



## How to Increase the Impacts of the REU Experience in an Interdisciplinary Research-based REU Site

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# **How to Increase the impacts of REU experience in an interdisciplinary research based REU site**

## **1. Introduction**

The Texas A&M University-Kingsville Integrating Research in Sustainable Energy and the Environment across Disciplines (IR-SEED) REU site adopted an interdisciplinary and balanced approach as a guiding principle, and provided fundamental research training to REU participants in sustainable energy and environment areas in the last three years. The REU site was designed to offer REU participants an opportunity to gain new insights and knowledge in the broad spectrum of energy challenges and to provide an in-depth research experience in the following areas: 1) renewable energy; 2) clean conventional energy; 3) energy policy, environmental and social impacts.

The IR-SEED REU site is interdisciplinary in nature and focused on different aspects of sustainable energy research. REU participants conducted research for 10 weeks during the summer session. The IR-SEED REU site provided initial orientation and training on how to conduct research, followed by a period of intensive research experience under the mentorship of a faculty member and a graduate student. In order to enhance REU participants' understanding and to broaden their perspective of energy systems challenges, they were given ample opportunities to share their research progress with the other REU participants in weekly group meetings, mid-term progress presentations, and final project poster and oral presentations. Weekly seminars were also provided to the REU participants to cover different research topics, technical writing skills, effective presentation skills, professional ethics, graduate school applications, etc. Since the REU participants spent most of their time interacting with the PIs of the REU site, faculty mentors and graduate students who advised their research projects, to balance the roles of PIs, faculty mentors, and graduate students is critical to being able to increase the impacts of REU experience on those REU participants.

In order to answer this question of "how can we increase the impacts of REU experience," different evaluation and assessment methods were implemented in the last three years. Surveys were conducted to collect feedbacks from REU participants (pre and post surveys), faculty mentors, and graduate students. A follow-up phone interview was conducted by an external evaluator around November every year to further collect REU participants' feedbacks. All the questions listed in the surveys were designed coordinately, so that the data can be compared during the analysis process. In this paper, the authors present detailed analysis results based on all survey data in the last three years, and discuss different approaches on increasing the impacts of REU experience in the IR-SEED REU site.

## **2. Program Overview**

In the last three years, the IR-SEED REU site had received 187 completed applications from 105 different universities in 38 states across the nation as shown in Figure 1 below. Table 1 shows the demographic information of the received applications and final selected REU participants.

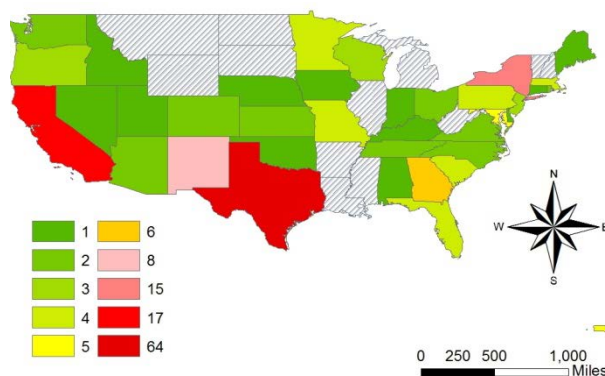


Figure 1: Number of applications received per state

Table 1: Number of applications received/selected and related demographic information

	Year-1	Year-2	Year-3	Total
<b># of completed applications received/selected</b>	58/10	89/12	40/11	187/33
<b>Hispanic students</b>	20/2	30/6	22/8	72/16
<b>African American students</b>	9/1	9/1	4/0	22/2
<b>American Indian or Native Hawaiian students</b>	3/1	1/0	0/0	4/1
<b>Female students</b>	24/3	50/5	17/7	91/15

The goal of the selection process is to recruit as many high-achieving, well-motivated underrepresented students (particularly Hispanics, African-American, and women) as possible. The IR-SEED REU site was able to support 33 REU students in three years from 19 different universities in 14 different states across the nation as shown in Figure 2 below.

