Board 329: Lessons Learned: NSF REU Site - Growing Entrepreneurially Minded Researchers with New Product Development in Applied Energy

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1. Introduction

The NSF REU Site program context was entrepreneurial development and applied energy research where participants were introduced to a graduate school like experience by simultaneously gaining entrepreneurial training via customer discovery interviews, market analysis, and patent research, and at the same time conducting lab research within the energy field.

Data collection methods included weekly photovoice reflections, retrospective surveys, and focus groups. The focus of data collection was to assess student learning and engagement concerning three key areas: (1) Career Goals, (2) Entrepreneurial Competencies, and (3)Research Skill Development.

The purpose of this poster is to provide lessons learned over the past three years of program delivery including:

1. Year 1 (2021-2022 academic year): virtual and part-time
2. Year 2 (2022 Summer): traditional in-person and full-time
3. Year 3 (2023 Summer): traditional in-person and full-time

The guiding research question is as follows: *How do perceived learning gains compare across a traditional REU (in-person, 10 weeks over summer, full-time) versus an REU delivered virtually, part-time, and over 10 months?*

2. Methods

2.1 Study Design and Participants

The study was based on an REU program at a Midwestern University. Program Participants were undergraduate students from various engineering majors across the United States. The program delivery and demographic characteristics are provided for each term. In **Year 1 REU (virtual + part-time + 10 months),** a total of 15 students participated in the study, 9 females and 6 males; 11 students from minority-serving institutions (including historically black college or university, tribal college or university, and Hispanic-serving institution); 5 juniors and 10 senior level students; all 4 time zones represented; 11 first-generation students; all 15 students come from a minoritized population (e.g., Black, Hispanic, American Indian); the 15 students were working with 5 different advisors, 3 students per advisor. In **Year 2 REU (in-person + full-time + 10 weeks),** a total of 10 students participated in the study, 6 females and 4 males; 8 students from minority-serving institutions (including historically black college or university and Hispanic-serving institutions); 4 juniors and 6 senior level students; 7 students come from a minoritized population (e.g., Black, Hispanic, American Indian); 10 students were working with 5 different advisors, 2 students per advisor. In **Year 3 REU (in-person + full-time + 10 weeks)**, a total of 14 students participated in the study, 4 females and 10 males; 8 students from minority-serving institutions (including historically black college or university and Hispanic-serving institutions);

4 juniors and 10 senior level students; 10 students come from a minoritized population (e.g., Black, Hispanic, American Indian); 4 advisors had 3 students and 1 advisor had 2 students.

2.2 Data Collection and Analysis

At the end of each REU experience, a retrospective post-then-pre survey was used to assess perceived learning gains taking into consideration topic areas of Career Goals (Figure 1), Entrepreneurial Competencies (Figure 2), and Research Skill Development (Figure 3). The data was input into SPSS to conduct paired-sample student t-tests for each survey item. An alpha value of 0.05 was used to test for a statistically significant difference between "before participating in the program" and "after participating in the program".

Career Goals
To what extent do you agree with the following statement?

	Before participating in the program						Current participating in the program					
	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	**Strongly disagree**	N/A	**Strongly agree**	Somewhat agree	Neither agree nor disagree	Somewhat disagree	**Strongly disagree**	N/A
I plan to attend graduate school.	○	○	○	○	○	○	○	○	○	○	○	○
I have a well-defined career plan.	○	○	○	○	○	○	○	○	○	○	○	○
I see myself in the future as a research scientist.	○	○	○	○	○	○	○	○	○	○	○	○
I see myself working in the future in an applied energy field.	○	○	○	○	○	○	○	○	○	○	○	○

Figure 1 Questions focused on career goals

Entrepreneurial Competencies
To what extent do you agree with the following statement?

