Where m_1 = mean of treatment group, m_2 = mean of comparison group, Spooled = pooled standard deviation, df_1 = sample size of treatment group, df_2 = sample size of comparison group, S1 = standard deviation of treatment group and S2 = standard deviation of comparison group. Cohen (1988) also proposed the benchmarks for interpreting Cohen's d, whereby 0.2 equates to a small effect, 0.5 equates to a medium effect, and effects larger than 0.8 equate to large effects. With Cohen's d and its benchmarks, the effect of experiments can be quantified and compared.

Evaluation procedures

The administration of pre-survey, post-survey and mentors survey is briefly introduced as follows. All surveys were administered through online survey tool, Surveymonkey. Links to the pre-survey were emailed to the 23 REU/RET participants on May 15, 2015. By May 28, 2015, 23 participants had given their feedback, for a response rate of 100%. However, before the REU/RET programs began three students voluntarily dropped out of program due to other commitments. The post-survey was sent to all REU/RET participants on July 9, 2015. By August 25, 2015 19 out of the remaining 20 participants had given their feedback for a response rate of 95%. The mentor's survey was emailed to ten faculty/graduate student mentors on September 21, 2015 and the survey closed on October 3, 2015. In total, five mentors have completed the survey, with a response rate of 50%.

Evaluation Findings

Part I: Results of Pre-and Post-survey

Based on the pre-test and post-test results, this section mainly focuses on analyzing the effect of REU/RET program on students' research skills, self-efficacy, career choices and program satisfaction. The open-ended responses are analyzed and interpreted below as well.

Research Skills

Comparisons of REU/RET students' self-reported academic achievement prior to the REU/RET program and after the program were assessed. Ten items were adopted in the survey to measure REUs' academic knowledge in research skills, writing ability and other pertinent

areas related to academic achievement. The mean difference and T test results are shown in Table 3.

Table 3: REU/RET Participant Self-Reported Research Skills Achievement

Items	Mean Difference	T Value	P Value
Data collection, interpretation	1.5	2.9	.011*
Conducting a research study	1.375	2.9	.011*
Finding research articles	1.1875	2.36	.032*
Technical and scientific writing	1.25	2.88	.011*
Research presentation preparation	1.5	3.5	.003**
Research presentation skills	1.18	2.64	.018*
Ethics in science	1.125	2.57	.021*
Reference citations	1	2.14	.048*
Conference participation	1.125	2.25	.04
Graduate school in STEM fields	1.285	2.71	.018*

*means p<0.05 ** means p<0.01

As showed above, this year's REU program had significant impacts on students' various measures of research skills. From the perspective of improvements in research skills, students have gained significantly more knowledge in research skills after participating in the program. More importantly this increased research skill improvement is statistically significant which indicates that this program at least succeeded in helping students gain more knowledge related to research skills. From the ten items analyzed, nine mean differences are statistically significant according to the paired-sample t test. The improvements of scientific knowledge are mainly reflected in data collection and interpretation, conducting research, literature review, technical report writing, presentation, scientific ethics, reference citation and graduate schools in STEM fields. In general, the acquisition of new knowledge in research skills by participating in

REU/RET program showed that this program successfully fulfilled one of the major objectives-improving students' knowledge and skills in doing STEM research.

Table 4: Effect sizes of research skills

Items	Cohen's d
Data collection, interpretation	1.45
Conducting a research study	1.45
Finding research articles	1.18
Technical and scientific writing	1.44
Research presentation preparation	1.75
Research presentation skills	1.32
Ethics in science	1.285
Reference citations	1.07
Conference participation	1.125
Graduate school in STEM fields	1.355

For the effect size analysis, nine effect sizes have been calculated and interpreted as follows. According to the benchmark of Cohen's d, 0.2 to 0.5 means a small effect; 0.5 to 0.8 suggests a medium effect and effect size larger than 0.8 is a large effect. Based on this benchmark, nine effect sizes are all large effects, which suggest a roughly large magnitude of the effect of this year's REU/RET program on students' research skill improvement. For instance, after participating in this year's REU/RET program, students gained more knowledge in data collection at 1.45 standard deviations since the program began.

Self-efficacy

REU/RET students' self-efficacy was assessed before and after the program. Ten items were created with a purpose of measuring REU/RET students' confidence in their research

ability and attending graduate schools. Table 5 shows the results from the data collected and analyzed.