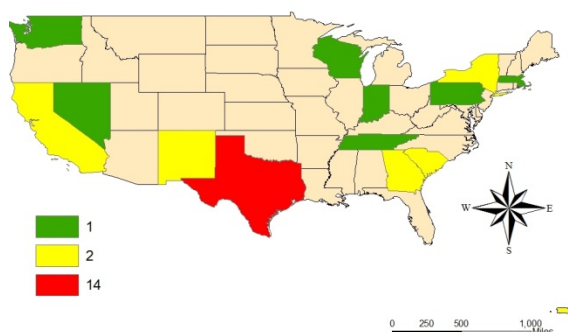


Figure 2: Number of REU students per state

The 33 REU students conducted 33 different research projects in three major areas: 1) Renewable Energy (14 projects), 2) Conventional Clean Energy (9 projects), 3) Energy Policy, Environmental & Social Impacts (10 projects). All 33 projects are either part of ongoing funded research projects or related to graduate students' ongoing thesis or dissertation research projects. Eight tenure-track and 4 tenured faculty mentors (3 female and 1 Hispanic) and 19 graduate assistants (8 PhD students and 11 second year Master students) from five different departments in the college were recruited to advise and mentor the REU participants.

### 3. Results and Discussions

Quantitative and qualitative analysis methods were used to compare the effects of different approaches implanted in the REU site. Pre and post surveys and follow-up phone interviews were conducted to collect REU participants' feedbacks, while different surveys were also conducted to collect feedback from faculty and graduate assistants. Table 2 shows selected REU students post survey results in all three years. After attending the IR-SEED REU site,

- About 91% REU participants rated their overall experience excellent or very good, which matches with the follow-up phone interview results.
- About 62% REU participants had increased interests in going to graduate school.
- Close to 70% REU participants had increased interests in pursuing research career.
- About 42% REU participants decided to pursue a higher degree.

Table 2: Selected REU participants' survey results (in percentage)

	Year-1	Year-2	Year-3	Total
Overall experience: Excellent/Very Good/Good	67/22/11	64/27/9	55/36/9	64/27/9
Interested in going to grad school: increased/same/decreased	67/33/0	73/18/9	46/54/0	62/35/3
Interested in research career: increased/same/decreased	78/22/0	64/27/9	64/36/0	68/29/3
Highest degree planned to obtain: increased/same/decreased	44/56/0	36/55/9	36/64/0	42/55/3

Although the overall satisfaction/impacts are almost same in the three years, REU participants themselves realized significant improvements in different aspects in different years. When comparing the pre and post survey results for 19 different questions about different abilities, such as formulating a research question, communicating with project faculty, making technical presentations, etc., there are some differences among the three yearly programs. By conducting two-tailed t-test, only one ability showed significant improvement in year-1, which is "Dealing with unanticipated delays in conducting research." In year 2, the following four abilities showed significant improvement [1]:

- Formulating a research question
- Planning a research project
- Conducting research
- Making technical presentations

In year 3, besides the four abilities with significant improvement in year 2, "Submitting a paper for publication" also showed significant improvement. It is obvious that the IR-SEED REU site had much more positive impacts on the REU participants in years 2 and 3 compared with year 1. The PIs believe that the major reason leading to the improvement in the positive impacts is that REU participants were more engaged during and after the 10-week program. There are different factors associated with REU participants' engagement [2]-[5], including students' interests in research, communication among students, communication between students and faculty advisor, etc. By comparing the survey results in all three years, more differences were founded that may be associated with the levels of engagement:

- More REU participants in years 2 and 3 thought that they had the right amount of time working with other REU participants and meeting with faculty and students.
- More REU participants in years 2 and 3 thought that working with other REU participants was valuable/very valuable
- Faculty advisors thought that REU participants in years 2 and 3 gained more knowledge by working collaboratively with other REU participants and graduate student mentors.