	Before participating in the program						Current participating in the program					
	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	**Strongly disagree**	N/A	**Strongly agree**	Somewhat agree	Neither agree nor disagree	Somewhat disagree	**Strongly disagree**	N/A
I strive to develop ideas.	○	○	○	○	○	○	○	○	○	○	○	○
I strive to develop creativity.	○	○	○	○	○	○	○	○	○	○	○	○
I strive to realize my short-, medium- and long-term goals.	○	○	○	○	○	○	○	○	○	○	○	○
I plan the necessary resources to realize my goals.	○	○	○	○	○	○	○	○	○	○	○	○
I work in accordance with ethics.	○	○	○	○	○	○	○	○	○	○	○	○
I work in accordance with sustainability.	○	○	○	○	○	○	○	○	○	○	○	○
I strive to develop empathy.	○	○	○	○	○	○	○	○	○	○	○	○
I take the initiative.	○	○	○	○	○	○	○	○	○	○	○	○
I make decisions fast and flexibly.	○	○	○	○	○	○	○	○	○	○	○	○

Figure 2 Questions focused on entrepreneurial competencies

Abilities to Conduct Research
To what extent do you agree with the following statement?

	Before participating in the program						Current participating in the program					
	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	**Strongly disagree**	N/A	**Strongly agree**	Somewhat agree	Neither agree nor disagree	Somewhat disagree	**Strongly disagree**	N/A
I am confident about my ability to work independently.	○	○	○	○	○	○	○	○	○	○	○	○
I am confident in writing a literature review in an academic article.	○	○	○	○	○	○	○	○	○	○	○	○
I am confident in writing results in an academic article.	○	○	○	○	○	○	○	○	○	○	○	○
I am confident in writing conclusions in an academic article.	○	○	○	○	○	○	○	○	○	○	○	○
I am confident in my data collection skills.	○	○	○	○	○	○	○	○	○	○	○	○
I am confident in my data analysis skills.	○	○	○	○	○	○	○	○	○	○	○	○
I am confident in my skill to develop the methods section in an academic article.	○	○	○	○	○	○	○	○	○	○	○	○
I am confident about my ability to understand all the sections in a scientific article.	○	○	○	○	○	○	○	○	○	○	○	○
I am confident in making oral presentations at conferences.	○	○	○	○	○	○	○	○	○	○	○	○
I am confident in managing my time properly.	○	○	○	○	○	○	○	○	○	○	○	○
I am comfortable working in a research team.	○	○	○	○	○	○	○	○	○	○	○	○

Figure 3 Questions focused on the abilities to conduct research

3. Results

In Year 1 (Virtual + Part-Time + 10 Months), data was collected midway in December 2021 (end of Fall 2021 semester) and at the end in May 2022 (end of Spring 2022 semester). The purpose of collecting data midway was primarily to implement corrective action if major issues were found. In Years 2 and 3 (In-Person + Full-Time + 10 Weeks), due to the shorter duration of the program, data was only collected at the end of the 10-week summer program.

A paired sample student's T-test was conducted for each item using a 0.05 alpha value to test for a statistically significant difference to assess perceived learning gains (e.g., pre vs post) across each of the 24 items shown according to category.

With the paired t-test, the null hypothesis is that the pairwise difference between the two samples is equal (H_0: $\mu_d = 0$). The goal is to assess if there is a statistically significant difference between the pre (before participating) and post (after participating), implying a learning gain within that specific item.

In total (Table 1), across all four categories, Year 1 Mid, Year 1 Final, Year 2 Final, and Year 3 Final assessments respectively demonstrated statistically significant learning gains across 17, 13, 11, and 21 items.

Table 1. Total Quantity of Statistically Significant Perceived Learning Gains by Group

Data Collection Period	Year 1 Mid	Year 1 Final	Year 2 Final	Year 3 Final
Career Goals	4	1	1	3
Entrepreneurial Competencies	6	3	2	11
Research Skill Development	7	9	8	7
Total Statistically Significant Perceived Learning Gains	17	13	11	21

4. Discussion and Conclusion

The guiding research question is as follows: *How do perceived learning gains compare across a traditional REU (in-person, 10 weeks over summer, full-time) versus an REU delivered virtually, part-time, and over 10 months?*

The results of this study show the potential for learning in an online environment. However, given only three samples, the results are mixed.

Before the COVID-19 Pandemic, limited studies on virtual vs. in-person REUs were available. During the pandemic, the world was forced to become virtual and transitioned to online learning. This change prompted the question of whether it is more advantageous to learn online or in person.

Moving forward, the authors recommend NSF consider being more intentional in testing new approaches to REU delivery (including length and format) to see what best suits specific audiences. Offering different delivery mechanisms can be used in an effort to broaden participation in engineering and engineering research experiences.