Table 5: REU/RET Participant Self-Efficacy

Items	Mean Difference	T Value	P Value
To use MATLAB.	-.187	-.446	.662
To perform supervised research.	1.125	2.76	.014*
To do the lab work.	.68	1.74	.102
To give an oral presentation	.937	2.39	.03*
To evaluate the quality of research studies.	.687	1.96	.068
To design a research study independently.	.812	2.14	.049*
Finding research challenging and exciting.	.125	.382	.708
To apply statistics to my research.	.75	1.732	.104
To apply various methodologies.	1.06	2.868	.012*
To succeed in graduate school.	.07	.434	.671

*means p<0.05

The results indicate this REU/RET program significantly improved participants' confidence in doing STEM research in a variety of ways. Of ten survey items analyzed above, four differences are statistically significant, which suggests that students have become more confident in doing STEM research by participating in the CReSIS REU/RET program. By engaging in the research this summer, students' confidence levels have been elevated in many aspects of scientific research such as giving oral presentations, designing research studies independently and applying research methodologies.

Table 6: Effect sizes of self-efficacy

Items	Cohen's d
To preform supervised research.	1.38
To give an oral presentation	1.19

To design a research study independently.	1.07
To apply various methodologies.	1.4

For the effect size analysis, four effect sizes have been calculated and interpreted here. According to the benchmarks of Cohen's d, four effect sizes are all large effects, which suggest a roughly large and positive magnitude of the effect of this year's REU/RET program on students' confidence in doing research. To further interpret, students are 1.38 standard deviations more confident in performing supervised research after participating than before the program.

Career Choices

REU/RET students were also assessed in terms of career choices and how their participation in the program impacted retention, career choice and attending graduate school. Table 7 shows the mean differences between the pre-test and post-tests and T test results.

Table 7: REU/RET Participants Career Choices

Item	Mean Difference	T Value	P Value
To finish the undergraduate degree.	.56	1.28	.218
To switch to another major.	-.62	-2.61	.02*
To find a job after bachelor's degree.	.125	.33	.743
To attend graduate schools in STEM.	.875	1.81	.089
To obtain a Master's degree in STEM field.	.812	1.84	.085
To obtain a PhD in STEM field.	.357	.836	.418

*means p<0.05

Table 8: Effect Size of Career Choices

Items	Cohen's d
To switch to another major	1.3

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This analysis regarding students' career choice suggested that students' perception of their career choice has not been significantly changed in terms of attending graduate school and by participating in this program students have reported that they are more likely to stay in their STEM fields instead of switching to other majors. In addition, by looking into the mean differences and p value of items related to attending graduate school, students are more committed in attending graduate schools after participating in this program however this difference was not large enough to be statistically significant.

Program Expectations

REU/RET participants were asked about their expectations of the program in both the pre- and post-survey. Comparisons to student responses were analyzed and the mean differences are shown in Table 8.

Table 9: REU/RET's Program Expectations

Items	Pre-Mean	Post-Mean	Mean Difference
Improved ability to complete research	4.56	4.18	.375
Determined whether graduate school fits me	4.06	3.87	.187
Provided me with faculty mentorship	4.5	4.18	.312
Encouraged me to pursue my own interests	4.56	3.81	.75
Developed research skills related to my major	4.31	3.93	.375
Built my confidence in working with faculty	4.5	4.25	.25
Developed my presentation skills	4.6	4.06	.375
Increased chances of entering graduate school	4.6	4.30	.562
Socialized with other REU students	4.85	4.78	.071

According to the pre-survey results, students had expectations of the REU/RET program improving their ability to do research, determine if graduate school was an option and develop research skills related to their majors. After the program, student's research abilities improved, they were more confident about attending graduate school and students were encouraged to pursue their research interests.

Program Satisfaction

REU/RET participants were asked about their level of satisfaction with the program in the pre-survey and post-survey. The following table (Table 10 and 11) provides information regarding students' satisfaction with the program administration and research experiences.