It seems like the communication among REU participants, faculty advisors, and graduate students were improved in years 2 and 3. Despite the differences of REU participants themselves and research project topics in the three years, the program design of the IR-SEED REU site itself was changed from year 1 to the last two years. In year 1, almost each REU participant worked on a separate research project with one faculty and one graduate student. In year 2, some REU participants worked on different tasks under same research project with one faculty and one graduate student as small groups instead of individual research project in year 1. In year 3, all REU participants worked in small research group setting with 2-3 REU participants per group with one faculty and one graduate student. Since all the research projects were related to sustainable energy and environment and were interdisciplinary in nature [6], The PIs believe that the change from individual project setting to group project setting is the major reason leading to the positive impacts on REU participants' communication and engagement levels. Working in a group setting allows more opportunities for communication and discussion among the REU students who have different backgrounds.

According to the follow-up phone interview, the same observations were found by comparing the phone interview results among the three years. Comparing the feedbacks from year 1 and year 2, the second year feedback showed significant improvement in communications with the mentors, continued mentoring, and student engagement after the REU program [1]. The year 3 follow-up phone interview results also showed several significant improvements:

- Those who continued with research following the 2017 REU experience did so to produce products based on activity from the summer or to continue to expand upon it to create additional presentation- or publication-worthy material.
- Individuals not continuing with research made this decision due to work or other significant time commitments but had a universal interest in renewing research activity in the future.
- Nine significant benefits of the project emerged (listed from most frequently noted across all applicable questions to least frequently stated)
  - a. Impact on perspective relevant to and plans for the future.
  - b. Encouragement toward involvement with academics and research.
  - c. Confirming interests and intentions related to research, careers, and degrees.
  - d. Learning achieved through involvement in the REU project.
  - e. Providing new experiences and expanding personal horizons.
  - f. Skill development.
  - g. Improving academic and professional qualifications.
  - h. Receiving mentoring.
  - i. Developing self-efficacy.

#### 4. Conclusion

The IR-SEED REU site supported by the National Science Foundation's Division of Engineering Education and Centers is designed to develop and implement a model environment for multidisciplinary collaborative efforts where research and education are tightly integrated around the different facets of energy research. The IR-SEED REU site is structured to teach students how to formulate research questions as well as how to develop and modify research plans with the guidance of their research mentors, and eventually increase their interests on STEM research and post-graduate education.

In the last three years, REU participants were uniformly complimentary of the IR-SEED REU site. In addition, since the REU students spent most of their time interacting with the PIs, faculty mentors and graduate students advising their research projects, the balance between the roles of PIs, faculty mentors, and graduate students is significantly important for increasing the impacts of REU experience on REU participants. However, the REU students have different opinions on how they were impacted by the PIs, faculty mentors and graduate students. In this paper, the authors presented detailed analysis results based on the survey data, and tried to figure out a better way to balance the roles of PIs, faculty mentors, and graduate students in the IR-SEED REU site to improve the impacts on REU students. According to REU participants' survey and follow-up phone interview results, more than 90% of the REU participants mentioned that close interaction with the PIs (almost daily) through research seminars, weekly progress group meeting, and field trips was the key factor helping them enjoy the REU program. While the REU participants enjoyed the field trips, they also expressed concerns about scheduling too many of them, which could interfere, delay or interrupt their planned research activities. They preferred to have most field trips and research seminars scheduled in the beginning of the REU program instead of towards the end of the program. At last, the PIs believe that strong institutional support was also a key factor helping improve REU participants' experiences. The IR-SEED REU site received fully support from different offices at the university. The AVP for Student Success and AVP for Student Access offered different seminars related to professional skills and writing workshops. The Housing department provided discounted room rate so that REU participants were able to stay in the best dorm in the campus. The recreation center provided discounted rate so that the program was able to provide access to recreation center for all REU participants. With the support from the college, the IR-SEED REU site was able to 1) provide a reserved classroom for REU students every year with computers and printers/scanners, 2) provide visiting student ID cards to access most university facilities including library, campus shuttle, etc. 3) apply keys of the reserved classroom and necessary laboratories for REU participants, and 4) creating university student account for accessing internet and computers.

#### 5. Acknowledgement

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