# REU student engagement during and after REU program: a case study comparing individual project with group project

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## 1. Introduction

This National Science Foundation funded research experiences for undergraduates (REU) site at Texas A&M University-Kingsville (TAMUK) seeks to provide an impactful summer research experience in the emerging field of sustainable energy and expand research opportunities for underrepresented students. Students are expected to learn to work independently and to collaborate with other group members as they conduct research in specific topics in energy research. This will enable them to understand their own levels of aptitude and interest in a career in science, technology, engineering, and mathematics (STEM) and give them the tools to prepare for the next stage in their education and career development. Students will report and present their research results in multiple settings. The research, educational, and career mentorship provided by the program is envisioned to stimulate the students to look at their academic work in a new light and to provide a spark for possible careers in academic research or industrial innovation.

Participation in REU programs has shown positive impacts on both undergraduate students and faculty mentors [1]. For undergraduate students themselves, most of the positive effects are in the areas of analytic and critical thinking, academic achievement and retention, and graduate school applications [2-3]. However, how to effectively engage the undergraduate students during and after REU program in order to maximize the positive impacts is always a challenge for most REU sites [4-6].

## 2. Project Design and Implementation

This REU site 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.

In the first year (Summer 2015), there were 53 completed applications, in which 15 from TAMUK and 37 from other universities. Ten students were selected as REU participants, including three from TAMUK and one from each of the following universities: Georgia Institute of Technology, Purdue University, UCLA, Texas Tech, University of Nevada, Polytechnic University of Puerto Rico, and Rensselaer Polytechnic Institute. Each research team was comprised of one faculty mentor, one graduate student and one REU student, while each REU student conducted different research projects. Unfortunately, one REU participant had to withdraw from the program in the fifth week due to serious health problems. The remaining nine projects in the first year are shown in Table 1 below.

In the second year (Summer 2016), there were 91 completed applications (5 from TAMUK, 86 from other universities). With additional support from NSF, 12 students were selected as REU participants including two students from TAMUK and one student from each of the following universities/colleges: Penn State University, UC Berkeley, University of Wisconsin-Madison, Georgia Institute of Technology, University of South Carolina, New Mexico State University, Seattle University, Texas Tech, Del Mar College, Laredo Community College. The project list

and team members are shown in Table 2. Most research teams (except one team) were comprised of one faculty mentor, at least one graduate student, and at least two REU students, while each REU student conducted different tasks under the same research project or related research areas.

Table 1: REU project list in the first year

| **Project Title** | **Department of Faculty Advisor** |
|---|---|
| Impact of membrane material in the electrodialysis metathesis process for desalination of salty water | Environmental Eng. |
| Feasibility of using desalination concentrate for hydraulic fracturing fluid | |
| Regeneration of toxic vapor-saturated activated carbon via microwave energy | |
| Two-axis position control of solar panels for maximum efficiency | Mechanical Eng. |
| Dynamics and control of wind turbines | |
| Bridging FEA software in mechanical engineering to nuclear reactor neutronics simulations | |
| Integration of photovoltaic thermal systems in residential buildings for energy Saving | Civil Eng. |
| Application of seawater-source heat pump in hot climate | |
| Influence of SCIG & DFIG based wind turbine on the voltage stability of a weak distribution power grid | Electrical Eng. |

Table 2: REU project list and team members in the second year

| **Project Title** | **Team Members** |
|---|---|
| Recycling of drilling waste for road base material from eagle ford shale area | Two REU participants with one faculty from Civil Eng. |
| Energy savings potential of phase change material integrated building envelope | One REU participant in each project. Both were advised by the same faculty and graduate student from Civil Eng. |
| Improving safety and energy performance of highway lighting system through dynamic simulation | |
| Microwave energy-induced activation to manufacture activated carbon for air pollution control applications | Two REU participants with one faculty and one graduate student from Environmental Eng. |
| Streamflow forecasting | One REU participant with one faculty and one graduate student from Environmental Eng. |
| Clean energy technologies to minimize carbon pollution from power plants | Three REU participants worked on the two projects advised by the same faculty and two graduate students from Chemical & Natural Gas Eng. |
| Waterless frac fluid for eco-friendly stimulation in unconventional reservoirs | |
| Social impact analysis of eagle ford shale development | One REU participant in each project. Both were advised by the same faculty and graduate student from Industrial Eng. |
| Onshore wind farm layout optimization using genetic algorithm | |

Despite the different project topics, the components and requirements in the first two years were almost same, including field trips, weekly seminars, weekly progress reports, mid-term and final project presentations and reports.

## 3. Project Results and Analysis

In this section, the authors analyze the student engagement in the first two years through REU participants' performance, REU participants' pre and post surveys, and follow-up phone interview. The follow-up phone interview was conducted by an external evaluator around November every year. The student engagement during the REU program is analyzed based on the results from REU participants' pre and post surveys, as well as part of the follow-up phone interview results. The REU participants engagement after the REU program is mainly related to the REU participants' continued research efforts, and is analyzed based on the follow-up phone interview, REU participants' publication efforts, and REU participants-faculty interaction after the REU program.

In the first year, nine REU participants completed the survey and phone interview, while there were eleven REU participants that completed the survey and twelve students that completed the phone interview in the second year. Based on the post survey results, most REU participants rated their overall experience very good or excellent, which matches with the follow-up phone interview results.