Table 10: REU/RET's satisfaction with program administration

Items\Ratings	Very poor	Poor	Adequate	Good	Very good	Average Rating
Clarity of the goals of the summer program	0.00%	0.00%	15.00%	20.00%	65.00%	4.5
Communication with the program staff	0.00%	0.00%	5.00%	15.00%	75.00%	4.74
Clarity of the expectations for participants	0.00%	0.00%	15.00%	25.00%	60.00%	4.45
Clarity of the research project topics	0.00%	5.00%	25.00%	35.00%	30.00%	3.95
Clarity of the REU schedule	0.00%	5.26%	21.05%	31.58%	42.11%	4.11
Travel arrangements	0.00%	0.00%	5.00%	15%	75.00%	4.74

Table 11: REU/RET satisfaction with research experience

Items/ratings	Very dissatisfied	Dissatisfied	Neither dissatisfied nor satisfied	Satisfied	Very satisfied	Average Rating

Interaction with faculty advisor	0.00%	5.26%	10.53%	31.58%	52.63%	4.32
Interaction with graduate students	0.00%	10.53%	5.26%	47.37%	36.84%	4.11
Interaction with project staff	0.00%	5.26%	0.00%	47.37%	47.37%	4.37
Housing arrangements	0.00%	0.00%	5.26%	36.84%	57.89%	4.53
Your research experiences	0.00%	0.00%	0.00%	42.11%	57.89%	4.58
Tutorials	0.00%	0.00%	15.79%	36.84%	47.37%	4.32

In general, students were largely satisfied with the administration of this REU program. Specifically, 85% of REUs believed that clarity of the goals of this program is good or very good; 90% of them rated communication with the program staff good or very good; 85% of them considered the clarity of expectations for participants good or very good; 85% of all students thought of the clarity of research topics as adequate, good or very good; over 85% of students rated the clarity of the REU/RET schedule and the travel arrangements good or very good. In terms of satisfaction with the research experience, students demonstrated higher level of satisfaction with the interaction with faculty, peers, project staff and housing arrangements. Other important survey items to note show that 84% of all students believed that they are satisfied or very satisfied with their interaction with their faculty advisor; roughly 83% of them rated their interaction with graduate students satisfied or very satisfied; 94% of them considered interaction with staff satisfied or very satisfied; 95% of them rated their housing arrangements satisfied or very satisfied. For the overall research experience, 100% of REU/RET participants believed that they are satisfied or very satisfied. Based on the satisfaction analysis

above, students are generally satisfied with the program administration and the research experiences.

Part II: Results of Open-ended questions (student survey)

As a supplemental evidence to evaluate the effect of REU/RET program, four open-ended questions are provided on the student survey. The responses were analyzed by identifying the commons themes to look for trends.

Analysis of Question One

The first question asked students what their most positive experiences were in the REU/RET program. The analysis of this question yielded three very significant themes related to the expected objectives of REU program.

The first theme is the research experience, which is the expected goal as examined in the literature review above. Students believed that this program provided them with an environment, where they can truly do research of their interest and improve their research ability. The following are direct responses from REU participants regarding this theme:

"I was glad that I was finally able to conduct research since I've never experienced it before."

"My most positive experience was completing my research and presenting it."

"The entire experience was entirely positive. I learned how to conduct research and the necessary tools needed to do so effectively."

"The ability to design, simulate, construct, and test a component that will be applied to CReSIS research was an unbelievable experience."

"The most positive experiences for my experience were hands on field work, constructive critiquing, and learning new programming languages."

The second theme is social networks created by this program, which is beyond the common goals of REU/RET program. More importantly, social networks between students and faculty can potentially help students prepare for the graduate school. The acquisition of social networks should be considered as a profound effect of this REU/RET program given its importance to REU/RET students' career prospects. A number of students mentioned the importance of social networks:

"I enjoyed interacting with individuals from different majors and learning more about North Carolina's watershed."

"I had a great time with my mentor and learned a lot of new information."

"Interacting with other REU students, faculty, and graduate students was valuable insight into life as a graduate student."

"My most positive experiences would have to be the relationships that were built here"

"Being able to meet other people within my field and we help each other work out our programming problems even though we were on different projects."

"Learning from others in my lab and making new connection while learning about my project to accomplish the goal of finishing it."

"The most positive experiences were the encouragement from the mentors in the program."