Table 3: REU participants' survey results about overall experience rating

| Overall experience | Year-1 | Year-2 | Total |
|---|---|---|---|
| Good | 11.1% | 9.1% | 10.0% |
| Very Good | 22.2% | 27.3% | 25.0% |
| Excellent | 66.7% | 63.6% | 65.0% |

Table 4: REU participants survey results about interests in research

| Responses | | Year-1 | Year-2 | Total |
|---|---|---|---|---|
| Interested in going to grad school | Decreased | 0.0% | 9.1% | 5.0% |
| | Stayed Same | 33.3% | 18.2% | 25.0% |
| | Increased | 66.7% | 72.7% | 70.0% |
| Interested in research career | Decreased | 0.0% | 9.1% | 5.0% |
| | Stayed Same | 22.2% | 27.3% | 25.0% |
| | Increased | 77.8% | 63.6% | 70.0% |
| Highest degree planned to obtain | Decreased | 0.0% | 9.1% | 5.0% |
| | Stayed Same | 55.6% | 54.5% | 55.0% |
| | Increased | 44.4% | 36.4% | 40.0% |

Based on the results shown in Table 3 and 4, it seems like there is no difference between the first and second year. However, when comparing the pre and post survey results for 19 different questions, there are some differences between the two years. Each question asks REU participants' confidence in one type of ability, such as formulating a research question. By

conducting two-tailed t-test for the first year's results, only one question (Dealing with unanticipated delays in conducting research) shows significant improvement with p-value of 0.03. For the second year, there are four questions show significant improvement as below:

- Formulating a research question (p-value 0.003)
- Planning a research project (p-value 0.017)
- Conducting research (p-value 0.015)
- Making technical presentations (p-value 0.020)

Although the overall satisfaction/impacts are almost same in the first two years, REU participants themselves realized significant improvements in different aspects. This REU was 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. As a matter of fact, the four improved abilities based on the second year survey responses are all related to the program's objectives. It is obvious that the second year REU participants were more engaged in the research projects compared with the first year REU participants.

As of publication efforts, in the first year, there was one journal paper published based on a REU project's results and two posters presented by REU participants in national conferences. In the second year, there are already three posters presented by REU participants in regional and national conferences, and there are at least four journal papers to be submitted based on REU projects' results.

As of the follow-up phone interview, its purpose was to further collect the feedbacks from REU participants to help improving this REU program. During the interviews, REU participants were given the opportunity to elaborate on:

- What they considered to be valuable experiences from the IR-SEED project
- Their continuing communication with faculty and graduate student mentors
- The continuation of their IR-SEED research efforts
- The personal, academic, and career impact of their project participation
- How the project could be improved
- Other comments/concerns/suggestions for project leaders

According to the phone interview results, of the nine REU participants in 2015, three were continuing their research efforts after their summer experiences, and the remaining six had not continued their research at that time. Two of the three REU participants who had continued their research were students at TAMUK so they were able to see their faculty mentors often. In the evaluation report, the external evaluator stated "… understands that follow-up with REU participants who are the institute students is easier than with non-institute students; however, WTER encourages the project leader to work with faculty mentors in conducting follow-up with all their scholars. This follow-up can be especially important in encouraging and possibly facilitating continuation to graduate school as well as presentation of scholars' research efforts."

According to the 2016 phone interview results, seven REU participants reported at least some communication with their faculty mentors which ranged from getting recommendation letters to working on papers and/or presentations based on their summer research. One REU participant shared that his/her paper had been accepted for publication, and another shared that he/she had

made one presentation. Six others indicated that they are either working on or have plans to work on papers or presentations. In the evaluation report, the external evaluator stated “Some scholars shared examples of how their faculty mentors are continuing to communicate with them about opportunities for presenting their research. WTER compliments the faculty for these efforts and hopes these efforts will continue and be expanded among more faculty mentors.”

## 4. Discussion and Conclusion

The results show there is improvement in the student engagement level by comparing the two years of data. Despite the differences of REU participants themselves (i.e. REU students, faculty and graduate student mentors) and research project topics in the two years, the authors believe that the major reason leading to the improvement in the student engagement is that the designs of the program itself in the first two years are different. Making REU participants work on different tasks under same research project as small groups instead of individual research project shows some advantages of helping engage REU participants during and after the REU program.

Based on the experiences gained during the two years, promoting discussion and communication among REU participants are as important as promoting communication between REU participants and faculty advisors in order to engage the REU participants into research during the REU program [7]. Although several approaches were used in the first year to promote discussion and communication among REU participants, including weekly group meeting, they are not effective compared with dividing REU participants into subgroups to work in same or similar research topics. REU participants in the same subgroups will by nature meet, discuss, and communicate more often.

In order to engage the REU participants into research after the REU program, promoting the communication between REU participants and faculty advisors are the most important and effective way [8]. Working together on publishing journal or conference papers is very effective since it is a win-win situation for both students and faculty. From this standing point, group projects will be easier to get more results for journal/conference publications compared with individual projects, which could also be supported by the publication efforts mentioned above.

Based on the survey and phone interview results, the authors believed this REU program was having a very positive impact on participating students. The program itself was able to provide an environment that allowed students to gain knowledge and skills, encouraged their continuation in research, and provided important information needed for their decisions about graduate school and careers. Faculty and graduate student mentors had provided good support and guidance for the REU participants. REU participants were pleased with their experiences and provided no major suggestions for changes.

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