Analysis of Question Two

The second question asked REU/RETS participants what was least helpful or informative from the REU/RET Program. In general, four students stated that specific tutorials, such as the Matlab tutorials, TeraScan traning and *The Python/C++ lessons*, were not helpful to themselves because they have previously learned these lessons or they thought these lessons are not applicable in their future study or work. (Note: Each program site had arranged various professional development workshops and activities.)

"The Python/C++ lessons were least helpful to me, but that is because I previously learned it in my major."

"TeraScan training was least helpful to me due to the fact it did not help with me learning about research or anything with my major. It was nice to learn but I cannot see myself using that information anywhere else in my life."

"The matlab tutorials were not helpful to me. I feel that they were oriented towards mapping and visualization, and I already have significant experience in matlab from my undergraduate studies."

"MacOsX and Python/C++ training were the least helpful because I am not sure that I will use them again in the future."

Analysis of Question Three

The third question was to evaluate if the student's academic and career interests were influenced by this REU/RET program. This analysis has showed that students' career planning have been influenced in three ways. First, this research experienced largely boosted students' confidence in succeeding in graduate school. Students commented

"It exposed me to a greater understanding of research. As a non-traditional minority student, it also boosted my confidence in applying to graduate programs, as I was allowed a nurturing environment to grow competencies in data analysis, satellite imagery, and overall conducting of research."

"Participating in an REU made me much more confident and prepared for graduate school. I am prepared to do research, and I have a better chance of a great grad school career."

In addition, students believed this REU experience increased their chance of getting into graduate school because of the knowledge about graduate school enrollment, their networking with faculty members and their improved research skills. They commented

"The REU program increased my chances of getting into grad school by not only providing me with research experience but also through various roundtables/lectures on grad school which were very helpful."

"During the REU experience, I took the opportunity to communicate with a faculty member on campus who is a professor in the graduate program I am interested in pursuing. This encounter with the faculty member was a wonderful experience because it provided me with clarity regarding the graduate program and helped me to greater understand my passion for wanted to be a unique part of it in the future."

"I had the opportunity to learn how to code which will help me when applying for graduate school."

"I feel more qualified now to get into a good grad program and later a good job, because REU is an amazing experience to have on a resume."

"I am more prepared in research and bettering my chances for graduate school."

Third, this research experience enabled students to develop a better understanding of research and academic environment in graduate schools and thereby influenced their decisions to enter graduate school. They mentioned

"Participating in this program allowed me to see the benefits of going to graduate school after obtaining my bachelor's degree versus rushing to find a job when I graduate."

"The REU program help me develop better understanding of what research is like and motivated me to go to grad school."

"I am considering graduate school more seriously now than I was entering the program."

"By participating in this program it help me look forward to what i should expect in grad school."

"Participating in this program helped me decide that I should pursue my masters soon after graduation."

"It has given me a more positive outlook on graduate studies and conference attending. It has also given me a chance to think broader as my research require a great amount of thinking and searching."

Analysis of Question Four

The fourth question was to collect REU/RET student's recommendations about how to improve the quality of the program. REU/RET students' recommendations generally reflected the need of continually improving the mentorship. One students recommended that mentors should be able to supervise students' research for the whole program and the other recommended that mentors should choose the research topic for students prior to their arrival.

"One thing I'd recommend is to make sure students are paired with faculty advisors who plan to be there for the whole program. One other student's mentor was gone for several weeks, which was very frustrating for her. My mentor was gone the week everything was due, so she didn't get to look over everything and wasn't satisfied with the paper I turned in when she eventually read it."

"I would recommend that faculty mentors and/or their respective graduate students, prior to the REU participants' arrival, be evaluated to ensure that they have chosen a

research topic or project for the students. With this in place, students will not have to

arrive to the REU program expecting to receive a research project or topic and receive

nothing or receive an unexpected delay in commencement of their research project due

to lack of preparation on the side of the faculty mentor and/or graduate student."

Part III: Analysis of Mentor survey

REU/RET mentors, including faculty members, graduate students and staff, were also surveyed to share their thoughts about this REU/RET program. This survey was sent to ten mentors and five of them completed the survey, which leads to a response rate of 50%. These five mentors consisted of four professional staff members and one graduate student. This survey showed that mentors met students at least two times a week. Specifically, 40% of mentors reported that they met students every day. Table 11 shows the rate of six items designed to measure students' academic achievement from mentors' perspective. The percentage of negative responses and positive responses were respectively reported in this table.

Table 12: REU/RET Program Mentor Perspective

Items	Strongly disagree	Disagree	Neither	Agree	Strongly agree
Developed insights into the process of scientific research	20% (1)	0.0% (0)	0.0% (0)	40% (2)	40.0% (2)
Developed an appreciation of the scientific research	20% (1)	0.0% (0)	0.0% (0)	80.0% (4)	0.0% (0)
Contributed to my research project	20.0% (1)	0.0% (0)	0% (0)	40% (2)	40% (2)

Improved their research skills	20% (1)	0.0% (0)	0.0% (0)	40.0% (2)	40.0% (2)
Improved their ability in creating technical presentations	20% (1)	0.0% (0)	0% (0)	20% (1)	60% (3)
Demonstrated increased enthusiasm toward research	20% (1)	0.0% (0)	0.0% (0)	40% (2)	40% (2)

The results show most mentors believed students participating in the REU/RET program developed insights into the process of scientific research, an appreciation of the daily work of researchers, contributed to research projects, improved their research ability and presentation skills, and demonstrated more enthusiasm toward science and research. Mentor's satisfaction with the 2015 REU/RET program was also analyzed and results shared in Table 12. The table includes mentors' satisfaction with students' achievement as well as mentoring experience.

Table 13: REU Mentor Satisfaction

Items	Strongly disagree	Disagree	Neither	Agree	Strongly agree
Be satisfied with REU's achievements.	20%	0%	0%	20%	60%
To participate in this program next year.	20%	0%	20%	20%	40%
My experience as a REU mentor was valuable.	20%	0%	0%	20%	60%

Based on the data analysis above, 80% of mentors surveyed were satisfied with REU/RET student achievements; 60% of mentors who participated this year agreed to mentor the students next year; 80% of mentors surveyed agreed that their experience as REU/RET mentors was valuable.

Part IV: Analysis of open-ended questions (mentor survey)

Mentors were also asked open-ended questions that centered on improving their mentoring experience as well as the future REU/RET programs. When asked how to improve the future REU/RET programs, mentors shed valuable light on how to improve the quality of future programs, including setting up a new scientific writing webpage and following up with students after the program. They commented

"The development of a central webpage dedicated to scientific writing, including the importance of a literature review may improve the REU program."

"Better follow-up during the academic school year to keep them in the pipeline."

Conclusion

The evaluation results suggest that the CReSIS REU/RET program has provided such a valuable experience that students have significantly improved their research skills, have largely increased their confidence in conducting research and have successfully encouraged them to consider attending graduate school. The effect size analysis confirmed that this program had a positive and large effect on students' three primary outcomes: research skills, confidence in conducting research and STEM career aspirations. It is worth noting that in addition to these three expected goals, this year's REU program has enabled students to form friendships with their peers, has allowed students to form close connections with faculty members and also has encouraged students to persist in their STEM studies. In terms of research experience

satisfaction, 2015 REU/RET students were largely more satisfied with this research experience and with various achievements they gained through this experience than 2014 REU/RET students. From mentors' perspectives, they suggested that the REU/RET program had a positive impact not only on students' research but also on attitudes toward their careers in STEM fields.

Recommendations

The following recommendations are made based on the data analyzed from the REU/RET pre- and post-survey and the mentor survey.

- Given that this research experience has largely boosted minority students' confidence in conducting research, CReSIS needs to continue its recruitment efforts and keep increasing the number of minority and underrepresented students in the REU/RET program.

- As compared to survey results of 2014, this year's REUs were more satisfied with their interactions with their mentors however CReSIS may continuously look for mentors who are available for the whole program and encourage more faculty interaction with students throughout the program.

- CReSIS may set up a new webpage related to scientific writing since knowledge about scientific writing are critical for students to prepare for writing research papers and making research posters.

- As recommended in the mentor survey, CReSIS may consider updating the database that keeps track of former REU/RET students in order to follow up with their career plans and

to provide necessary help for their success in STEM fields. This should be made available

to mentors.

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Appendix

Appendix A – List of Student Research Projects *(Name/Project Title)*

Appendix B: The pre-survey of REU (all-campuses)

Appendix C: The post-survey of REU (all-campuses)

Appendix D: The mentor survey